FOREWORD INTRODUCITON

PERSULFATES

7727-54-0: AMMONIUM PERSULFATE

7727-21-1: POTASIUM PERSULFATE

7775-27-1: SODIUM PERSULFATE

SIDS Initial Assessment Report

For

SIAM 20

Paris, France, 19-21 April, 2005

1. Chemical Name:	Ammonium persulfate, potassium persulfate, sodium persulfate as members of the persulfate category
2. CAS Number:	7727-54-0, 7727-21-1, 7775-27-1
3. Sponsor Country:	United States, National SIDS Contact Point: Oscar Hernandez, PhD. HPVCB/RAD/OPPT U.S. Environmental Protection Agency 1200 Pennsylvania Avenue Mail Code 7403M Washington, DC 20460, USA
4. Shared Partnership with:	CEFIC Persulfate Working Group
5. Roles/Responsibilities of the Partners:	Dr. Philip Block, Chairman, CEFIC Persulfate Working Group FMC Corporation 1735 Market Street Philadelphia, PA 19103, USA
– Name of industry sponsor /consortium	CEFIC Persulfate Working Group
– Process used	This document was prepared by FMC Corporation and peer-reviewed by all of the persulfate manufacturers in the CEFIC Persulfates Working Group.
6. Sponsorship History	
– How was the chemical or category brought into the OECD HPV Chemicals Programme ?	This substance is sponsored by the United States of America under the ICCA Initiative and is submitted for first discussion at SIAM 20.
7. Review Process Prior to the SIAM:	The industry consortium collected new data and prepared the updated IUCLIDs for the three salts in the persulfate category, draft versions of the SIAR and SIAP. The United States government peer-reviewed the documents.
8. Quality check process:	
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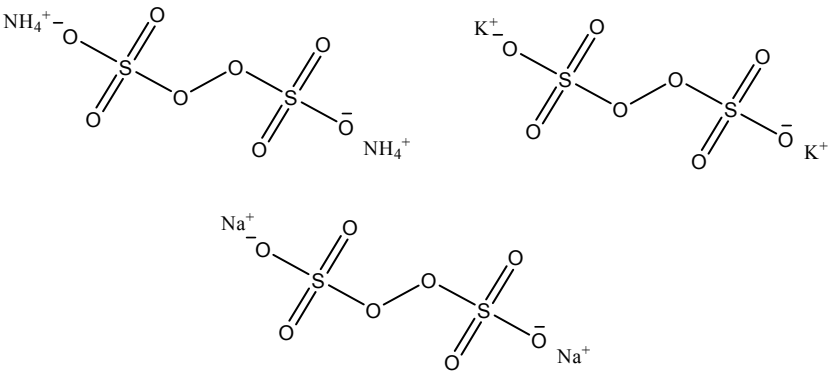
10. Date of last Update:	16 August 2005
11. Comments:	The Industry contact point is Dr. Philip Block, FMC Corporation, acting on behalf of the CEFIC Persulfates Work Group.

SIDS INITIAL ASSESSMENT PROFILE

CAS No.	7727-54-0, 7727-21-1, 7775-27-1
Chemical Name	Ammonium persulfate, potassium persulfate, sodium persulfate
Structural Formula	

SUMMARY CONCLUSIONS OF THE SIAR

Category Rationale

The persulfates category includes molecules with similar chemical structure and similar physical-chemical properties. The inorganic substances differ only by the cationic portion of the salt, which is not expected to influence the hazardous properties of the molecule. The anionic part is identical and, therefore, the three salts are expected to display the same environmental, ecotoxicological and toxicological behaviour based on the available data.

Human Health

Toxicokinetics and dynamics of the salts will be influenced mainly by the persulfate anion. This anion is likely to decompose to hydrogen peroxide and the sulfate ion. The hydrogen peroxide will be rapidly converted to oxygen and water by catalase and peroxidase enzymes.

The acute oral LD_{50} in rats, for the three salts, ranged from 495 mg/kg bw for the ammonium salt to 895 mg/kg bw for the sodium salt to 1130 mg/kg bw for the potassium salt. The acute dermal LD_{50} in rats and rabbits, for all three salts, was greater than 2000 mg/kg bw for the ammonium salt to greater than 10,000 mg/kg bw for the potassium and sodium salts. In acute inhalation studies in rats, the 4-hour LC_{50} was generally greater than the maximum attainable concentration (>5,100 mg/m^3 for sodium persulfate and >2,950 mg/m^3 for ammonium persulfate). Clinical signs in the inhalation studies included ocular and nasal discharge and respiratory distress.

Ammonium persulfate is slightly irritating to eyes and skin in rabbits. Older eye and skin irritation studies on the potassium and sodium salts produced little irritation in rabbits. Studies in humans indicate that aqueous solutions of 5% persulfate or higher can cause skin irritation. Persulfates also can be irritating to skin and the respiratory track of occupationally exposed individuals (hairdressers).

Results of animal skin sensitization tests (Buehler Test and Maximization Test) were negative when persulfate was applied topically and positive when persulfate was injected intradermally in induction and challenge phases in a non-standard Maximization Test. Numerous dermal challenge tests indicate that all three persulfates are dermal and respiratory sensitizers in humans occupationally exposed to persulfates in hairdressing salons and, in one case, in a production facility. In controlled clinical trials with non-occupationally exposed-subjects (NH_4 & Na salts), no sensitization reactions were observed.

In repeated-dose studies, local effects to the gastro-intestinal tract and the airways were reported. Administration of

sodium persulfate to rats in the diet for 13 weeks resulted in a LOAEL of 3000 ppm (225 mg/kg bw/day) based on gastrointestinal lesions and reduced body weights. In a subchronic inhalation study in male and female rats, adverse effects at a high dose of 25 mg/m^3 ammonium persulfate aerosol consisted of inflammation of the trachea, bronchi, bronchioles, increased lung weight, decreased body weights, rales and increased respiratory rate. A NOAEL of 10.3 mg/m^3 was established. Pulmonary function tests of workers in a persulfate production plant (cation not identified) indicated that there were no short- or long-term effects on pulmonary function at levels in the plant (0.5 mg/m^3).

None of the three persulfates cause gene mutations or chromosomal effects *in vitro*. *In vivo* tests on sodium persulfate (micronucleus test and UDS test) were negative.

A 51 week dermal study in female SENCAR mice exposed to 0.2 ml of a 200 mg/ml solution of ammonium persulfate showed that ammonium persulfate is neither a tumor promoter nor a complete carcinogen when applied to the skin.

In a developmental/reproduction study with ammonium persulfate in rats (OECD TG 421), no effects on reproductive performance, fertility, fetal anomalies, fetal viability, spermatogenesis, spermatogenic cycle were reported up to 250 mg/kg-bw/day. Dose levels were chosen based on the acute lethality studies for the ammonium salt and on a 90-day repeat-dose study in rats with the sodium salt (high dose: 225 mg/kg-bw/day). In the developmental/reproduction study, animals were dosed prior to and during mating through gestation until lactation day 4. There was a transient depression in pup body weight at the 250 mg/kg dose level on lactation day 0 which resolved by day 4. This effect was not considered adverse. Based on the available data, the persulfates do not show evidence of reproductive or developmental toxicity. The NOAEL is 250 mg/kg bw/day.

Environment

Because they decompose below their melting and boiling points, persulfate decomposition temperatures are reported in their stead as 120, ~100, and >180ºC for the ammonium, potassium and sodium persulfates, respectively. The inorganic persulfates are soluble in water (≥ 60 g/L) and their vapour pressures are negligible.

The three persulfate salts will be distributed into the water compartment in the ionic form of the cation, (NH_4, Na or K) and persulfate anion. Aqueous persulfates are expected to degrade in the environment mainly via hydrolysis, but metal catalyzed decomposition, and reactions with organic chemicals in the soil or water also are possible.

Persulfates are not expected to adsorb to soil due to their dissociation properties, instability (hydrolysis) and high water solubility. They should behave as free ions or decompose into sulfate ions. In soils, upon decomposition, the cation could form more stable sulfate or bisulfate salts.

Persulfates are not expected to bioaccumulate in the soil or in aqueous solution. They will decompose into inorganic sulfate or bisulfate.

The LC_{50} values for acute toxicity to fish ranged between 76 and 323 mg/L for ammonium persulfate and from 163 to 771 mg/L for sodium persulfate. The acute toxicity EC_{50}-values for invertebrates were between 120 and 391 mg/L for ammonium persulfate and between 133 and 519 for sodium persulfate. In algae the EC_{50} for ammonium persulfate was 83.7 mg/L and for sodium persulfate 116 mg/L. For potassium persulfate, non-GLP data on fish and daphnia toxicity fell within the range of the other two category members.

Exposure

For the year 2003 the global market for persulfate salts was estimated to be ca. 76,000 tonnes. The substances are used in polymerization reactions and printed circuit manufacturing. Persulfates also are used as oxidants in hair-bleaching products.

Occupational exposure occurs during manufacturing and during use as hair dyes. The dermal and inhalation routes will be the most important routes of exposure.

During end-use, consumers may be exposed to these substances (e.g., hair dyes may come into contact with the scalp and the hands).

There is potential for environmental exposure during production and processing; however, solid and liquid wastes will be treated to decompose the material or discharged properly as hazardous waste.

RECOMMENDATION AND RATIONALE FOR THE RECOMMENDATION AND NATURE OF FURTHER WORK RECOMMENDED

Human Health: The chemicals in this category possess properties indicating a hazard for human health (eye and skin irritation and skin and respiratory sensitisation). Based on data presented by the Sponsor country, adequate risk management measures (MSDS's and labelling) are being applied and therefore the chemicals in this category are currently of low priority for further work. Other countries may wish to consider their own risk management measures.

Environment: Some chemicals in this category possess properties indicating a hazard for the environment (acute toxicity for fish and algae). However, they are of low priority for further work due to rapid degradation and the absence of bioaccumulation.

SIDS Initial Assessment Report

1 IDENTITY

1.1 Identification of the Substance

	Ammonium persulfate	Potassium persulfate	Sodium persulfate
CAS Number:	7727-54-0	7727-21-1	7775-27-1
IUPAC Name:	diammonium peroxodisulphate	dipotassium peroxodisulphate	disodium peroxodisulphate
Molecular Formula:	H8N2O8S2	K2O8 S2	Na2O8 S2
Structural Formula:	$(NH_4)_2S_2O_8$	$K_2S_2O_8$	$Na_2S_2O_8$
Molecular Weight:	228.3	270.3	238.1
Synonyms:	Ammonium peroxydisulfate; Peroxydisulfuric acid, di ammonium salt	Potassium peroxydisulfate; Peroxydisulfuric acid, di potassium salt	Sodium peroxydisulfate; Peroxydisulfuric acid, di sodium salt

1.2 Purity/Impurities/Additives

Ammonium, potassium and sodium persulfate all have a purity of greater than 98% with a moisture content of about 0.3% or less.

1.3 Physico-Chemical properties

Table 1 summarizes the physical/chemical properties of the three persulfate salts.

Table 1 Summary of Physical/Chemical Properties

Property	Value: ammonium persulfate	Ref.	Value: potassium persulfate	Ref.	Value: sodium persulfate	Ref.
Physical state	Solid		Solid		Solid	
Melting point	Decomposes at about 120° C	Sax	Decomposes at ca. 100°C	Sax	Decomposes at > 180° C	Sodium Persulfate MSDS
Boiling Point	NA		NA		NA	
Relative density:	1.98 g/cm^3 at 20° C	Sax	2.48 g/cm^3 at 20° C	CRC	2.6 g/cm^3 at 20° C	Sodium Persulfate MSDS
Vapor Pressure	NA		NA		NA	
Water solubility	850 g/l at 25° C	Ammonium persulfate MSDS	60 g/l at 25° C	Potassium Persulfate MSDS	730 g/l at 25° C	Sodium Persulfate MSDS
pH	4-6 for a 1% solution	Ammonium persulfate MSDS	5-8 for a 1% solution	Potassium Persulfate MSDS	5-7 for a 1% solution-	Sodium Persulfate MSDS
Dissociation Constant	NA		NA		NA	
Partition coefficient n-octanol/water (log value)	NA		NA		NA	
Oxidizing Properties	Oxidizer	Ammonium persulfate MSDS	Oxidizer	Potassium Persulfate MSDS	Oxidizer	Sodium Persulfate MSDS

NA = not applicable. Values were taken from handbooks (Sax, CRC, Merck) and MSDS for the individual substances (Sodium Persulfate MSDS, FMC Corporation; Potassium Persulfate MSDS, FMC Corporation;Ammonium persulfate MSDS, FMC Corporation)

Ammonium, potassium and sodium persulfate are inorganic, solid substances with strong oxidizing properties. All three salts decompose before melting upon heating to 100°C or higher. The salts do exhibit somewhat different solubilities with ammonium persulfate being the most soluble and potassium being the least soluble, but once in solution dissociations are comparable for all three salts. Upon thermal decomposition, persulfates can potentially generate SOx species. In addition, ammonium persulfate can potentially generate NOx species upon thermal decomposition.

1.4 Category Justification

Ammonium, potassium and sodium persulfate consist of a dianion and two identical cations. The dianion consists of two sulfate groups connected via one of the oxygen atoms resulting in a peroxodisulfate dianion. Persulfates are produced by electrolysis of the corresponding sulfate at low temperature and high current densities. Decomposition is promoted by water and heat. Dissolving a persulfate in water yields an acidic solution due to oxidation of water.

Contrary to the sodium and potassium cations, ammonia can, in principle, be oxidized by persulfate. Under acidic conditions, however, the ammonia/ammonium equilibrium lies completely at the side of the ammonium ion (K_{eq} = 1.8x10 $^{-5}$ at 25^{o} C), which is stable in a persulfate solution (internal communication). Hence the ammonium persulfate shows similar behavior to the other salts.

The physical/chemical properties and the structural similarity of the three salts, differing only by the cation portion of the salt, as well as the consistent results of ecotoxicology and mammalian toxicology studies support the conclusion that the ammonium, sodium and potassium derivatives are expected to behave similar and form one chemical group.

The data in the table below are a summary of the results available for the three persulfates. These are described in more detail in the SIDS dossier.

Table 2 SIDS Data Matrix

	Ammonium persulfate CAS 7727-54-0		**Potassium persulfate CAS 7727-21-1**		**Sodium persulfate CAS 7775-27-1**	
	Value	**Comment**	**Value**	**Comment**	**Value**	**Comment**
Physico-chemical properties						
Melting point (°C)	decomp. at ca. 120°C	Sax	decomp. at ca. 100°C	Sax	decomp. at >180°C	MSDS
Boiling point (°C)						
Relative Density (at 20°C)	1.98	Sax	2.48	CRC	2.6	MSDS
Vapor Pressure (hPa)	NA		NA		NA	
Partition Coefficient	NA		NA		NA	
Water Solubility (g/L)	850 at 25°C	MSDS	60 at 25°C	MSDS	730 at 25°C	MSDS
Environmental fate						
Photodegradation (t1/2 hrs)	NA		NA		NA	
Hydrolysis	decomposition	Koltoff and Miller, 1951	decomposition	Koltoff and Miller, 1951	decomposition	Koltoff and Miller, 1951
Transport between compartments (%in water/air/soil/sediment)	NA		NA		NA	
Ready Biodegradability	NA		NA		NA	
Ecotoxicology						
96-h LC50 Fish (mg/L)	76.3			Read across	163	
48-h EC50 Daphnia (mg/L)	120			Read across	133	
72-h EC50 Algal Inhibition (mg/L)	83.7	72-h EC50		Read across	116	72-h EC50
Human health effects						
Acute Oral LD50 (mg/kg bw)	495-742		1130		895	
Acute Dermal LD50 (mg/kg bw)	>2000		>10,000		>10,000	
Acute Inhalation LC50 (mg/m^3)	>2950		>42,900	1 h exposure time	>5,100	
Mutagenicity in vitro						
Ames Test	negative	review article		Read across	negative	
UDS					negative	
Chrom. Aberration	negative			Read across		
Genetic toxicity in vivo						
Micronucleus				Read across	negative	
Unscheduled DNA					negative	
Subchronic/Reproduction						
28 day (NOAEL)	41.1 mg/kg bw/day		131.5 mg/kg bw/day		137.2 mg/kg bw/day	
90 day (NOAEL)	10.3 mg/m3	inhalation		Read across	LOAEL = 3000 ppm	= 200 mg /kg bw/day (M*); 250 mg /kg bw/day (F*)

	Ammonium persulfate CAS 7727-54-0		Potassium persulfate CAS 7727-21-1		Sodium persulfate CAS 7775-27-1	
	Value	**Comment**	**Value**	**Comment**	**Value**	**Comment**
Reproduction toxicity (NOAEL)	250 mg/kg bw/day			Read across		Read across
Developmental toxicity (NOAEL)	250 mg/kg bw/day			Read across		Read across

Values for physicochemical data were taken from handbooks (Sax, CRC, Merck) and MSDS for the individual substances (Sodium Persulfate MSDS, FMC Corporation; Potassium Persulfate MSDS, FMC Corporation; Ammonium Persulfate MSDS, FMC Corporation).

2 GENERAL INFORMATION ON EXPOSURE

2.1 Production Volumes and Use Pattern

In 2003 the estimated production of all three persulfates, in the countries represented by consortium members (North America, Europe and Japan) is 65,400 tonnes per year. Europe accounts for about 42%, North America about 38% and Japan about 20%. There is also an estimated 10,000 tonnes of persulfates produced in China by a company affiliated with one of the European companies. There are no reported volumes for the individual persulfate products.

Ammonium and sodium persulfate are produced in electrolytic cells using the appropriate sulfate as starting material. The electrolyte removed from the cell containing the persulfate product is concentrated and crystallized in a proprietary vacuum crystallization process to produce the final solid persulfate product. Potassium persulfate can be produced in similar fashion, but in this case crystallization of the potassium persulfate occurs in the electrolytic cell. An alternate method uses a displacement reaction whereby potassium ion replaces the sodium ion from sodium persulfate. In all cases, the solids are dried to remove moisture, then packaged in fiber drums, polybags and IBCs (supersacks), ready for shipment. Production of persulfates occurs in systems that are vented to the atmosphere. Control of fumes is accomplished by air-sweeping and scrubbing if necessary.

Approximately 80% of all persulfates are used in two industrial applications, i.e., polymerization reactions (>60%; for example in manufacture of fluorocarbon elastomers and small scale production of electrophoretic gels) and printed circuit manufacture (about 20%). Persulfates are also used as oxidants in cosmetics and hair bleaching products; non-biocidal shock treatment in swimming pools and other recreational waters; pulp and paper board manufacture; textile processing and in the photographic industry. Since persulfates are oxidants, they could have applications in other reactions requiring an oxidizing agent.

In the Nordic Countries (Norway, Sweden and Denmark) the persulfates are used in the production of chemicals products, metal coating, the paper industry, the textile industry, the paint industry and in construction. The substances are mainly used as oxidizers and process regulators (SPIN database 08-12-04).

2.2 Environmental Exposure and Fate

2.2.1 Sources of Environmental Exposure

In the United States and several European countries, persulfates are approved for injection into soils for decontamination of organic contaminants. Releases of persulfates into the environment are

expected to be low. In the manufacturing process care is taken to prevent persulfate discharges. Waste persulfate solids or solutions will be treated to decompose the material into innocuous metal sulfates or diluted to levels where they are no longer hazardous. There could be some release to the environment from the products used by consumers. Used product containers and residual (waste) persulfate solutions will either be diluted and sent to a wastewater treatment facility or sent into a domestic waste system. Under these conditions the product is expected to be dilute and to degrade into sulfate or bisulfate salts. Large quantities of persulfate waste materials are usually collected in appropriate containers and disposed of as hazardous waste.

2.2.2 Photodegradation

There are no photodegradation data available. Photodegradation in air is not relevant for the persulfates because their volatility is negligible.

2.2.3 Stability in Water

Rates of hydrolysis are expected to be similar for each salt, independent of the cation. Koltoff and Miller (1951) measured the rates of decomposition in water for potassium persulfate at various pH's. Half lives at 50ºC varied from 20 hours at pH 1 up to 210 hours at pH 10. The persulfate anion, independent of the cation, undergoes decomposition in normal water or acid conditions. Persulfate readily oxidizes water to oxygen, producing acid conditions at the same time.

net reaction : $S_2O_8^{-2} + H_2O \rightarrow {}^1\!/\!_2 O_2 + 2SO_4^{-2} + 2H^+$

Ammonium, sodium and potassium derivatives are structurally similar and expected to behave similarly in solution.

2.2.4 Transport between Environmental Compartments

All three persulfate salts are soluble in water and their vapour pressures are negligible. Thus, any persulfate released into the environment is distributed into the water compartment in the ionic form of the cation, (NH_4, Na or K) and persulfate ion. Persulfates are not expected to sorb to soil due to their dissociation properties, instability (hydrolysis) and high water solubility. They should behave as free ions or decompose into sulfate ions. In soils, upon decomposition, the cation could form more stable sulfate or bisulfate salts. These compounds should not present any environmental hazards.

2.2.5 Biodegradation

Not applicable to inorganic compounds.

2.2.6 Bioaccumulation

Persulfates are not expected to bioaccumulate in the soil or in aqueous solution. They will decompose into inorganic sulfate or bisulfate.

2.2.7 Other Information on Environmental Fate

Persulfates have a very low vapour pressure, therefore they are not expected to volatilize under field conditions. They will remain in solution and readily hydrolyze (decompose) into innocuous sulfate ions. Persulfates will react with organic species and contaminants in soil and groundwater. Persulfates will readily degrade benzene, xylene, toluene, ethylbenzene and chlorinated benzenes to mineralised end products. Reaction rates with chlorinated solvents will be much slower. Aqueous persulfates are expected to degrade in the environment via several mechanisms, e.g., hydrolysis, metal catalysed decomposition, and reactions with organic chemicals in the soil or water.

2.3 Human Exposure

2.3.1 Occupational Exposure

Occupational exposure occurs in the manufacture of persulfates and in their use in hair dyes by professional hairdressers (CIR 2001, Leino T et al. 1999a, 1999b, Kellett and Beck. 1985). The number of manufacturing sites of persulfates is 2 in Europe, 1 in North America., 2 in Japan, one in Taiwan and many small ones in China. There are numerous well-documented literature reports of skin sensitisations and allergic responses by professional hairdressers see 3.1.4. Exposure in air to persulfates in hair salons during mixing of the chemicals and application to the hair has been estimated at 0.9 to 2.9 $\mu g/m^3$ (Leino 1999b).

Hair products make up the largest consumer use. A 1998 survey of hair dyes, colours, bleaches and other hair-colouring preparations in the United States found 92 products that contained persulfates (CIR, 2001). There were 30 products out of 2436 products containing ammonium persulfate; 36 out of 1813 products containing potassium persulfate and 26 out of 1813 products containing sodium persulfate. Persulfates are contained in hair lighteners at concentrations up to 60%, in bleaches and lighteners at up to 22% and 16%, respectively, and in off-the-scalp products used to highlight hair strands at up to 25%. The three persulfate salts are used in Europe and Japan for hair products. The liquid and gel lighteners for general hair lightening contain $\leq$12% persulfate and off-the-scalp products used to highlight hair strands generally contain $\leq$25% (on head). Persulfates are contained in bleaches and lighteners at concentrations of 12% to 22% (use concentration of 4% to 8%) and 2% to 16% (use concentration of 1% to 6%).

In the United States ammonium persulfate is approved as a bleaching agent for food starch at $\leq$0.075%; as an industrial starch modifier at $\leq$0.3% and as an alkaline starch reactant at $\leq$0.6%; in adhesives; as a component of paper and paperboard in contact with aqueous, fatty and dry foods; and in cellophane film. Potassium persulfate is permitted in certain types of coatings for fresh citrus fruits; in adhesives, as a reducing agent in photography, in modification of starch; as a flour-maturing agent and in de-sizing textiles (CIR, 2001). Countries may wish to investigate any exposure scenarios that were not assessed by the sponsor country.

Sodium persulfate is used as a shock treatment to clarify swimming pool water. Swimming pool products: 5-6 Million pounds were used in the USA. Formulations contain 50% to 100% sodium persulfate. These products are used in combination with other pool products.

Workers in production facilities manufacturing persulfates have also reported clinical symptoms, but, in most cases, these were controlled by improved occupational industrial hygiene practices. Allergic contact dermatitis was reported on the hands of professional bakers or technicians handling flour containing persulfates and on the hands of professional hair dressers using hair products

containing persulfates (CIR 2001, Veien et al, 2001). Persulfates are no longer used in flour. No further data on workplace exposure are available.

In the USA a TLV of 0.1 mg/m^3 has been published for the three persulfates (ACGIH on NIOSH website). The occupational exposure limit in Belgium was established at 1.0 mg/m^3 (TLV) and in Germany at 6 mg/m^3 (MAK).

2.3.2 Consumer Exposure

Consumers can be exposed through products used by professional hairdressers or through home use of hair products (CIR, 2001 and NICNAS, 2001). Consumers are most likely to be exposed via the inhalation and dermal routes. Inhalation exposure by consumers is expected to be low, due to the use of small quantities and infrequent use of the products. Dermal exposure can occur when the product comes in contact with the scalp. Dermal exposure can also occur on the hands during mixing and application of the product. This exposure can be largely avoided using a 'no touch technique' which involves use of gloves and applicator sticks. Inhalation exposure from home and salon is expected to be low. Consumers may be exposed via cleaning and washing agents, disinfectants, adhesives, pharmaceuticals and cosmetics. These uses come from the SPIN database, website: www.SPIN2000.net. See Section 2.3.1 Occupational Exposure.

3 HUMAN HEALTH HAZARDS

3.1 Effects on Human Health

3.1.1 Toxicokinetics, Metabolism and Distribution

There are no toxicokinetic, metabolism or distribution studies available on the persulfates; however, based on chemical structure, simple ionic dissociation will initially remove the respective cation from the anionic persulfate. Toxicokinetics and dynamics will be influenced mainly by the persulfate anion, which is present in all substances under evaluation. The influence of the cations on toxicity is expected to be negligible for the sodium and potassium derivatives, because sodium and potassium will be added to the available supply present in the body. The ammonium ion is also expected to have a negligible effect on mammalian toxicity.

Metabolism of the persulfate anion will likely generate reactive oxygen species (hydrogen peroxide) and sulfate ion radicals. A decrease in pH would be expected from the hydrolysis of the persulfate moiety, but systemic effects would be inconsequential in the presence of physiologic buffer systems. Hydrogen peroxide, if formed, would be rapidly metabolised to oxygen and water by catalase and peroxidase enzymes (NICNAS, 2001). Although catalase and glutathione peroxidase enzymes are intracellular, hydrogen peroxide can readily penetrate biological membranes at a level comparable to that of water. Extracellular hydrogen peroxide is rapidly decomposed by mammalian tissues (ECETOC, 1993).

3.1.2 Acute Toxicity

Studies in Animals

The acute toxicity of the persulfates is summarized in Table 3.

Acute oral LD50 values from studies with rats for the persulfate salts were between 495 mg/kg to 742 mg/kg for ammonium persulfate; 1130 mg/kg for potassium persulfate and 895 mg/kg for sodium persulfate. Clinical signs included ocular and nasal discharge and irregular breathing (FMC 1979b, 1979c, 1991b, 2001). Acute dermal LD50's in rats and rabbits were all greater than the highest treatment level, e.g., >2000 mg/kg for ammonium persulfate and >10,000 mg/kg for the sodium and potassium salts. Ocular and nasal discharge and slight irritation were reported among the exposed animals in the acute dermal toxicity studies (FMC 1979a, 1979c, 1991a). Similarly, inhalation LC50 studies on ammonium, sodium and potassium persulfate performed under guideline conditions with rats indicated an LC50 value of greater than the maximum attainable concentration, 2950 mg/m^3, 5100 mg/m^3 and 42900 mg/m^3 respectively. After exposure animals exhibited dyspnea, respiratory distress and increased nasal, ocular and oral secretion (FMC 1987, FMC 1995). Older less reliable studies on sodium and potassium persulfate also indicate a low toxicity by the inhalation route.

The similar results obtained on all three salts on the acute toxicity tests further support the persulfate toxicity category.

Table 3 Acute Animal Toxicity Studies

Acute Test	**Ammonium Persulfate**		**Potassium Persulfate**		**Sodium Persulfate**	
Acute Oral LD50 (rat) (mg/kg)	495 (female) 700 (female) 742 (male)	FMC (1991b) FMC (2001)	1130 (male)	FMC (1979a)	895 (male)	FMC (1979c)
Acute Dermal LD50 (mg/kg)	>2000 (rat)	FMC (1991a)	>10,000 (rabbit)	FMC (1979a)	>10,000 (rabbit)	FMC (1979c)
Acute Inhalation (rat) LC50 (mg/m^3)	>2950 (4 hr exposure)	FMC (1987)	>42900 (1 hr exposure)	FMC (1979a)	>5100 (4 hr exposure)	FMC (1995)

Conclusion

The results of the acute toxicity tests on ammonium, potassium and sodium persulfate by oral, dermal and inhalation routes of exposure in multiple animal studies are indicative of similar toxicity for the three salts.

3.1.3 Irritation

Skin Irritation

Studies in Animals

Ammonium persulfate was not irritating to the rabbit skin in a study performed according to OECD TG 404 (FMC 1988b). Older studies on ammonium, sodium and potassium persulfates did not show irritation when tested in rabbits using the Draize Scoring method (FMC 1979a, FMC 1979b, FMC 1979c, FMC, 1979d, FMC, 1980).

Studies in Humans

In controlled studies, aqueous solutions of ammonium persulfate were found to be irritating to humans at concentrations of 5% and higher (Calnan and Shuster, 1963). Application of 17.5% aqueous solution of the persulfate salts under an occlusive wrap for four hours was found to cause irritation in 8/46 subjects (Jordan, 1998 cited in CIR, 2001).

Eye Irritation

Studies in Animals

Sodium and potassium persulfates were non-irritating when tested in rabbits using the Draize Scoring method (FMC 1979c, FMC 1979a). Ammonium persulfate was slightly irritating when instilled into the eyes of rabbits (FMC 1988a).

Respiratory Tract Irritation

Studies in Animals

A sensory irritation study with sodium persulfate in mice resulted in a 50% decrease of the respiratory rate at a concentration of 2250 mg/m^3 in air (FMC 1994). Sodium persulfate was considered a slight sensory irritant (RD50 2250 mg/m^3).

Conclusion

The persulfate salts are non-irritating to the skin and non-irritating to slightly irritating to the eyes in animal studies. Patch tests in humans indicate that irritation occurs in some subjects from exposure to aqueous solutions of ≥5%. There are no data on the skin irritation potential of the solid form of the persulfates to humans. Sodium persulfate was found to be a slight sensory irritant in mice. Persulfates can be irritating to skin and the respiratory track of occupationally exposed individuals (hair dressers).

3.1.4 Sensitization

Skin sensitization

Table 4 below summarizes the available animal and human data on skin sensitisation studies.

Table 4 Skin Sensitization Studies with the Persulfates

Study Type	Salt	Species	Result	Reference
Maximization Test	Ammonium	Guinea pig	Negative for epidermal challenge (3/20)	Degussa, 1985a
Buehler Test	Sodium	Guinea pig	Not sensitizing	FMC 1990b
Maximization Test	Sodium	Guinea pig	Negative for epidermal challenge (2/20 test animals positive and 0/20 controls)	Degussa, 1985b
Repeated Insult Patch Test	Sodium	Human	Not sensitizing at 5000 ppm in water	FMC 1996
Patch Test	Ammonium, Potassium and Sodium	Human	Not sensitizing under occluded and non-occluded wraps as a 17.5% aqueous solution,	Jordan, 1998 cited in CIR 2001
Skin prick test	Sodium	Human (hairdressers)	Positive in case study via dermal (and inhalation) routes (n=2)	Pepys et al, 1976
Patch test	Potassium	Human (workers)	Positive in case study (n=1)	Kanerva at al, 1999
Skin prick test	Ammonium and potassium	Human (hairdressers)	Positive in case study (n=1 for each reference)	Veine et al, 2001, Reiffers et al, 1974
Patch test	Ammonium	Human (hairdressers)	3 case studies with 7 of 9 positive	Fisher and Dooms-Goossens, 1976
Patch test	Not given	Human (hairdressers)	1 case with positive prick test	Pankow at al, 1989
Patch test	Ammonium	Human (hairdressers)	Case control 12/49 positive (1/69 controls)	Kellett and Beck, 1985
Lung function, skin prick test and patch test	Ammonium	Human (hairdressers)	Case control study of hairdressers, persulfate were associated with allergic rhinitis in 1.6% (6/355); contact dermatitis in 0.5% (2/355) and with occupational asthma in 0.8% (3/355). 6.5% (7/107) of hairdressers tested gave positive skin prick tests and 1.85% (1/54) of hairdressers gave positive patch tests.	Leino at al, 1999a
Skin prick test , histamine response and lung function	Ammonium and Sodium	Human (workers)	Cross sectional study at 1 mg/m^3 no positive response in a skin prick test, 4/32 positive histamine response (2/18 in controls), 3/32 minor effects on bronchial responsiveness	Merget 1997
Skin prick test and lung function	Ammonium and potassium	Human (workers)	8/52 positive in skin prick test possibly correlated to reduction of FEV_1	Wrbitzky 1995
Epicutaneous test	Ammonium, potassium, sodium	Human (workers)	3/3 workers gave positive results	Baur and Fruhmann, 1979

Studies in Animals

Sodium persulfate was not sensitising when applied to the skin of Guinea pigs in the Buehler Test and was positive in the Guinea Pig Maximization Test (FMC, 1990b, Degussa, 1985b). Ammonium persulfate showed a negative response (in 3/20 animals) in a Maximization Test (Degussa, 1985a). The maximisation tests are not conducted according to standard protocols and include an intracutaneous challenge, which was positive for both sodium and ammonium persulfate.

Studies in Humans

There are strong indications that all three persulfates are sensitisers in occupationally-exposed human subjects (see Table 4) In general, persulfates are associated with eczema, dermatoses, rashes and occupational asthma (White et al, 1982). Most reports on these endpoints are human case reports. In a patch test 12 out of 49 hairdressers with dermatologic complaints were positive, whereas in the control group of patients with similar complaints 1 out of 69 was found to be positive (Kellett and Beck, 1985). In a skin prick test of 52 workers in a persulfate production plant, eight workers were positive (no controls were included) (Wribitzky et al, 1995). In non-occupationally exposed subjects, persulfate was not sensitising in a repeated insult patch test at up to 5000 ppm (FMC, 1996) and at 17.5% under occlusive wrap, followed by challenges at lower concentrations (2%) (Jordan 1998 cited in CIR, 2001).

Respiratory tract

Studies in humans

A number of well-conducted studies of hairdressers provide evidence that persulfate salts are capable of inducing asthma and can cause specific reactions at bronchial challenge under conditions which do not induce a response in normal or previously non-exposed asthmatic people. (Blainey et al., 1986; Agustin et al., 1992; Parra et al., 1992; Pankow et al., 1989; Schwartz, 1989).

These studies are backed up by several case reports of occupational asthma associated with persulfate use (Pepys et al., 1976; Therond et al., 1989; Gamboa et al., 1989; Schwaiblmair et al., 1990; Wallenstein et al., 1993). Also workers using ammonium and potassium persulfate during the manufacture of hydrogen peroxide (Barsotti *et al.*, 1951) and workers who bagged persulfates developed asthmatic symptoms (Baur *et al.*, 1979).

Conclusion

Animal studies indicate that the persulfates are not sensitising or are marginally sensitising to skin when applied topically. However, the results from human studies indicate that the persulfates are capable of inducing skin and respiratory tract sensitisation in occupationally exposed individuals. No differences between the three salts were identified.

3.1.5 Repeated Dose Toxicity

The repeated dose toxicity studies in rats on the three persulfates by oral and inhalation routes of exposure are summarized in Table 5.

Studies in Animals

Inhalation

Rats (10/sex/group) were exposed in whole body chambers to dust aerosol concentrations of 0, 5, 10 and 25 mg/m^3 ammonium persulfate 6 hours/day, 5 days/week for 13 weeks (FMC 1998a). Additional groups of 5 animals/sex/group were exposed for 13 weeks followed by a 6-week or 13-week recovery period. Rales and increased respiratory rate were noted in high dose males and females during the study and sporadically in the mid-dose group. At 25 mg/m^3 inflammation of the trachea and bronchi/bronchioles, decreased body weights and increased lung weights were found after 13 weeks. These lesions had reversed to normal by the end of the 6-week recovery period. The No Observed Adverse Effect Level (NOAEL) was determined to be 10.3 mg/m^3. Due to the sporadic rales and effects on respiratory rate, the NOEL was considered to be 5 mg/m^3. There were no pathological findings in reproductive organs.

Table 5 Repeated Dose Toxicity of Persulfates in Rats

Route	Salt	Doses	NOAEL	Exposure period	References
Oral (diet)	Sodium	0, 100, 316, 1000 ppm (males only)	1000 ppm (137 mg/kg bw/day)	28 days	FMC (1979c)
Oral (diet)	Sodium	0, 300, 3000 and 1000 ppm for 7 weeks raised to 5000 ppm for final 6 weeks (male and female)	The LOAEL is 3000 ppm (200-250 mg/kg bw/day) based on local effects on the gastrointestinal tract (epithelial necrosis and atrophy) at 13 weeks and depressed body weight.	90 days	FMC (1979e)
Oral (diet)	Potassium	0, 12.6, 41.2, 131.5 mg/kg bw/day (males only)	131.5 mg/kg bw/day in diet. No effects noted	28 days	FMC (1979a)
Oral (diet)	Ammonium	0, 100, 300, 600 ppm (males only)	300 ppm (41 mg/kg bw/day) based on decreased adrenal weight:body weight ratio at 600 ppm (82 mg /kg bw/day)	28 days	FMC (1979b)
Inhalation	Ammonium	0, 5, 10 and 25 mg/m^3 (male and female)	Dust: 10.3 mg/m^3 based on elevated lung weights, clinical signs and depressed body weights. All effects were reversible during a six-week recovery period. NOEL = 5 mg/m^3 based on rales, increased respiration	6 hr/day, 5 days/week for 13 weeks	FMC (1998a)

Dermal

No data available.

Oral

Twenty-eight-day repeated-dose oral (dietary) toxicity studies in rats were conducted on all three salts. NOAEL levels for sodium and potassium salts were 137 and 131.5 mg /kg bw/day, respectively (the highest doses tested, FMC 1979c, 1979a). The 28-day NOAEL for ammonium persulfate was 41 mg/kg bw/day (FMC, 1979b).

In addition, an oral (dietary) subchronic toxicity study using sodium persulfate was conducted in rats (FMC 1979e). Rats (20/sex/group) were fed rodent chow with 0, 300, 1000 or 3000 ppm sodium persulfate (0, 23, 100 and 225 mg/kg bw/day) for 90-days. On day 48 of the study, the concentration of the group receiving 1000 ppm was increased to 5000 ppm for the remainder of the study. At the two high dose levels body weight was decreased during the last 6 weeks of treatment. There were no treatment-related effects on urinalysis, clinical chemistry or hematology parameters. Pathological findings were limited to the 3000 ppm group only and consisted of necrosis and atrophy of the gastrointestinal tract epithelial lining. The absence of the gastrointestional lesions in the group receiving 1000 ppm for 8 weeks, followed by 5000 ppm for 5 weeks, indicates that the lesions are related both to concentration in diet (dose) and length of exposure. There were no treatment-related pathological findings in reproductive organs or any other organ system or tissue.

Studies in Humans

Inhalation

Pulmonary function tests (FEV_1 and FVC) conducted on employees of a production facility indicated no adverse effects on pulmonary function at workplace levels, measured at 0.5 mg/m^3 (FMC, 1992). Long-term follow-up of these same employees indicated that exposure at 0.5 mg/m^3 had no long-term effects on pulmonary function (Greaves, 1997).

Conclusion

Persulfates produced lesions at the site of contact via the oral and inhalation routes of exposure. The findings were gastrointestinal lesions in the subchronic dietary study (FMC, 1979d) and inflammatory lesions of the bronchi and trachea, rales, and increased respiratory rate in the subchronic inhalation study (FMC, 1998a). All treatment-related effects noted during the subchronic inhalation exposure were reversible following a six-week recovery period. There were no differences in effects between the three salts.

3.1.6 Mutagenicity

Mutagenicity studies on the persulfates are summarized in Table 6.

Table 6 Genotoxicity studies on the Persulfate Salts

Test	Salt	Result	Reference
***in vitro* tests**			
Ames Test	Sodium	Negative with and without metabolic activation by S9	FMC, 1990a
Ames Test	Ammonium	Negative with and without metabolic activation by S9	Shimizu, 1985; Ishidate, 1984
Unscheduled DNA Synthesis Test	Sodium	Negative in rat primary hepatocytes	FMC, 1990d
Chromosome Aberration Test	Ammonium	Negative in Chinese hamster fibroblasts	Ishidate, 1984
***in vivo* tests**			
Micronucleus Test	Sodium	Negative when administered at single doses of 85, 169 and 338 mg/kg i.p. to male and female mice. Erythrocytes were sampled at 24, 48 and 72 hours for evaluation of micronuclei.	FMC, 1990c
Unscheduled DNA Test	Sodium	Negative when dosed orally by gavage to male rats at doses of 41, 164 and 820 mg/kg. Hepatocytes were cultured 2-4 or 12-18 hours after exposure and evaluated for unscheduled DNA synthesis.	FMC, 1991c

Studies in Animals

In vitro Studies

Both ammonium and sodium persulfates were negative, with and without metabolic activation by S9, in the Ames test (FMC, 1990a; Ishidate, 1984; Shimizu, 1985). Sodium persulfate was negative in the DNA damage and repair test using rat hepatocytes (FMC, 1990d). Ammonium persulfate was negative in an *in vitro* chromosome aberration test (Ishidate, 1984).

In vivo Studies

Sodium persulfate was negative in two separate *in vivo* genotoxicity studies. Doses of sodium persulfate up to 338 mg/kg injected into male and female mice intraperitoneally did not increase the incidence of micronuclei in erythrocytes, evaluated 24, 48 and 72 hours after exposure (FMC, 1990c). Sodium persulfate was found to be non-genotoxic when tested in an *in vivo/in vitro* unscheduled DNA synthesis test in rats (FMC, 1991c).

Conclusion

Both *in vitro* and *in vivo* genotoxicity studies on sodium and ammonium persulfates are negative. Based on the presence of the persulfate anion in the three salts, it is concluded that persulfates as a category are not genotoxic.

3.1.7 Carcinogenicity

No guideline tests of carcinogenicity are available. A 51 week dermal study in female SENCAR mice exposed to 0.2 ml of a 200 mg/ml solution of ammonium persulfate concluded that ammonium persulfate is neither a tumor promoter nor a complete carcinogen when applied to the skin. (Kurokawa et al., 1984.

Conclusion

Ammonium persulfate has no skin tumor promoting activity.

3.1.8 Toxicity for Reproduction

The potential reproductive and developmental toxicity of the persulfate salts were evaluated in a combined reproductive/developmental study, according to OECD Guideline 421 (Weaver, 2004). Ammonium persulfate was chosen as a representative salt of the persulfate category.

Studies in Animals

Effects on Fertility

Groups of rats (12/sex/group) were administered ammonium persulfate in the diet at constant doses of 0, 40, 100 and 250 mg/kg body weight/day (Weaver, 2004). Selection of the high dose was based on lethality in acute oral toxicity studies and the sodium persulfate ninety-day study (FMC, 1979c). The two lower doses were chosen based on the results of the 28-day dietary study with ammonium persulfate with an NOAEL of 41 mg /kg bw/day (FMC, 1979b). Animals were exposed two weeks prior to mating, during mating and for an additional three and a half weeks for males. Females were exposed following mating, through gestation until lactation day 4. During the mating period one male and one female from the same dose group were placed together. Once mating was confirmed, the male and female were separated. In the parental generation there were no treatment related clinical signs or mortality, no effects on body weight and no effects on organ weights and no treatment-related gross lesions. One high-dose male had a hypoplastic testicle and aspermia of the epididymides. There was a sporadic occurrence of minimal degeneration of the testicle, which occurred in both controls and high-dose animals; therefore, it was not considered related to treatment. There was a normal progression of the spermatogenesis and all stages of the spermatogenic cycle were present and within normal limits in control and treated animals. Pregnancy rates were 100%, 100%, 92% and 92% for the 0, 40, 100 and 240 mg /kg bw/day dose groups. It is concluded that the no observed effect level for male and female fertility indices and reproductive performance is equal to or greater than 250 mg /kg bw/day, the high dose.

Developmental Toxicity

Groups of rats (12/sex/group) were administered ammonium persulfate in the diet at constant doses of 0, 40, 100 and 250 mg/kg body weight/day (Weaver, 2004). Animals were exposed two weeks prior to mating, during mating and for an additional three and a half weeks for males. Females were exposed following mating, through gestation until lactation day 4. There were no treatment-related clinical signs, mortality or necropsy findings among pups. The live birth and viability indices were similar across all groups. The mean number of live pups and the mean number of live pups surviving to day 4 were similar across all groups. There was a slight dose-related depression in mean pup body weight for both sexes on lactation day 0 and 4. The pup body weight depression reached statistical significance for the high dose on day 0 only, and resolved by day 4. Due to the transient nature of the body weight effect it is not considered to be an adverse effect on development. The NOAEL for embryo/fetal viability is considered to be equal to or greater than 250 mg /kg bw/day, the high dose.

Conclusion

Ammonium persulfate did not cause reproductive and developmental toxicity in rats exposed to 250 mg/kg bw/day via the oral route. The NOAEL for reproduction and developmental toxicity is 250 mg/kg bw/day.

3.2 Initial Assessment for Human Health

Ammonium, potassium and sodium persulfates have similar physical/chemical properties, decomposition > 100 ºC and a high water solubility. Animal and human studies indicate that these three salts have similar toxicological properties. Thus, the three persulfate salts form an appropriate chemical category for assessment of human health.

Toxicokinetics and dynamics of the salts will be influenced mainly by the persulfate anion, which is present in all category members. The persulfate anion will likely be degraded to hydrogen peroxide and sulfate ion. The hydrogen peroxide will be rapidly degraded to oxygen and water by catalase and peroxidase enzymes. Although catalase and glutathione peroxidase enzymes are intracellular, hydrogen peroxide can readily penetrate biological membranes at a level comparable to that of water. Extracellular hydrogen peroxide is rapidly decomposed by mammalian tissues. No bioaccumulation is expected.

Animal studies on the acute toxicity of the three salts by oral, dermal and inhalation routes of exposure are available. The acute oral LD_{50} for the three salts ranged from 495 mg/kg to 1130 mg/kg. The acute dermal LD_{50} was greater than 2000 mg/kg. Acute inhalation studies generally found that the 4-hour LC_{50} was greater than the maximum attainable dose (>5100 mg/m^3 for sodium persulfate and >2950 mg/m^3 for ammonium persulfate). The persulfate salts were non-irritating to slightly irritating to eyes and skin in animal studies. Studies in humans indicate that aqueous solutions of 5% persulfate or higher can cause irritation. Although the results of animal studies indicate a low potential to cause eye and skin irritation, human irritation can occur in highly exposed individuals in an occupational setting.Both animal and human skin sensitisation studies have been conducted. Results in the Guinea pig Buehler Test and Maximization Test in which persulfate is applied topically were negative. Results in the Guinea Pig Maximization Test were positive when persulfate was injected intradermally for the induction and challenge phases. In humans a mixture of the three persulfate salts was not sensitising to humans at levels of 17.5% aqueous solution under occlusive wrap. However, numerous case reports provide strong indications that all three persulfates can be dermal and respiratory sensitisers in human subjects.

After both oral and inhalation subchronic exposure local effects were reported. Gastrointestinal lesions and reduced body weights were noted in rats consuming diets with 3000 ppm sodium persulfate (225 mg/kg bw/day) for 13 weeks. In a subchronic inhalation study adverse effects at a high dose of 25 mg/m^3 were inflammation of the trachea, bronchi, bronchioles, increased lung weight, decreased body weights, rales and increased respiratory rate. A NOAEL of 10.3 mg/m^3 was established. Pulmonary function tests of workers in a production plant indicated that there were no short- or long-term effects on pulmonary function at levels in the plant (0.5 mg/m^3).

The persulfates do not induce gene mutations or chromosomal effects *in vitro*. *In vivo* tests on sodium persulfate (micronucleus test and UDS test) were negative. Persulfates were also shown to lack tumor promotion activity in a mouse skin model.

In an OECD TG 421 developmental/reproduction study with rats exposed to ammonium persulfate, no effects on reproductive performance, fertility, fetal anomalies, fetal viability, spermatogenesis, spermatogenic cycle were reported up to oral doses of 250 mg/kg bw/day. Animals were dosed prior to and during mating, gestation and following gestation until lactation day 4. There was a transient depression in pup body weight at the 250 mg /kg bw/day dose level on lactation day 0 which resolved by day 4. This effect was not considered adverse. Based on the available data, the persulfates do not show evidence of reproductive or developmental toxicity. The NOAEL for reproductive toxicity is 250 mg/kg bw/day.

The category is a low priority for further work for human health.

4 HAZARDS TO THE ENVIRONMENT

4.1 Aquatic Effects

Table 7 summarizes the aquatic toxicity studies available on the three persulfate salts.

Studies on all three trophic levels with measured concentrations were available. The LC50-values for acute toxicity to fish ranged between 76 and 323 mg/L for ammonium persulfate (FMC 1993a, FMC 1993b, Degussa 1988c) and from 168 to 771 mg/L for sodium persulfate (FMC 1993e, FMC 1993f). The slightly higher toxicity of the ammonium salt has to be attributed to the ammonium cation, which is known to be toxic to aquatic organisms. The acute toxicity EC50-values for invertebrates were between 120 and 391 mg/L (FMC 1993c, Degussa 1988b, FMC 1993d) for ammonium persulfate and between 133 and 519 for sodium persulfate (FMC 1993g, FMC 1993h).

Algal tests were also conducted with ammonium persulfate (FMC 1998b) and sodium persulfate (FMC 1998c) indicating a comparable degree of toxicity: EC50 for ammonium persulfate was 83.7 mg/L and for sodium persulfate 116 mg/L.

The less reliable data from Svobodova on potassium persulfate demonstrate that potassium persulfate toxicity to aquatic organisms is comparable, and in the same effect category, as ammonium and sodium persulfates.

Data on chronic toxicity to aquatic organisms are not available.

Table 7 Toxicity of Persulfates to Aquatic Organisms

Organism	Salt	Expo-sure	Relia-bility	LC/EC50 (mg/L)	Reference
Fish					
Rainbow trout (*Oncorhynchus mykiss*)	ammonium	96-hr	1	LC50=76.3 (m)	FMC (1993b)
Rainbow trout (*Oncorhynchus mykiss*)	Sodium	96-hr	1	LC50=163 (m)	FMC (1993f)
Bluegill sunfish (*Lepomis macrochirus*)	ammonium	96-hr	1	LC50=103 (m)	FMC (1993a)
Bluegill sunfish (*Lepomis macrochirus*)	Sodium	96-hr	1	LC50=771 (m)	FMC (1993e)
Guppy (*Poecilia reticulata*)	ammonium	96-hr	2	LC50=323 (nc)	Degussa AG (1988b)
Guppy (*Poecilia reticulata*)	potassium	-	4	LC50=845	Svobodova (1983)
Invertebrates					
Water flea (*Daphnia magna*)	ammonium	48-hr	1	EC50=120 (m)	FMC (1993c)
Water flea (*Daphnia magna*)	ammonium	24-hr	2	EC50=357 (nc)	Degussa AG (1988a)
Water flea (*Daphnia magna*)	Sodium	48-hr	1	EC50=133 (m)	FMC (1993g)
Water flea (*Daphnia magna*)	potassium	-	4	EC50=92-251	Svobodova (1983)
Grass shrimp (*Palaemonetes pugio*)	ammonium	96-hr	1	EC50=391(m)	FMC (1993d)
Grass shrimp (*Palaemonetes pugio*)	Sodium	96-hr	1	EC50=519 (m)	FMC (1993h)
Tubificidae	potassium	-	4	EC50=575	Svobodova (1983)
Cyclops strenuus	potassium	-	4	EC50=1175	Svobodova (1983)
Algae					
Green alga (*Selenastrum capricornutum*)	ammonium	72-hr	1	EC50=83.7 (m) NOEC=39.2	FMC (1998b)
Green alga (*Selenastrum capricornutum*)	Sodium	72-hr	1	EC50=116 (m), (biomass)	FMC (1998c)

(m) – measured (analytically verified) concentrations (nc) – nominal concentrations

Conclusion

The results presented here support the category approach for these substances.

Toxicity to Microorganisms

The data on toxicity to microorganisms are limited and show a wide variety of results. None of the studies were considered reliable, so no conclusion on toxicity to microorganisms can be drawn.

4.2 Terrestrial Effects

There are no data on Terrestrial Effects. Any persulfate released into the environment is distributed into the water compartment in the ionic form of the cation, (NH_4, Na or K) and persulfate ion. Persulfates are not expected to adsorb to soil due to their dissociation properties, instability (hydrolysis) and high water solubility. They should behave as free ions or decompose into sulfate

ions. In soils, upon decomposition, the cation, could form more stable sulfate or bisulfate salts. These compounds should not present any environmental hazards.

4.3 Other Environmental Effects

There are no data on other environmental effects.

4.4 Initial Assessment for the Environment

All persulfates are soluble in water and their vapour pressures are negligible. Any persulfate released into the environment is distributed into the water compartment in the ionic form of the cation, (NH_4, Na or K) and persulfate ion. They will remain in solution and readily hydrolyze (decompose) into innocuous sulfate ions. Aqueous persulfates are expected to degrade in the environment mainly via hydrolysis, but metal catalysed decomposition, and reactions with organic chemicals in the soil or water are also possible. Persulfates are not expected to adsorb to soil due to their dissociation properties, instability (hydrolysis) and high water solubility. They should behave as free ions or decompose into sulfate ions. In soils, upon decomposition, the cation could form more stable sulfate or bisulfate salts.

Persulfates are not expected to bioaccumulate in the soil or in aqueous solution. They will decompose into inorganic sulfate or bisulfate.

The LC_{50} values for acute toxicity to fish ranged between 76 and 323 mg/L for ammonium persulfate and from 163 to 771 mg/L for sodium persulfate. The acute toxicity EC_{50}-values for invertebrates were between 120 and 391 mg/L for ammonium persulfate and between 133 and 519 for sodium persulfate. In algae the EC_{50} for ammonium persulfate was 83.7 mg/L and for sodium persulfate 116 mg/L. For potassium persulfate, non-GLP data on fish and daphnia toxicity fell within the range of the other two category members.

5 RECOMMENDATIONS

Human Health: The chemicals in this category possess properties indicating a hazard for human health (eye and skin irritation and skin and respiratory sensitisation). Based on data presented by the Sponsor country, adequate risk management measures (MSDS's and labelling) are being applied and therefore the chemicals in this category are currently of low priority for further work. Other countries may wish to consider their own risk management measures.

Environment: Some chemicals in this category possess properties indicating a hazard for the environment (acute toxicity for fish and algae). However, they are of low priority for further work due to rapid degradation and the absence of bioaccumulation.

6 REFERENCES

Agustin P, Martinez-Cocera C, Cimarra M *et al* (1992) Persulphate-induced occupational respiratory allergy *Rev Esp Alergol Inmunol Clin.* **7**; 91-97.

Baur X and Fruhmann G (1979). Bronchial asthma of allergic and irritative origin as an occupational disease. Prax. Pneumol. **33** (1), 317-322.

Blainey AD, Ollier S, Cundell D *et al* (1986) Occupational asthma in a hairdressing salon *Thorax.* **41**; 42-50.

Calnan C and Shuster S (1963) Reactions to Ammonium Persulfate. Arch. Dermatol. **88**, 812-815.

Cosmetics Ingredient Review (CIR) (2001). Final report on the safety assessment of ammonium, potassium, and sodium persulfate. International Journal of Toxicology, **20** (3), 7-21.

Degussa AG (1985a). Ammonium-Persulfat (APS); Prüfung auf sensibilisierende Eigenschaften an der Haut des Meerschweinchens (Optimierungs-Test), Study no. 85-0014-DKT.

Degussa AG (1985b). Natrium-Persulfat (APS); Prüfung auf sensibilisierende Eigenschaften an der Haut des Meerschweinchens (Optimierungs-Test), Study no. 85-0048-DKT.

Degussa AG (1988a). Acute immobility test with Daphnia magna exposed to ammoniumperoxydisulfate, unpublished report.. Degussa AG, US-IT-Nr.: 88-0015-DGO.

Degussa AG (1988b). Acute toxicity study with Poecilia reticulata exposed to ammoniumperoxydisulfate, unpublished report.. Degussa AG, US-IT-Nr.: Study no. 88-0016-DGO.

ECETOC JACC Report No. 22 Hydrogen Peroxide, Jan. 1993

Fisher A and Dooms-Goossens, A (1976). Persulfate Hair Bleach Reactions, Cutaneous and Respiratory Manifestations. Arch. Dermatol. **112**, 1407-1409).

FMC Corporation (1979a). Acute and 28-day subacute toxicity of potassium persulfate, Study no. ICG/T-79-024.

FMC Corporation (1979b). Acute and 28-day subacute toxicity of ammonium persulfate, Study no. ICG/T-79-025.

FMC Corporation (1979c). Acute and 28-day subacute toxicity of sodium persulfate, Study no. ICG/T-79-029.

FMC Corporation (1979d). Sodium Persulfate: skin irritation and corrosion study in rabbits, Study no. I79-326.

FMC Corporation (1979e). Safety evaluation of sodium persulfate: a 90-day dietary feeding study in rats, Study no. I90-1151.

FMC Corporation (1980). Sodium Persulfate: skin corrosion study in rabbits, Study no. I80-403.

FMC Corporation (1987). Acute inhalation toxicity study with ammonium persulfate in the rat, Study no. I87-0969.

FMC Corporation (1988a). Ammonium persulfate: primary eye irritation study in rabbits, Study no. I87-0968.

FMC Corporation (1988b). Ammonium persulfate: primary skin irritation study in rabbits, Study no. I87-0970.

FMC Corporation (1990a). Sodium persulfate: Salmonella/mammalian-microsome plate incorporation mutagenicity assay (Ames test) Study no. I90-1119.

FMC Corporation (1990b). FMC shock treatment: Skin sensitization study in guinea pigs, Study no. I90-1113.

FMC Corporation (1990c). Micronucleus cytogenetic assay in mice (sodium persulfate), Study no. I90-1120.

FMC Corporation (1990d). Unscheduled DNA synthesis in rat primary hepatocytes, Study no. I90-1121.

FMC Corporation (1991a). Ammonium persulfate: acute dermal toxicity study in rats, unpublished report. Study no. I91-1200

FMC Corporation (1991b). Ammonium persulfate: acute oral toxicity study in rats, unpublished, Study no. I91-1201

FMC Corporation (1991c). In vivo – in vitro rat hepatocyte unscheduled DNA synthesis assay (sodium persulfate), Study no. I90-1173

FMC Corporation (1992). Report of persulfate worker study of the FMC plant in buffalo, New York. unpublished report. FMC study I1992-1712.

FMC Corporation (1993a). Acute toxicity of ammonium persulfate to bluegill (Lepomis macrochirus), unpublished report. Study no. I92-1246.

FMC Corporation (1993b). Acute toxicity of ammonium persulfate to rainbow trout (Oncorhynchus mykiss), unpublished report. Study no. I92-1247.

FMC Corporation (1993c). Acute toxicity of ammonium persulfate to the water flea (Daphnia Magna), unpublished report. Study no. I92-1248.

FMC Corporation (1993d). Acute toxicity of ammonium persulfate to grass shrimp (Palaemonetes pugio), unpublished report. Study no. I92-1249.

FMC Corporation (1993e). Acute toxicity of sodium persulfate to bluegill (Lepomis macrochirus), unpublished report. Study no. I92-1250.

FMC Corporation (1993f). Acute toxicity of sodium persulfate to rainbow trout (Onchorhynchus mykiss), unpublished report. Study no. I92-1251.

FMC Corporation (1993g), Acute toxicity of sodium persulfate to the water flea (Daphnia Magna), unpublished report. Study no. I92-1252.

FMC Corporation (1993h). Acute toxicity of sodium persulfate to grass shrimp (Palaemonetes pugio), unpublished report. Study no. I92-1253.

FMC Corporation, 1994. Sodium persulfate: sensory irritation study in Swiss Webster mice, unpublished report. Study no. I93-1803.

FMC Corporation, 1995. Sodium persulfate: acute inhalation toxicity study in rats, unpublished report. Study no. I95-2017.

FMC Corporation (1996). Repeated insult patch study, unpublished report. Study no. I95-2037.

FMC Corporation (1998a). A 13-week inhalaton toxicity study (with recovery) of ammonium persulfate in albino rats, unpublished report. Study no. I97-2205.

FMC Corporation (1998b). Ammonium persulfate: acute toxicity to the freshwater green alga, Selenastrum capricornutum, under static test conditions, unpublished report. Study no. I97-2227.

FMC Corporation (1998c). Sodium persulfate: acute toxicity to the freshwater green alga, Selenastrum capricornutum, under static test conditions, unpublished report. Study no. I97-2228.

FMC Corporation (2001). Acute oral toxicity of ammonium persulfate in rats. Study no. I2001-2331.

Gamboa PM, de la Cuesta CG, Garcia BE *et al* (1989) Late asthmatic reaction in a hairdresser, due to the inhalation of ammonium persulphate salts *Allergol Immunopathol (Madr)*. **17**; 109-111.

Greaves W (1997). Preliminary Report: Lung Function Assessment of Persulfate Workers: 1990-1996. Unpublished report.

Ishidate M (1984). Primary mutagenicity screening of food additives currently used in Japan, Fd. Chem. Toxic. **22** (8), 623-636.

Jordan W (1998). Human sensitization study of three persulfates in a representative vehicle used for bleaching hair. Unpublished data submitted by CTFA (34 pages) (Cited in CIR, 2001).

Kanerva L, Alanko K, Jolanki R, Aalto-Korte K, and Estander T. (1999). Occupational allergic contact dermatitis from potassium persulfate. Contact Dermatitis **40**, 116-117.

Kellett, J and Beck M (1985). Ammonium persulphate sensitivity in hairdressers. Contact Dermatitis **13**, 26-28.

Kirk-Othmer (1967). Kirk-Othmer Encyclopedia of Chemical Technology, 2nd edition, Volume 11, p 396-397.

Koltoff I. and Miller I K (1951). The chemistry of persulfate. I. The kinetics and mechanism of the decomposition of the persulfate ion in aqueous medium. J. Am. Chem. Soc., **73**, 3055-3059.

Kurokawa, Y, Takamura, N, Matsushima, Y, Imazawa, T and Hayashi, Y (1984). Studies on the promoting and complete carcinogenic activities of some oxidizing chemicals in skin carcinogenesis. Cancer Letters, **24**, 299-304.

Leino T, Tammilehto L, Hytonen M, Paakkulainen S, and Kanerva L (1999a). Occupational skin and respiratory diseases among hairdressers, Scandinavian Journal of Work, Environment & Health **24**, 398-406.

Leino, T, Kahkonen, E, Saarinen, L, Henriks-Eckerman, M-L and Paakkulainen, H (1999b). Working Conditions and Health in Hairdressing Salons, Applied Occupational and Environmental Hygiene **14**, 26-33.

Meindl, K and Meyer, R. (1969). Asthma and Utricaria in the Hairdresser's Trade due to Bleaching Agents Containing Persulfates Zbl. Arbetsmed **19** (3), 75-79.

Merget R. et al. (1997). Cross sectional study of chemical workers exposed to sodium and ammonium persulfate. Dermatosen in Beruf und Umwelt. 45 (3), 130-131.

National Industrial Chemicals Notification and Assessment Scheme NICNAS (2001). Ammonium, Potassium and Sodium Persulfate, Priority Existing Chemical Assessment Report No. 18.

Pankow W, Hein H, Bittner K and Wichert V (1989). Persulfate-asthma in the hairdressing trade. Pneumologie **43**, 173-175.

Parra FM, Igea JM, Quirce S *et al* (1992) Occupational asthma in a hairdresser caused by persulphate salts *Allergy (Eur J Allergy Clin Immunol).* **47**; 656-660.

Pepys J. et al., (1976). Asthma due to inhaled chemical agents – Persulphate salts and henna in hairdressers. Clinical Allergy, **6**, 399-404.

Schwaiblmair M, Baur X and Fruhmann G (1990) Bronchial asthma caused by hair bleach in a hairdresser *Dtsch Med Wochenschr.* **115**; 695-697.

Schwartz HJ (1989) Effect of chronic chromolyn sodium therapy in a beautician with occupational asthma *J Occup Med.* **31**; 112-114.

Shimizu, H. (1985). The results of microbial mutation test for forty-three industrial chemicals, Jpn, J. Ind. Health, **27**, 400-419.

Svobodova, Z., Machova, J., Faina, R., Stanek, P., Schneedorfer, J. (1983). Acute Toxicity of Peroxidisulphates to Aquatic Organisms. Buletin VURH Vodnany, 4, 17-24.

Therond M, Geraut C, Dupas D and Gayoux C (1989) Pathology of alkaline persulphates: concerning 19 recent cases *Arch Mal Prof Med Trav Secur Soc.* **50**; 837-838.

Veien N, Hattel T and Laurberg G (2001). Contact dermatitis due to potassium persulfate. Contact Dermatitis **45** (3), 176 Weaver E (2004). Oral Reproductive/Developmental Toxicity Screening Test in Rats with Ammonium Persulfate in Feed. Covance Laboratories, Inc. Vienna, VA, USA. Covance Study Number 7463-101, FMC Study Number I2003-2337.

Wallenstein G, Wagner E and Schoneich R (1993) Airway symptoms in hairdressers with occupational contact eczema *Arbeitsmed Sozialmed Praventivmed.* **28**; 441-444.

White I, Catchpole H and Rycroft R (1982). Rashes amongst persulphate workers. Contact Dermatitis, **8**, 168-172.

Wrbitzky R., Drexler H, and Letzel S (1995). Early reaction type allergies and diseases of the respiratory passages in employees from persulphate production, Int. Arch. Occup. Inviron. Health **67**, 413-417.

S I D S

Dossier

Existing Chemical	:	ID: 7775-27-1
CAS No.	:	7775-27-1
EINECS Name	:	disodium peroxodisulphate
EC No.	:	231-892-1
TSCA Name	:	Peroxydisulfuric acid ([(HO)S(O)2]2O2), disodium salt
Generic name	:	sodium persulfate
IUPAC Name	:	disodium peroxodisulphate
Molecular Formula	:	H2O8S2.2Na

Producer related part

Company	:	Notox
Creation date	:	30.08.2001

Substance related part

Company	:	Notox
Creation date	:	30.08.2001
Status	:	
Memo	:	30 Category
Printing date	:	06.06.2005
Revision date	:	
Date of last update	:	06.06.2005
Number of pages	:	63
Chapter (profile)	:	Chapter: 1, 2, 3, 4, 5, 6, 7, 8, 10
Reliability (profile)	:	Reliability: without reliability, 1, 2, 3, 4
Flags (profile)	:	Flags: without flag, confidential, non confidential, WGK (DE), TA-Luft (DE), Material Safety Dataset, Risk Assessment, Directive 67/548/EEC, SIDS

1.0.1 APPLICANT AND COMPANY INFORMATION

Type : cooperating company
Name : Asahi Denka Kogyo K.K.
Contact person : Takanobu Ohshima
Date : 12.11.2004
Street : 8-6 Nihonbashi Kobunacho
Town : J-103 Chou-ku Tokyo
Country : Japan
Phone : 81 545 34 1032
Telefax : 81 545 34 0695
Telex :
Cedex :
Email : osima@adk.co.jp
Homepage :

Remark : Within CEFIC (European Chemical Industry Council) a Persulfate Working Group was formed to comply with the ICCA High Production Volume (HPV) initiative. Dominique de Halleux (CEFIC employee) is the secretary of this group. The members (cooperating companies) of the Persulfates Group are noted in this section.

19.11.2004

Type : cooperating company
Name : Degussa AG
Contact person : Werner Ponikwar
Date : 12.11.2004
Street : Dr-Gustav-Adolph-Strasse, 3
Town : D-82049 Pullach
Country : Germany
Phone : 49 89 744 22 421
Telefax : 49 89 744 22 6421
Telex :
Cedex :
Email : werner.ponikwar@degussa.com
Homepage :

19.11.2004

Type : cooperating company
Name : FMC Corporation
Contact person : Philip Block
Date : 12.11.2004
Street : 1735 Market Street
Town : PA 19103 Philadelphia
Country : United States
Phone : 215 299 6645
Telefax : 215 299 6272
Telex :
Cedex :
Email : philip_block@fmc.com
Homepage :

19.11.2004

Type : cooperating company
Name : Mitsubishi Gas Chemical Company, INC
Contact person : Ken Yamagishi

Date : 12.11.2004
Street : Mitsubishi Building 5-2 Marunouchi 2 chome
Town : Chiyoda-ku
Country : Japan
Phone : 81 33 283 4888
Telefax : 81 33 287 2643
Telex :
Cedex :
Email : yamagishi@mgc.co.jp
Homepage :

19.11.2004

Type : cooperating company
Name : RheinPerChemie GmbH
Contact person : Dirk Ostwald
Date : 12.11.2004
Street : Alex-Springer-Platz 2
Town : D-20354 Hamburg
Country : Germany
Phone : 49 403 2509 512
Telefax : 49 403 2509 510
Telex :
Cedex :
Email : ostwald@rheinperchemie.com
Homepage :

19.11.2004

1.0.2 LOCATION OF PRODUCTION SITE, IMPORTER OR FORMULATOR

Remark : In 2003 the estimated production amount of all three persulfates, in the countries represented by consortium members (North America, Europe, and Japan) is 65,400 tonnes per year. Europe accounts for about 42%, North America about 38% and Japan about 20%. There is also an estimated 10,000 tonnes of persulfates produced in China by a company affiliated with one of the European companies. There are no reported volumes for the individual Persulfate products.

15.12.2004

1.0.3 IDENTITY OF RECIPIENTS

1.0.4 DETAILS ON CATEGORY/TEMPLATE

Comment : Persulfates

Remark : Each persulfate salt in this group consists of a dianion (persulfate) and two identical cations. Only the cation is different for each substance: Na, K or NH4. The persulfate salts are expected to display the same environmental, ecotoxicological and toxicological behaviour.

19.11.2004

1.1.0 SUBSTANCE IDENTIFICATION

IUPAC Name : disodium peroxodisulphate
Smiles Code : Na- O3-S-O-O-S-O3-Na
Molecular formula : Na2S2O8
Molecular weight : 238.1
Petrol class :

06.03.2002

1.1.1 GENERAL SUBSTANCE INFORMATION

Purity type : typical for marketed substance
Substance type : inorganic
Physical status : solid
Purity : > 98 % w/w
Colour : white
Odour : odourless

Reliability : Only 28-d study available
19.11.2004

1.1.2 SPECTRA

1.2 SYNONYMS AND TRADENAMES

sodium peroxydisulfate

19.11.2004

1.3 IMPURITIES

Purity : typical for marketed substance
CAS-No : 7757-82-6
EC-No : 231-820-9
EINECS-Name : sodium sulphate
Molecular formula : Na2SO4
Value : <= .3 % v/v

08.12.2004

Purity : other
CAS-No : 7732-18-5
EC-No : 231-791-2
EINECS-Name : water
Molecular formula : H2O
Value : <= .3 % v/v

19.11.2004

1.4 ADDITIVES

Purity type	:	other
CAS-No	:	
EC-No	:	
EINECS-Name	:	
Molecular formula	:	
Value	:	
Function of additive	:	
Remark	:	Most products do not contain additives. Some producers may add proprietary drying agents.

19.11.2004

1.5 TOTAL QUANTITY

Quantity	:	- tonnes produced in
Remark	:	Ca. 75,400 tonnes are produced per year of all three persulfate salts. There are no reported values for the individual salts. 2003: Europe: 27,200 t/y Japan: 13,600 t/y North America: 24,600 t/y China: 10,000 t/y

15.12.2004

1.6.1 LABELLING

Labelling	:	as in Directive 67/548/EEC
Specific limits	:	
Symbols	:	O, Xn, Xi,
Nota	:	, ,
R-Phrases	:	(8) Contact with combustible material may cause fire (22) Harmful if swallowed (36/37/38) Irritating to eyes, respiratory system and skin (42/43) May cause sensitization by inhalation and skin contact
S-Phrases	:	(2) Keep out of reach of children (22) Do not breathe dust (24) Avoid contact with skin (26) In case of contact with eyes, rinse immediately with plenty of water and seek medical advice (37) Wear suitable gloves

19.11.2004

1.6.2 CLASSIFICATION

Classified	:	
Class of danger	:	oxidizing
R-Phrases	:	(8) Contact with combustible material may cause fire (22) Harmful if swallowed (36/37/38) Irritating to eyes, respiratory system and skin (42/43) May cause sensitization by inhalation and skin contact
Specific limits	:	

19.11.2004

1.6.3 PACKAGING

Memo : Fiber drums, poly bags or IBC (supersacks).

19.11.2004

1.7. USE PATTERN

Remark : Approximately 80% of all persulfates are used in two industrial applications, i.e., polymerization reactions (>60%; for example in manufacture of fluorocarbon elastomers and small scale production of electrophoretic gels) and printed circuit manufacture (about 20%). Persulfates are also used as an oxidant in cosmetics and hair bleaching products; non-biocidal shock treatment in swimming pools and other recreational waters; pulp and paper board manufacture; textile processing and in the photographic industry. Since persulfates are oxidants, they could have applications in other reactions requiring an oxidizing agent.

19.01.2005

1.7.1 DETAILED USE PATTERN

Industry category : 11 Polymers industry
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : not available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application : .6
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : Persulfates function as polymerization initiators and/or depolymerizers; and as an oxidant/bleaching agent in most other applications.

19.11.2004

Industry category : 4 Electrical/electronic engineering industry
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : not available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application : .2
Fraction of chemical in formulation :
Production : :
Formulation : :

Processing : :
Private use :
Recovery :

19.11.2004

Industry category : 3 Chemical industry: chemicals used in synthesis
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application :
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : No reliable data available concerning tonnage for this application.
19.11.2004

Industry category : 12 Pulp, paper and board industry
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application :
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : No reliable data available concerning tonnage for this application.
19.11.2004

Industry category : 13 Textile processing industry
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application :
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : No reliable data available concerning tonnage for this application.

19.11.2004

Industry category	:	5 Personal / domestic use
Use category	:	15 Cosmetics
Extra details on use category	:	No extra details necessary No extra details necessary
Emission scenario document	:	available
Product type/subgroup	:	
Tonnage for Application	:	
Year	:	
Fraction of tonnage for application	:	.03
Fraction of chemical in formulation	:	
Production	:	:
Formulation	:	:
Processing	:	:
Private use	:	
Recovery	:	

Remark : Fraction of tonnage for application: 2-3%.
08.12.2004

Industry category	:	15/0 other
Use category	:	
Extra details on use category	:	No extra details necessary No extra details necessary
Emission scenario document	:	not available
Product type/subgroup	:	
Tonnage for Application	:	
Year	:	
Fraction of tonnage for application	:	.01
Fraction of chemical in formulation	:	
Production	:	:
Formulation	:	:
Processing	:	:
Private use	:	
Recovery	:	

Remark : Non-biocidal shock treatment of swimming pools and other recreational waters.
15.12.2004

Remark : In the Nordic Countries (Norway, Sweden and Denmark) the persulfates are used in the production of chemicals products, metal coating, the paper industry, the textile industry, the paint industry and in construction. The substances are mainly used as oxidizers and process regulators.
15.12.2004 (1)

1.7.2 METHODS OF MANUFACTURE

Origin of substance	:	Synthesis
Type	:	Production

Remark : Sodium persulfate is produced in electrolytic cells using sodium sulfate as starting material. The electrolyte removed from the cell containing the persulfate product is concentrated and crystallized in a proprietary vacuum crystallization process to produce the final solid persulfate product. The solid is dried to remove moisture, then packaged in polybags, fiber drums or IBCs (supersacks), ready for shipment.

16.12.2004

1.8 REGULATORY MEASURES

1.8.1 OCCUPATIONAL EXPOSURE LIMIT VALUES

Type of limit : TLV (US)
Limit value : .1 mg/m3
Short term exposure limit value
Limit value :
Time schedule : 8 hour(s)
Frequency : times

Remark : Belgium: TLV = 1.0 mg/m3
Germany: (MAK) OEL = 6 mg/m3

19.11.2004

1.8.2 ACCEPTABLE RESIDUES LEVELS

1.8.3 WATER POLLUTION

Classified by :
Labelled by :
Class of danger : 1 (weakly water polluting)

Remark : Weakly water polluting, product is expected to degrade in water forming sulfate salts.

19.11.2004

1.8.4 MAJOR ACCIDENT HAZARDS

1.8.5 AIR POLLUTION

1.8.6 LISTINGS E.G. CHEMICAL INVENTORIES

Remark : TSCA (USA), WHMIS (Canada), AICS (Australia), ENCS (Japan), KE Korea), PICCS (Philippines), EINECS (Europe).

09.12.2004

1.9.1 DEGRADATION/TRANSFORMATION PRODUCTS

Type : combustion products
CAS-No : 13870-29-6
EC-No : 237-625-5
EINECS-Name : disodium disulphate
IUCLID Chapter :

Remark : Gaseous oxides of sulfur and oxygen upon combustion (sulfur dioxide CAS 7446-09-5; oxygen CAS 7782-44-7)

1.9.2 COMPONENTS

1.10 SOURCE OF EXPOSURE

Source of exposure :
Exposure to the : Substance

Remark : Occupational exposure occurs in the manufacture of persulfates and in their use in hair dyes by professional hairdressers (CIR 2001, Leino T et al. 1999a, 1999b, Kellett and Beck. 1985). There are numerous well-documented literature reports of skin sensitisations and allergic responses by professional hairdressers (Fisher and Dooms-Goossens, 1976, Meindl and Meyer, 1969, Pankow et al, 1989). Workers in production facilities manufacturing persulfates have also reported clinical symptoms, but in most cases, these were controlled by improved occupational industrial hygiene practices (Baur and Fruhmann, 1979; Kanerva et al, 1999, Merget et al, 1997, White et al, 1982). Allergic contact dermatitis was reported on the hands of professional bakers or technicians handing flour containing persulfates and on the hands of professional hair dressers using hair products containing persulfates (CIR 2001, Veien et al, 2001). Exposure to persulfates from other applications is negligible.
For description of studies see section 5.10.

30.05.2005

1.11 ADDITIONAL REMARKS

1.12 LAST LITERATURE SEARCH

Type of search : Internal
Chapters covered : 3, 4, 5
Date of search : 18.08.2004

Remark : The databases searched were RTECS, Toxcenter, Biosis, Cancerlit, Medline and Embase.
The HSDB database had no listing for any of the three persulfates.

19.11.2004

1.13 REVIEWS

2.1 MELTING POINT

Decomposition : yes, at > 180 °C

Conclusion : Most relevant data available.
Reliability : (4) not assignable
Secondary literature (MSDS).
Flag : Critical study for SIDS endpoint
11.10.2001 (2)

Decomposition : yes, at °C

Reliability : (4) not assignable
Secondary literature (MSDS).
11.11.2004 (3)

Value : = 120 °C

Source : NORKEM LIMITED KNUTSFORD
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
23.05.1997

Remark : Thermal decomposition may be lowered by moisture, contamination of heavy metals, dust etc. and container size (< 100 degree C).
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
16.05.1994

2.2 BOILING POINT

2.3 DENSITY

Type : relative density
Value : = 2.6 at °C

Conclusion : Only data available.
Reliability : (4) not assignable
Secondary literature (MSDS).
Flag : Critical study for SIDS endpoint
11.11.2004 (2) (3)

Type : density
Value : ca. 1.1 g/cm³ at 20 °C

Remark : Literature could not be retrieved.
Source : Bilgram & Co. GmbH Ostrach
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
17.12.1998

Type : bulk density
Value : 1250 - 1300 kg/m3 at °C

Remark : Literature could not be retrieved.
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
02.02.1994 (4)

2.3.1 GRANULOMETRY

2.4 VAPOUR PRESSURE

2.5 PARTITION COEFFICIENT

2.6.1 SOLUBILITY IN DIFFERENT MEDIA

Solubility in : Water
Value : = 549 g/l at 20 °C
pH value :
concentration : at °C
Temperature effects :
Examine different pol. :
pKa : at 25 °C
Description :
Stable :

Conclusion : Most reliable data available.
Reliability : (2) valid with restrictions
Flag : Critical study for SIDS endpoint
07.01.2002 (5)

Solubility in : Water
Value : = 730 g/l at 25 °C
pH value :
concentration : at °C
Temperature effects :
Examine different pol. :
pKa : at 25 °C
Description :
Stable :

Remark : pH of 1% solution is 5.0-7.0 at 25 C.
Reliability : (4) not assignable
Secondary literature (MSDS).
07.01.2002 (3)

Solubility in : Water
Value : = 556 g/l at 20 °C
pH value :
concentration : at °C
Temperature effects :
Examine different pol. :
pKa : at 25 °C
Description :
Stable :

Remark : pH of 250 g/l solution is 4.3 at 20 C.
Reliability : (4) not assignable

Secondary literature (MSDS).
11.11.2004 (2)

Solubility in : Water
Value : = 70.7 g/l at 120 °C
pH value :
concentration : at °C
Temperature effects :
Examine different pol. :
pKa : at 25 °C
Description :
Stable :

Remark : Literature could not be retrieved.
Source : NORKEM LIMITED KNUTSFORD
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004

Solubility in : Water
Value : = 430 g/l at 25 °C
pH value :
concentration : at °C
Temperature effects :
Examine different pol. :
pKa : at 25 °C
Description :
Stable :

Remark : Literature could not be retrieved.
pH 6 - 8 for 1 % solution
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (6)

Solubility in : Water
Value : ca. 556 g/l at 20 °C
pH value :
concentration : at °C
Temperature effects :
Examine different pol. :
pKa : at 25 °C
Description :
Stable :

Remark : Literature could not be retrieved.
Source : Bilgram & Co. GmbH Ostrach
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004

2.6.2 SURFACE TENSION

2.7 FLASH POINT

Method : other
Year :
GLP :
Test substance :

Remark : no combustion
21.12.2004

2.8 AUTO FLAMMABILITY

Remark : No combustion up to 800 degrees C.
Reliability : (4) not assignable
Secondary literature (MSDS).
11.11.2004 (3)

2.9 FLAMMABILITY

2.10 EXPLOSIVE PROPERTIES

Remark : On decomposition releases oxygen which may intensify fire.
Reliability : (4) not assignable
Secondary literature (MSDS).
11.11.2004 (2) (3)

Remark : Literature could not be retrieved.
not explosive - decomposition could be rapid, but of low energy.
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
16.05.1994 (6)

2.11 OXIDIZING PROPERTIES

Remark : Test substance is an oxidizer.
Reliability : (4) not assignable
Secondary literature (MSDS).
11.11.2004 (2) (3)

Result : other: oxidizing properties

Remark : Literature could not be retrieved.
Yes, oxidizing properties (according to Dir. 67/548/EEC and amendments, EEC A17 test)
Yes, oxidizing properties (according to UN transportation regulation, UN test)
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
29.05.1994 (7)

2.12 DISSOCIATION CONSTANT

2.13 VISCOSITY

2.14 ADDITIONAL REMARKS

Remark : Kinetics of oxidation of hair by sodium persulfate:
The half-life of persulfate decomposition as a function of pH: t1/2 (pH 2; pH 12) = approx. 15 - 20 h
t1/2 (pH 10) = approx. 125 h
When hair is oxidized with sodium persulfate, certain groups interact with the reagent in a stoichiometrically defined manner. Disulphide bonds are involved but other groups (not specified) are also reactive.
Literature could not be retrieved.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
02.02.1994 (8)

Remark : Transport classification (UN 1505):

	ADR	RID	IMDG	ICAO
Class	5.1	5.1	5.1	5.1
Item	18C	18C	Page 5185	
Label	5.1	5.1	5.1	5.1
Hazard code	50	50	-	-
Packaging group	III	III	III	III

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
10.05.1994

3.1.1 PHOTODEGRADATION

3.1.2 STABILITY IN WATER

Remark : Hydrolysis: in alkaline, neutral and dilute acid solutions persulfate decomposes according to reaction (1) while in strongly acid solutions reactions (2) and (3) occur:
S2O8(-) + H2O --> 2HSO4(-) + 1/2 O2 (1)
H2S2O8 + H2O --> H2SO5 + H2SO4 (2)
H2SO5 + H2O --> H2O2 + H2SO4 (3)
Literature could not be retrieved.

Koltoff and Miller (1951) measured the rates of decomposition in water for potassium persulfate at various pH's. Since the decomposition (hydrolysis) rate is first order, the half life is independent of initial concentration. Half lives of potassium persulfate at 50 deg C as a function of pH were calculated from data in the Koltoff and Miller (1951) report, indicated below.

pH	1.0	1.6	3.0	7.0	10.0
Half Life (hours)	20	65	120	130	210

The mechanism of decomposition (hydrolysis), described in detail by Koltoff and Miller (1951) for dilute persulfate solutions, was also confirmed for saturated persulfate solutions using isothermal microwatt calorimetry. The main kinetic mechanism begins with homolytic cleavage of persulfate to form sulfate ion radicals. These radicals initiate a series of propagating reactions producing hydroxyl radicals, which ultimately produce hydrogen peroxide and a solution of acid sulfate. The net reaction is:
(S2O8)2- + H2O gives 1/2O2 + 2(SO4)2- + 2H+

The rate equation was described as having two terms once the solution became sufficiently acid:

-d[(S2O8)2-]/dt = k1(H2O)((S2O8)2-) + k2 (H+)((S2O8)2-)

Koltoff and Miller (1951) evaluated the rate constant for the acid-catalyzed term, k2, and it was determined to be 3.5 x 10-3 min-1 (m/l)-1. This term becomes dominant at low pH's.

Reliability : (2) valid with restrictions
Flag : Critical study for SIDS endpoint
21.12.2004 (9)

Remark : Decomposition is promoted by moisture and heat.
Conclusion : Most reliable data available.
Reliability : (2) valid with restrictions
21.12.2004 (5)

Remark : Unstable in presence of heat, moisture and contamination.
Reliability : (4) not assignable
Secondary literature (MSDS).
21.12.2004 (3)

Type : abiotic
t1/2 pH4 : at °C
t1/2 pH7 : at °C

t1/2 pH9 : at °C

Remark : Decomposes in water releasing sodium sulphate and oxygen.
Literature could not be retrieved.
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (4)

Type : abiotic
t1/2 pH4 : at °C
t1/2 pH7 : at °C
t1/2 pH9 : at °C

Remark : Hydrolysis:
in alkaline, neutral and dilute acid solutions persulfate decomposes according to reaction (1) while in strongly acid solutions reactions (2) and (3) occur:
S2O8(-) + H2O --> 2HSO4(-) + 1/2 O2 (1)
H2S2O8 + H2O --> H2SO5 + H2SO4 (2)
H2SO5 + H2O --> H2O2 + H2SO4 (3)
Literature could not be retrieved.
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (10) (11)

3.1.3 STABILITY IN SOIL

Remark : Product will hydrolyse on contact with moisture (see chapter 3.1.2)
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
10.05.1994

3.2.1 MONITORING DATA

3.2.2 FIELD STUDIES

3.3.1 TRANSPORT BETWEEN ENVIRONMENTAL COMPARTMENTS

3.3.2 DISTRIBUTION

3.4 MODE OF DEGRADATION IN ACTUAL USE

Remark : During use oxygen could be formed. Degradation produces sulfate and at elevated temperatures pyrosulfate.
Literature could not be retrieved.
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
16.05.1994 (6)

Remark : During use oxygen is transfered or can be released. Degradation products in the environment are finally sodium (Na+) and sulphate ions.
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
31.05.1994

3.5 BIODEGRADATION

3.6 BOD5, COD OR BOD5/COD RATIO

3.7 BIOACCUMULATION

Remark : The substance is not expected to bioaccumulate in cell systems (see 2.6; water solubility).
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
10.05.1994

3.8 ADDITIONAL REMARKS

4.1 ACUTE/PROLONGED TOXICITY TO FISH

Type	:	static
Species	:	Oncorhynchus mykiss (Fish, fresh water)
Exposure period	:	96 hour(s)
Unit	:	mg/l
LC50	:	163
Limit test	:	
Analytical monitoring	:	yes
Method	:	EPA OPP 72-1
Year	:	
GLP	:	yes
Test substance	:	

Method :

TEST ORGANISMS
- Species: Oncorhynchus mykiss
- Supplier: Mt. Lassen Trout Farm, Red Bluff, CA
- Age/weight/loading: juveniles of 500-1000 mg, 0.05-0.1 g/L
- Feeding (pretreatment): Trout chow until 24-48 hours prior to testing
- Feeding during test: none

STOCK AND TEST SOLUTION AND THEIR PREPARATION
- Other procedures: test solutions were prepared from a stock solution of 10 g/L prepared in filtered deionised well water

DILUTION WATER
- Source: Well located near the test facility (Florida, USA)
- Chemistry (Alkalinity 271-273 mg CaCO3/L; Hardness 277 mg CaCO3/L; TOC 2.1 mg/L; TSS <4 mg/L; pH 7.0-8.3; Conductance 435 umhos/cm)

TEST SYSTEM
- Test type: static
- Concentrations: 0, 19, 32, 54, 90 and 150 mg/L (nominal)
- Exposure vessel type: 30 L glass exposure chambers (covered) containing 10 L of dilution water or test solution
- Number of fish: 10 per replicate, 2 replicates/treatment
- Photoperiod: 16 hours light

PHYSICAL MEASUREMENTS
- Measuring times: Daily
- Test temperature: 12-14 C
- Dissolved oxygen: 67-98%
- pH: 7.5-8.4
- Adjustment of pH: no

DURATION OF THE TEST: 96 hours

TEST PARAMETER: mortality/behavioral changes
OBSERVATION TIMES: Daily

ANALYSES:
- Method: spectrophotometrically using CHEMets Kit No. K-7870. This kit consists of self-filling ampoules containing ammonium biocyanate and ferrous iron in an acidic solution. When reacted with persulphate a red-orange ferric thiocyanate complex was formed which has a maximum absorbance at 460 nm. A standard curve was generated with

five concentrations ranging from 5-100 mg/L sodium persulphate in well water (r2 = 0.997). LOQ 5 mg/L. Validation samples of 10 and 100 mg/L showed recoveries of respectively 92 and 97%
- Sampling times: At 0 h (replicate A) and at 96 hours (replicate B) for all concentrations.

STATISTICAL METHOD: Stephan, C.E., 1977 In Aquatic Toxicology and Hazard Evaluation, ASTM STP 634, Philadelphia, pp.65-84.

Remark : The study was also performed in agreement with ASTM 1980, Standard practice for conducting acute toxicity tests with fishes, macroinvertebrates, and amphibians, publication E729-80.

Result : RESULTS:
- Nominal concentrations (mg/L): 0, 19, 32, 54, 90, 150
- Measured concentrations (mg/L): ND*, 21, 35, 55, 92, 163
- Mortality [%]: 0, 5, 0, 5, 0, 50, respectively
- Other effects: not indicated
- Dose related effects: yes

*ND: not detected

Test substance : CAS 7775-27-1 (sodium persulfate), purity 99.0%.

Conclusion : 96 h LC50 163 mg/L (95% CI 92 mg/L-infinite)
Most sensitive LC50 available.

Reliability : (1) valid without restriction
The test is performed under GLP with the following exception: periodic analyses of dilution water and trout food for the presence of pesticides, hydrocarbons and heavy metals was not carried out in complete compliance with GLP.

Flag : Critical study for SIDS endpoint

21.12.2004 (12)

Type : static
Species : Lepomis macrochirus (Fish, fresh water)
Exposure period : 96 hour(s)
Unit : mg/l
LC50 : 771
Limit test :
Analytical monitoring : yes
Method : EPA OPP 72-1
Year :
GLP : yes
Test substance :

Method : TEST ORGANISMS
- Species: Lepomis macrochirus
- Supplier: Shongaloo Fisheries, Waldo, FL
- Age/weight/loading: juveniles of 100-400 mg, 0.6 g/L
- Feeding (pretreatment): Combination of trout chow, brine shrimp, flake food until 24-48 hours prior to testing
- Feeding during test: none

STOCK AND TEST SOLUTION AND THEIR PREPARATION
- Other procedures: test solutions were prepared from a stock solution of 10 g/L prepared in filtered deionised well water

DILUTION WATER
- Source: Well located near the test facility (Florida, USA)
- Chemistry (Alkalinity 264 mg CaCO3/L; Hardness 275 mg CaCO3/L; TOC 2.1 mg/L; TSS <4 mg/L; pH 8.2; Conductance 482 umhos/cm)

TEST SYSTEM
- Test type: static
- Concentrations: 0, 130, 216, 360, 600 and 1000 mg/L (nominal)
- Exposure vessel type: 12 L glass exposure chambers (covered) containing 5 L of dilution water or test solution
- Number of fish: 10 per replicate, 2 replicates/treatment
- Photoperiod: 16 hours light
PHYSICAL MEASUREMENTS
- Measuring times: Daily
- Test temperature: 21-23 C
- Dissolved oxygen: 69-103%
- pH: 7.9-8.4
- Adjustment of pH: no

DURATION OF THE TEST: 96 hours

TEST PARAMETER: mortality/behavioral changes
OBSERVATION TIMES: Daily

ANALYSES:
- Method: spectrophotometrically using CHEMets Kit No. K-7870. This kit consists of self-filling ampoules containing ammonium biocyanate and ferrous iron in an acidic solution. When reacted with persulphate a red-orange ferric thiocyanate complex was formed which has a maximum absorbance at 460 nm. A standard curve was generated with five concentrations ranging from 5-100 mg/L ammonium persulphate in well water (r2 = 0.998). LOQ 5 mg/L. Validation samples of 10 and 100 mg/L showed recoveries of respectively 92 and 97%
- Sampling times: At 0 h (replicate A) and at 96 hours (replicate B) for all concentrations.

STATISTICAL METHOD: Stephan, C.E., 1977 In Aquatic Toxicology and Hazard Evaluation, ASTM STP 634, Philadelphia, pp.65-84.

Remark : The study was also performed in agreement with ASTM 1980, Standard practice for conducting acute toxicity tests with fishes, macroinvertebrates, and amphibians, publication E729-80.

Result : RESULTS:
- Nominal concentrations (mg/L): 0, 130, 216, 360, 600, 1000
- Measured concentrations (mg/L): ND*, 136, 233, 391, 634, 1029
- Mortality [%]: 0, 5, 0, 10, 25, 85, respectively
- Other effects: not indicated
- Dose related effects: yes

*ND: not detected

Test substance : CAS 7775-27-1 (sodium persulfate), purity 99.0%.

Conclusion : 96-h LC50 771 mg/L (95% CI 634-1029 mg/L)

Reliability : (1) valid without restriction
The test is performed under GLP with the following exception: periodic analyses of dilution water and bluegill food for the presence of pesticides, hydrocarbons and heavy metals was not carried out in complete compliance with GLP.

21.12.2004 (13)

4.2 ACUTE TOXICITY TO AQUATIC INVERTEBRATES

Type	:	static
Species	:	Daphnia magna (Crustacea)
Exposure period	:	48 hour(s)
Unit	:	mg/l
EC50	:	133
Analytical monitoring	:	yes
Method	:	EPA OPP 72-2
Year	:	
GLP	:	yes
Test substance	:	

Method :

TEST ORGANISMS
- Species: Daphnia magna
- Source/supplier: Environmental Science & Engineering, Inc., Gainesville, Florida, USA
- Breeding method: laboratory bred
- Age: <24 hours
- Feeding (pretreatment): Synthetic food composed of yeast, trout chow, cereal leaves
- Feeding during test: no

STOCK AND TEST SOLUTION AND THEIR PREPARATION
- Other procedures: test solutions were prepared from a stock solution of 10 g sodium persulfate/L in filtered, deionized well water.

DILUTION WATER
- Source: Reconstituted well water (Gainesville, Florida)
- Chemistry: Hardness 166 mg CaCO3/L; Alkalinity 119 mg CaCO3/L; Conductivity 510 umhos/cm; pH 8.3-8.4

TEST SYSTEM
- Test type: static
- Concentrations: 0, 65, 108, 180, 300, 500 mg/L
- Exposure vessel type: (covered) glass cylinders (d 100 mm, h 50 mm) containing 250 mL dilution water or test solution
- Number of individuals: 10 per replicate, 2 replicates/treatment
- Photoperiod (intensity of irradiation): 16 hours (1008 lux)

PHYSICAL MEASUREMENTS
- Measuring times: 0, 24, 48 h
- Test temperature: 21 C
- Dissolved oxygen: 94-99%
- pH: 8.3-8.4
- Adjustment of pH: no

DURATION OF THE TEST: 48 hours

TEST PARAMETER: Immobility/behavioral changes
OBSERVATION TIMES: 24, 48 h

ANALYSES:
- Method: spectrophotometrically using CHEMets Kit No. K-7870. This kit consists of self-filling ampoules containing ammonium biocyanate and ferrous iron in an acidic solution. When reacted with persulphate a red-orange ferric thiocyanate complex was formed which has a maximum absorbance at 460 nm. A standard curve was generated with five concentrations ranging from 5-100 mg/L ammonium

persulphate in well water (r2 = 0.997). LOQ 5 mg/L.
Validation samples of 10 and 100 mg/L showed recoveries of respectively 92 and 97%
- Sampling times: At 0 h (replicate A) and at 48 hours (replicate B) for all concentrations.

STATISTICAL METHOD: Stephan, C.E., 1977 In Aquatic Toxicology and Hazard Evaluation, ASTM STP 634, Philadelphia, pp.65-84.

Remark : The study was also performed in agreement with ASTM 1980, Standard practice for conducting acute toxicity tests with fishes, macroinvertebrates, and amphibians, publication E729-80.

Result : RESULTS:
- Nominal concentrations (mg/L): 0, 65, 108, 180, 300, 500
- Measured concentrations (mg/L): ND*, 68, 113, 187, 310, 504
- Immobility [%]: 0, 5, 20, 90, 100, 100, respectively
- Other effects: Lethargic behavior at 187 mg/L
- Dose related effects: yes

Test substance : CAS 7727-54-0 (sodium persulfate), purity 100.12%.

Conclusion : 48-h EC50 133 mg/L (95% CI 116-153 mg/L)
Most sensitive, reliable study available.

Reliability : (1) valid without restriction
The test is performed under GLP with the following exception: periodic analyses of dilution water and daphnid food for the presence of pesticides, hydrocarbons and heavy metals was not carried out in complete compliance with GLP.

Flag : Critical study for SIDS endpoint

21.12.2004 (14)

Type : static
Species : Palaemonetes pugio (Crustacea)
Exposure period : 96 hour(s)
Unit : mg/l
EC50 : 519
Analytical monitoring : yes
Method : EPA OPP 72-3
Year :
GLP : yes
Test substance :

Method : TEST ORGANISMS
- Species: Palaemonetes pugio (test end: 0.06-0.15 g)
- Supplier: Aquatic Indicators, St. Augustine, FL
- Feeding during test: no

STOCK AND TEST SOLUTION AND THEIR PREPARATION
- A stock solution containing 10 g/L test substance was prepared infiltered deionized well water.

DILUTION WATER
- Source: Atlantic Ocean water near Whitney Laboratory, Marineland, FL (salinity adjusted with well water to 20 ppt)
- Chemistry: alkalinity 183 mg/L CaCO3

TEST SYSTEM
- Test type: static
- Conentrations: 130, 216, 360, 600, 1000 mg/L (no vehicle), untreated controls.
- Exposure vessel type: 25 L glass jars (covered, shrimps were individually caged in screen cups) containing 10 L of solution

- No. of shrimps: 1/screen cup, 10 screen cups/replicate, 2 replicates/treatment.
- Photoperiod: 16 h light

PHYSICAL MEASUREMENTS
- Measuring times: daily for all test vessels
- Test temperature: 22°C
- Dissolved oxygen: 85-100%
- pH: 8.1-8.2
- Salinity: 17-21 ppt

DURATION OF THE TEST: 96 h

TEST PARAMETER: Mortality/symptoms

OBSERVATION TIMES: 24, 48, 72, 96 h

ANALYSES: At 0 and 96 h (repl. B) from all concentrations by colorimetric reaction followed by spectrophotometrical analysis.

STATISTICAL METHOD: Stephan, C.E., 1977 In Aquatic Toxicology and Hazard Evaluation, ASTM STP 634, Philadelphia, pp.65-84.

Remark : The study was also performed in agreement with ASTM 1980, Standard practice for conducting acute toxicity tests with fishes, macroinvertebrates, and amphibians, publication E729-80.

Result : Mortality at the measured concentrations 0, 146, 229, 366, 603 and 974 mg/L was 0, 10, 25, 15, 55 and 85%, respectively. No behavioral changes were reported.

Analytical results: Calibration curve with r2=0.997.
Validation samples of 10 and 100 mg/L showed recoveries of 96-98%.
Mean measured test concentrations were 97-113% of nominal.

Test substance : CAS 7727-54-0 (sodium persulfate), purity 100.12%.

Conclusion : 96-h LC50 519 mg/L (95% CI 409-710 mg/L)

Reliability : (1) valid without restriction
1. Non-key study (saltwater organism).
2. GLP-study with the following exception: the periodic analysis of dilution water and shrimp food was not carried out in complete compliance with GLP.
3. Two version of page 8 were included. One provided the theoretical purity of the test substance (=99.0%) and the other provided the experimental purity (=100.12%). In this summary the measured value is included.

21.12.2004 (15)

4.3 TOXICITY TO AQUATIC PLANTS E.G. ALGAE

Species	:	Selenastrum capricornutum (Algae)
Endpoint	:	biomass
Exposure period	:	120 hour(s)
Unit	:	mg/l
LOEC	:	= 17.1
72 h-EC50	:	= 116
Limit test	:	
Analytical monitoring	:	yes
Method	:	OECD Guide-line 201 "Algae, Growth Inhibition Test"
Year	:	1984
GLP	:	yes

Test substance :

Method : TEST ORGANISMS
- Species: Selenastrum capricornutum
- Source/supplier: University of Texas, Austin (1989)
- Laboratory culture: yes, since 1989 until study (1998) kept at performing lab (Florida)
- Method of cultivation: cultured on freshwater algal medium (ASTM, 1990), continuous illumination (~3333 lux), 24+/-2 C
- Pretreatment: 3 day old inoculum culture
- Initial cell concentration: 3000 cells/mL

STOCK AND TEST SOLUTION AND THEIR PREPARATION
Test solutions were prepared from a stock solution of 500 mg/L sodium persulphate.

DILUTION WATER
- Source: deionised water (reconstituted)

GROWTH/TEST MEDIUM CHEMISTRY
- Chemistry: not specified, reported to be reconstituted in accordance with ASTM (1990)
- pH: 7.5+/-0.1

TEST SYSTEM
- Test type: static
- Concentrations: 0, 16, 31, 63, 125, 250, 500 mg/L
- Exposure vessel type: 250 mL glass Erlenmeyer flasks containing 100 mL of medium
- Number of replicates: 3 for treatments, 6 for control
- Photoperiod (intensity of irradiation): continuous illumination (2593-3873 lux)

PHYSICAL MEASUREMENTS
- Test temperature: 23-25 C (daily, 1 parallel uninoc. flask)
- pH: 7.4-8.4 (0, 72, 120 h)

DURATION OF TEST: 120 hours

TEST PARAMETER: cell counts (electronic particle counter)
OBSERVATION TIMES: 24, 48, 72, 96, 120 h

ANALYSES:
- Method: Colorimetric analysis at 460 nm with a spectrophotometer (corrected for blank values). A calibration curve was generated with five concentrations ranging from 5-100 mg/L sodium persulphate in algae medium (r2 = 0.999). LOD/LOQ 1.50/3.92 mg/L. Validation samples of 9 and 598 mg/L showed recoveries of respectively 92 and 100%. QCs spiked at 9 and 500 mg/L showed recoveries of 90-101%.
- Sampling times: 0, 72 (extra inoculated parallel flasks), 120 h

STATISTICAL METHOD: Probit analyses, ANOVA, Dunnett's procedure

Result : RESULTS:
- Nominal concentrations (mg/L): 0, 16, 31, 63, 125, 250, 500
- Measured concentrations (mg/L): <2.43, 18, 35, 67, 136,

267, 531
- Cell density data: see attached document
- Inh. growth rate (% of control-120 h): 0, 13, 36, 51, 58, 68, 78
- Inh. biomass (AUC) (% of control-72 h): 0, 24, 23, 42, 43, 64, 82

GROWTH FACTOR CONTROL: 98 after 72 h; 1177 after 120 h

STATISTICAL RESULTS: At 72 hours the cell numbers at all test concentrations are significantly reduced when compared to the control values. At 120 hours significant reduction is seen at all test concentrations except 16 mg/L.

Test substance : CAS 7775-27-1 (sodium persulfate), purity 99.7%.
Attached document : see ref33.xls and ref33A.xls
Conclusion : 72-h EbC50 116 mg/L (95% CI 85-165 mg/L)
120-h ErC50 93.1 mg/L (95% CI 75-116 mg/L)
Only study available.
Reliability : (1) valid without restriction
1. Because the calculation of the inhibition on growth rate and biomass was not in accordance with the method used by OECD 201, the reviewer recalculated the EC50 values using log-linear regression analysis. This resulted in 120 h EbC50 of 72 mg/L (95% CI 35-148 mg/L) and 120 h ErC50 >499 mg/L. In the attached document the percentages of inhibition calculated in accordance with OECD 201 and used for the recalculation of the EC50 values are included. The values for LOEC and EC50 presented are the 72 h-values, because these are the standards according to OECD 201.
2. There was insufficient information on the medium used for this test (reported to be in accordance with ASTM, 1990).
Since however the control growth was acceptable, the study reliability was not lowered.
Flag : Critical study for SIDS endpoint
21.12.2004 (16)

4.4 TOXICITY TO MICROORGANISMS E.G. BACTERIA

Type : other
Species : Escherichia coli (Bacteria)
Exposure period :
Unit :
Analytical monitoring : no data
Method : other: Macdonald et al. (see remark)
Year : 1973
GLP : no
Test substance : other TS: analytical grade (no further data)

Remark : Literature could not be retrieved.
Test conc. : 0.238 - 2.38 g/l
Test duration: no data
Result: Sodium persulfate inhibited the enzyme activity of 7alpha-hydroxysteroid dehydrogenase (7alpha-HSDH) from E. coli noncompetively. The denaturation of the enzyme oxidation of -SH groups was discussed.
Method: a known concentration of the agent was mixed with a constant quantity of the enzyme (protein conc.: 0,34 mg/ml) into a final volume of 3 ml.
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (17)

Type : other

Species	:	other bacteria: Brevibacterium thiogenitalis (ATCC 19240)
Exposure period	:	48
Unit	:	mg/l
NOEC	:	= 20
Analytical monitoring	:	no data
Method	:	other: Fukuda et al.
Year	:	1971
GLP	:	no
Test substance	:	no data

Remark : Effect: increased formation of L-glutamic acid
Literature could not be retrieved.
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (18)

Type	:	Other
Species	:	other bacteria: Nitrobacter agilis
Exposure period	:	
Unit	:	
Analytical monitoring	:	no data
Method	:	other: Tsai, Tuovinen
Year	:	1989
GLP	:	No
Test substance	:	no data

Remark : Effect: Fixation of carbon dioxide was inhibited at a concentration of 4.05 g/l sodium persulfate in the presence of 0.46 g/l NO2(-); (incubation: 1 h). In the absence of NO2(-), sodium persulphate did not affect the CO2 fixation. Complete inhibition of the reduction of cytochrome c (415; 550 nm) and cytochrome a1 (438 nm) were observed in the presence of 4.05 g/l sodium persulfate. Oxygen uptake coupled with nitrite oxidation was not influenced by sodium persulfate.
Literature could not be retrieved.
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (19)

Type	:	Other
Species	:	other bacteria: Nitrobacter winogradskyi
Exposure period	:	7
Unit	:	mg/l
EC100	:	> 23.8
Analytical monitoring	:	no data
Method	:	other: washed cell suspension; Tsai, Tuovinen
Year	:	1985
GLP	:	No
Test substance	:	no data

Remark : Effect: Complete inhibition of growth was observed at concentrations > 23.8 mg/l (incubation: 7 days). The oxygen uptake of N. winogradskyi was not influenced at a concentration of 4.05 g/l (incubation: 1 h).
Literature could not be retrieved.
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (20)

4.5.1 CHRONIC TOXICITY TO FISH

4.5.2 CHRONIC TOXICITY TO AQUATIC INVERTEBRATES

4.6.1 TOXICITY TO SEDIMENT DWELLING ORGANISMS

4.6.2 TOXICITY TO TERRESTRIAL PLANTS

4.6.3 TOXICITY TO SOIL DWELLING ORGANISMS

4.6.4 TOX. TO OTHER NON MAMM. TERR. SPECIES

4.7 BIOLOGICAL EFFECTS MONITORING

4.8 BIOTRANSFORMATION AND KINETICS

4.9 ADDITIONAL REMARKS

Remark : Literature could not be retrieved.
Toxicity to amphibia:
Type : in-vitro-test
Species : Rana temporaria, rectus abdominis
Concentration : 0.5 %
Exposure : 30 - 60 min.
Effect : insignificant Lundsgaard effects (= cramp and no excitable stage of a muscle after work)
Method : Bacq et al. (1940)
Test substance: no data
GLP : no

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (21)

Remark : Literature could not be retrieved.
Toxicity to fungis:
Species : Microsporum gypseum
Concentration : 1.31 g/l
Incubation : 11 days
Effect : Sodium persulfate is a suitable source for the growth of M. gypseum (similarly effective as sulphur sources).
Method : The dry mass of the mycelium was determined in each culture (pH 8.0; 28 degree C); control

Test substance: analytical grade (no further data)
GLP : no data

Source **:** Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (22)

5.0 TOXICOKINETICS, METABOLISM AND DISTRIBUTION

5.1.1 ACUTE ORAL TOXICITY

Type	:	LD50
Value	:	= 895 mg/kg bw
Species	:	Rat
Strain	:	
Sex	:	Male
Number of animals	:	6
Vehicle	:	other: corn oil
Doses	:	
Method	:	other: not indicated
Year	:	
GLP	:	No
Test substance	:	

Method :
TEST ORGANISMS:
- Number: 6/treatment
- Controls: none
- Weight at study initiation: 193 g (mean)

ADMINISTRATION:
- Doses: 500, 1000 mg/kg bw (vehicle corn oil)

EXAMINATIONS: mortality, clinical signs, macroscopy

Result :
MORTALITY
- Number of deaths at each dose: 0/6 (500), 4/6 (1000)
- Time of death: within 24 hours

CLINICAL SIGNS: sluggish weak (recovery within 2-14 days)

NECROPSY FINDINGS: within normal limits

Test substance : CAS 7775-27-1 (sodium persulfate), purity not indicated

Conclusion : Only study available.

Reliability : (2) valid with restrictions
1. The information in the report is confined to the above.
2. Only males were tested; no body weight reported.

Flag : Critical study for SIDS endpoint

07.01.2002 (23)

Type	:	LD50
Value	:	= 920 mg/kg bw
Species	:	Rat
Strain	:	
Sex	:	
Number of animals	:	
Vehicle	:	
Doses	:	
Method	:	other: see remark
Year	:	
GLP	:	No
Test substance	:	no data

Remark : Literature could not be retrieved.
Remark: LD50 = 920 mg/kg for females
LD50 = 930 mg/kg for males

Method: animals: 70 rats (10 per dose and sex); strain: Sprague-Dawley; administration: 0.8 % - solution of sodium persulfate in hydroxypropyl-methylcellulose E 4 M; administration volume: 10 ml/kg, observation time: 4 weeks

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (24)

5.1.2 ACUTE INHALATION TOXICITY

Type	:	LC50
Value	:	> 5.1 mg/l
Species	:	Rat
Strain	:	Sprague-Dawley
Sex	:	male/female
Number of animals	:	10
Vehicle	:	
Doses	:	
Exposure time	:	4 hour(s)
Method	:	OECD Guide-line 403 "Acute Inhalation Toxicity"
Year	:	1981
GLP	:	Yes
Test substance	:	

Method :

TEST ORGANISMS:
- Source: Charles River Laboratories, Kingston, NY
- Age: 7 weeks (male) and 9 weeks (female)
- Weight at study initiation: 207-225 g (male) and 214-232 g (female)
- Number of animals: 5/sex/treatment
- Controls: none

ADMINISTRATION:
- Type of exposure: nose only
- Exposure duration: 4 hours
- Concentrations(nominal/measured): 19.0/5.10 mg/L
- Particle size (MMAD): 0-5.6% <=1 µm; 77-81% <= 10 µm
- Type or preparation of particles: dust feeding of grounded substance
- Air changes: 211 per hour

EXAMINATIONS: mortality and clinical signs at 15 minute-intervals during the first hour of exposure, hourly for the remainder of the exposure, at 1 hour post-exposure and daily thereafter for 14 days, body weight on day 0, 7 and 14 and necropsy on day 14

ANALYSES:
- Method: gravimetry
- Sampling times: at 17, 54, 91, 133, 175 and 215 min during exposure

Result : MORTALITY:
- Number of deaths: none

CLINICAL SIGNS: chromodacryorrhea, chromrhinorrhea, decreased faeces, decreased locomotion, dyspnea, nasal discharge and oral discharge, wet material on fur (reversible within 2 days); abdominal staining or stained fur until day 9

NECROPSY FINDINGS: no gross lesions

ANALYSES:
Measured concentration: 4.41-6.09 mg/L (mean 5.10 mg/L)

Test substance : CAS 7775-27-1 (sodium persulfate), purity not indicated
Conclusion : Only guideline study available.
Reliability : (1) valid without restriction
1. The number of air changes per hour is much higher than required by OECD 403 (12-15 air changes per hour). This high air flow is probably used to prevent excessive sedimentation of the substance.
2. Oral uptake from the fur cannot be excluded.
Flag : Critical study for SIDS endpoint
21.12.2004 (25)

Type : other: respiratory decrease
Value : = 2.25 mg/l
Species : Mouse
Strain : Swiss Webster
Sex : Male
Number of animals : 4
Vehicle :
Doses : 0.26, 0.77, 1.38 and 3.22 mg/L
Exposure time : 30 minute(s)
Method : other: Standard test method for estimating sensory irritation or airborne chemicals (ASTM standards E981-84)
Year : 1984
GLP : Yes
Test substance :

Method : TEST ORGANISMS:
- Source: Harlan Sprague Dawley, Indianapolis, IN
- Age: 60-62 days
- Weight at study initiation: 23-26 g
- Number of animals: 4/treatment

ADMINISTRATION:
- Type of exposure: head-only
- Exposure duration: 30 min.
- Concentrations(nominal/measured): 35.6/0.26, 167.8/0.77, 386.7/1.38 and 642.2/3.22 mg/L
- Particle size (MMAD): 9.0, 7.3, 11.7 and 16.0 µm for 0.26, 0.77, 1.38 and 3.22 mg/L, respectively
- Type or preparation of particles: dust feeding
- Air changes: ca. 520-780 per hour

EXAMINATIONS: mortality daily after exposure until day 7, clinical signs (incl. irritation) during exposure and daily after exposure until day 7, body weight on days 0 and 7, respiratory frequency continuously during 10 min. pre-exposure, 30 min exposure and 10 min post-exposure

ANALYSES:
- Method: gravimetric
- Sampling times: 3 times during exposure at 6-14 minutes intervals

STATISTICAL METHOD:
least squares method of Draper and Smith (1966)

Result : MORTALITY:
- Number of deaths at each dose: 0/4 (0.26 mg/L); 1/4 (0.77 mg/L); 2/4 (1.380 mg/L); 4/4 (3.22 mg/L)
- Time of death: day 0-4

CLINICAL SIGNS: during exposure in all animals white powder on fur, blepharospasm and lacrimation and these signs persisted throughout post-exposure period; post-exposure signs (increasing in severity with concentration) included periocular wetness (0.26 mg/L), unkempt fur (0.77 mg/L, 1.38 mg/L, 3.22 mg/L), white eye opacity (0.77 mg/L, 1.38 mg/L), decreased respiration (0.77, 3.22 mg/L), head tremor (0.77, 3.22 mg/L), periocular (3.22 mg/L) and perinasal encrustation (1.38 mg/L), whole body tremor and abnormal gait (1.38, 3.22 mg/L), perinasal discharge and wetness (3.22 mg/L)

BODY WEIGHT GAIN: a dose-related effect might be present (decrease at 1.38 mg/L), but could not be established because of mortality in higher doses

RESPIRATORY FREQUENCY: mean decrease is 9.3, 39, 36 and 56 % at 0.26, 0.77, 1.38 and 3.22 mg/L, respectively

Test substance : CAS 7775-27-1 (sodium persulfate), purity 98.5%.
Conclusion : 50% respiratory decrease (RD50) = 2.252 mg/L
Reliability : (1) valid without restriction
1. Ocular opacity was related to damage by high velocity air loaded with dust.
2. A great variability in sensory irritation response was seen in all concentration groups.
3. Oral uptake from the fur cannot be excluded.

21.12.2004 (26)

Type : LC50
Value : > 191.7 mg/l
Species : Rat
Strain :
Sex : Male
Number of animals : 7
Vehicle : Water
Doses :
Exposure time : 1 hour(s)
Method : other: not indicated
Year :
GLP : No
Test substance :

Method : TEST ORGANISMS:
- Number of animals: 7/treatment
- Controls: none
- Body weight at initiation: 169 g (mean)

ADMINISTRATION:
- Type of exposure: aerosol of 50% sodium persulfate suspension in water
- Exposure duration: 1 h
- Concentration(nominal): 191.7 mg/L

EXAMINATIONS: mortality, clinical signs, macroscopy

Result : MORTALITY:
- Number of deaths: none

CLINICAL SIGNS: slightly irritated and slightly lethargic

NECROPSY FINDINGS: hyperemic kidney (3/7)

Test substance : CAS 7775-27-1 (sodium persulfate), purity not indicated

Reliability	:	(2) valid with restrictions 1. The information in the report is confined to the above. 2. Only males were tested; no body weight reported. 3. Type of exposure not indicated and the exposure time is only 1 hour (OECD402: 4 hours).
11.11.2004		(23)
Type	:	LC0
Value	:	
Species	:	Rat
Strain	:	
Sex	:	
Number of animals	:	
Vehicle	:	
Doses	:	
Exposure time	:	4 hour(s)
Method	:	other
Year	:	1978
GLP	:	No
Test substance	:	no data
Remark	:	Literature could not be retrieved. Method: 10 rats /dose group were exposed to 0, 7.4 mg/l or 21.6 mg/l (gravimetric concentration); observation period: 14 days Effect: Clinical signs included conjunctivitis and rhinitis. Only 17 - 19 % particles < 5 um diameter. 7.4 mg/l : 1/10 dead 21.6 mg/l: 0/10 dead
Source	:	Degussa AG Frankfurt am Main EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004		(27)

5.1.3 ACUTE DERMAL TOXICITY

Type	:	LD50
Value	:	> 10000 mg/kg bw
Species	:	Rabbit
Strain	:	
Sex	:	Male
Number of animals	:	4
Vehicle	:	
Doses	:	
Method	:	other: not indicated
Year	:	
GLP	:	No
Test substance	:	
Method	:	TEST ORGANISMS: - Weight at study initiation: 2175 g - Controls: none ADMINISTRATION: - Dose: 10000 mg/kg bw EXAMINATIONS: mortality, clinical signs, macroscopy
Result	:	MORTALITY - Number of deaths: none

CLINICAL SIGNS: irritation, erythema and eschar formation on accidently damaged skin

NECROPSY FINDINGS: within normal limits

Test substance : CAS 7775-27-1 (sodium persulfate), purity not indicated
Conclusion : Only study available.
Reliability : (2) valid with restrictions
1. The information in the report is confined to the above.
2. Only males were tested.
Flag : Critical study for SIDS endpoint
11.11.2004 (23)

5.1.4 ACUTE TOXICITY, OTHER ROUTES

Type : LD50
Value : = 226 mg/kg bw
Species : mouse
Strain :
Sex :
Number of animals :
Vehicle :
Doses :
Route of admin. : i.p.
Exposure time :
Method : other: see remark
Year :
GLP : no
Test substance : other TS: pure commerc. grade
Remark : Literature could not be retrieved.
Method: application volume: 20 ml solution/kg bw.
animals: swiss albino, male
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (28) (29)

Type : LDLo
Value : = 178 mg/kg bw
Species : rabbit
Strain :
Sex :
Number of animals :
Vehicle :
Doses :
Route of admin. : i.v.
Exposure time :
Method : other: no data
Year :
GLP : no
Test substance : no data
Remark : Literature could not be retrieved.
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (30) (28)

5.2.1 SKIN IRRITATION

Species : rabbit

Concentration	:	
Exposure	:	no data
Exposure time	:	4 hour(s)
Number of animals	:	6
Vehicle	:	
PDII	:	
Result	:	not irritating
Classification	:	
Method	:	other: not indicated
Year	:	
GLP	:	no
Test substance	:	

Method	:	ADMINISTRATION/EXPOSURE - Examination time points: 24 and 72 h (intact and abraded skin)
Result	:	AVERAGE SCORE - Erythema: 0 (intact and abraded) - Edema: 0 (intact and abraded)
Test substance	:	CAS 7775-27-1 (sodium persulfate), purity not indicated
Reliability	:	(2) valid with restrictions 1. The information in the report is confined to the above. 2. Information on the time of exposure was given by FMC Corporation (personal communication).

17.01.2005 (31)

Species	:	rabbit
Concentration	:	
Exposure	:	
Exposure time	:	
Number of animals	:	
Vehicle	:	
PDII	:	
Result	:	not irritating
Classification	:	
Method	:	other
Year	:	1979
GLP	:	no
Test substance	:	other TS: 30 % sodium persulfate

Remark	:	Literature could not be retrieved. Method: DOT skin corrosion test; 4 hour exposure; intact site; occluded wrap. Scored by Draize method at: 4 h, 48 h and 7 days

21.12.2004 (32)

Species	:	rabbit
Concentration	:	
Exposure	:	
Exposure time	:	
Number of animals	:	
Vehicle	:	
PDII	:	
Result	:	not irritating
Classification	:	
Method	:	other
Year	:	1980
GLP	:	no
Test substance	:	other TS: 30 % sodium persulfate

Remark	:	Literature could not be retrieved. Method: DOT skin corrosion test; 4 hour exposure; 1 intact site and 1 abraded site; occluded wrap. Scored by Draize method at: 4 h, 48 h and 7 days

21.12.2004 (33)

Species	:	rabbit
Concentration	:	
Exposure	:	
Exposure time	:	
Number of animals	:	
Vehicle	:	
PDII	:	
Result	:	not irritating
Classification	:	
Method	:	other: Patch-Test (see remark)
Year	:	
GLP	:	no
Test substance	:	no data

Remark	:	Literature could not be retrieved. Method: Federal Register, Vol. 38, No. 187, paragraph 1500.41, p. 27019. Year: 1973
Source	:	Degussa AG Frankfurt am Main EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (34)

Species	:	rabbit
Concentration	:	
Exposure	:	
Exposure time	:	
Number of animals	:	
Vehicle	:	
PDII	:	
Result	:	
Classification	:	
Method	:	other: Draize-Test (see remark)
Year	:	
GLP	:	no
Test substance	:	no data

Remark	:	Literature could not be retrieved. Result: very slightly irritating Method: Federal Register, Vol. 38, No. 187, paragraph 1500, p. 27019. Year: 1973
Source	:	Degussa AG Frankfurt am Main EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (35)

5.2.2 EYE IRRITATION

Species	:	rabbit
Concentration	:	
Dose	:	
Exposure time	:	72 hour(s)
Comment	:	
Number of animals	:	8
Vehicle	:	

Result	:	not irritating
Classification	:	
Method	:	other: not indicated
Year	:	
GLP	:	no
Test substance	:	
Method	:	EXAMINATIONS - cornea, iris, conjunctivae - Observation times: 24, 48, 72 h
Result	:	AVERAGE SCORE - Cornea: 0 - Iris: 0 - Conjunctivae: 0 (at 48 h score 1 in 5/8 animals)
Test substance	:	CAS 7775-27-1 (sodium persulfate), purity not indicated
Reliability	:	(2) valid with restrictions The information in the report is confined to the above.

11.11.2004 (23)

5.3 SENSITIZATION

Type	:	Patch-Test
Species	:	human
Concentration	:	1st: Induction occlusive epicutaneous 2nd: Challenge occlusive epicutaneous 3rd: Challenge other: both semiocclusive and occlusive
Number of animals	:	
Vehicle	:	water
Result	:	not sensitizing
Classification	:	
Method	:	
Year	:	
GLP	:	
Test substance	:	
Method	:	About 100 persons were included in the study design. During the induction phase they received 9 consecutive applications of 10, 200, 2500 and 5000 ppm sodiumpersulfate in distilled water and 0.1% SLS (all under occlusion) on their back. Patches were applied during 24 hours, 3 times weekly for 3 weeks. In the sixth week subjects were challenged on sites that were previously unexposed with identical patches for 24 hours. Readings were performed 24 and 48 hours after the challenge. In subjects with evidence of possible sensitization a rechallenge was performed 2 weeks after the challenge. Occlusive and semi-occlusive patches with concentrations eliciting the positive response in the first challenge were applied for 24 hours. Readings were performed 24, 48 and 72 hours after the rechallenge. Evaluation: a response is considered positive if the reaction during the challenge phase (erythema and oedema score) is more severe than the reaction seen during the induction phase and this reaction becomes evident 24 hours after the challenge and does not diminish at the 48 (and 72) hour reading.
Result	:	After the first challenge 6 subjects had reactions that may be indicative for sensitization. Rechallenge of 5 of these subjects indicated that the characteristics of the response could not be interpreted as sensitizing, but as irritant.
Test substance	:	CAS 7775-27-1 (sodium persulfate), purity not indicated

Conclusion : Only human test for sensitization available.
Reliability : (1) valid without restriction
The repeated insult patch test is an accepted test to investigate sensitizing properties of a test substance.
21.12.2004 (36)

Type : Buehler Test
Species : guinea pig
Number of animals : 20
Vehicle : water
Result : not sensitizing
Classification :
Method : OECD Guide-line 406 "Skin Sensitization"
Year : 1981
GLP : yes
Test substance :

Method : TEST ANIMALS:
- Strain: Hartley
- Sex: male/female
- Source: Hazleton Research Animals, Inc., Denver, Pennsylvania
- Age: young adults
- Weight at study initiation: 306-442 g
- Number of animals: 20
- Controls: 10
ADMINISTRATION/EXPOSURE
- Study type: Buehler
- Induction schedule: day 0, 7 and 14 during 6 hours epidermal application
- Concentrations used for induction: 0.3 g undiluted
- Challenge schedule: 14 days after last induction for 6 hours epidermal application
- Concentrations used for challenge: 0.3 g undiluted
EXAMINATIONS
- Grading system: Draize at 24 and 48 h after challenge
- Pilot study: yes

Result : RESULTS OF PILOT STUDY: undiluted test substance is not irritating
RESULTS OF TEST
- Sensitization reaction: 1/20 slight erythema (control: 3/10 slight erythema)
- Body weight gain: within normal limits
- Clinical signs (during induction period): slight to moderate erythema, slight oedema and desquamation

Test substance : CAS 7775-27-1 (sodium persulfate), purity 60-75% (remainder sodium sulfate).
Conclusion : Most reliable test with animals available.
Reliability : (1) valid without restriction
1. The relative humidity was reported to range between 18 and 74%, which is not according to OECD406 (30-70%).
21.12.2004 (37)

Type : Guinea pig maximization test
Species : guinea pig
Concentration : 1st: Challenge .1 % intracutaneous
2nd: Challenge 1 % occlusive epicutaneous
3rd:
Number of animals : 20
Vehicle : other: physiol. saline for intracutaneous application and water for epicutaneous application

Result	:	ambiguous
Classification	:	
Method	:	OECD Guide-line 406 "Skin Sensitization"
Year	:	1981
GLP	:	no data
Test substance	:	

Method :

TEST ANIMALS:
- Strain: Pirbright White (Bor: DHPW)
- Sex: male/female
- Source: Winkelmann, Borchen
- Age: males 5-10 weeks; females 6-7 weeks
- Weight at study initiation: 314-387 g
- Number of animals: 20
- Controls: 20

ADMINISTRATION/EXPOSURE
- Study type: guinea pig maximization
- Test substance for induction/challenge: 0.1 ml 0.1 % in physiol. saline
- Preparation of test substance for second challenge: 0.2 ml 1 % in water
- Induction schedule: day 1, 3, 5 (test substance); day 8, 10, 12, 15, 17, 19 (test substance + FCA)all intradermal
- Challenge schedule: day 36 intradermal
- Second challenge schedule: day 50 epidermal (24 h application)

EXAMINATIONS
- Grading system: thickness of skin at the application site and size of erythema on day 37 (intracutaneous); Draize scores for oedema and erythema on day 52 and 53 (epicutaneous)

STATISTICAL METHOD: Fisher test

Result : RESULTS OF TEST
- Sensitization reaction first challenge: 18/20 animals (intracutaneous)
- Sensitization reaction second challenge: 2/20 animals after 24 h (epicutaneous); 0/20 in control

Test substance : CAS 7775-27-1 (sodium persulfate), purity >99%.

Conclusion : Intradermal challenge: positive
Epidermal challenge: negative

Reliability : (2) valid with restrictions
1. No pilot study was performed to determine the highest non-irritant dose. It is reported that the 1% solution used is sub-irritant.
2. The induction/challenge schedule is more thorough than that required by OECD 406. The challenging schedule is also different, but appropriate to test sensitizing properties of the test substance.
3. From the results of the intradermal challenge the test substance would be categorised as sensitizing. According to the OECD 406 method (Magnusson and Kligman) only 10% of the animals tested is positive in the epidermal challenge and therefore the substance would not be sensitizing.

06.06.2005 (38)

Type	:	other: in vitro-test
Species	:	
Number of animals	:	
Vehicle	:	
Result	:	
Classification	:	
Method	:	other: Wass et al.
Year	:	1990

GLP	:	no data
Test substance	:	other TS: analytical grade (no further data)
Remark	:	Literature could not be retrieved. Remark : In vitro test method for predicting sensitizing properties of inhaled chemicals Results: No detectable reaction with the peptide L-lysyl-L-tyrosyl-L-lysine, 2 formiate (LTL) could be noted. Therefore it was suggested that sodium persulfate has no potential to induce respiratory tract dysfunctions. Method : 4 umol/ml test substance (50ul) was added to 0,1 umol/ml LTL solution (500 ul).
Source	:	Degussa AG Frankfurt am Main EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (39)

5.4 REPEATED DOSE TOXICITY

Type	:	Sub-chronic
Species	:	rat
Sex	:	male/female
Strain	:	other: CRR
Route of admin.	:	oral feed
Exposure period	:	13 weeks
Frequency of treatm.	:	
Post exposure period	:	
Doses	:	300, 3000 and 1000/5000 ppm
Control group	:	yes, concurrent no treatment
LOAEL	:	= 3000 ppm
Method	:	other: not indicated
Year	:	
GLP	:	no
Test substance	:	

Method :

TEST ORGANISMS
- Age: not indicated (weanlings)
- Weight at study initiation: 79-83 g (males), 75-82 g (females)
- Number of animals: 20/sex/treatment

ADMINISTRATION / EXPOSURE
- Exposure period: 13 weeks (for the high dose group 7 weeks at 1000 ppm and the remaining 6 weeks at 5000 ppm)
- Route of administration: diet
- Doses: 0, 300, 3000 and 1000/5000 ppm (0, 22, 200, 91/300 mg/kg bw (males), 0, 24, 250, 110/330 mg/kg bw (females))
- Vehicle: none

CLINICAL OBSERVATIONS AND FREQUENCY:
- Mortality: daily
- Clinical signs: weekly
- Body weight: weekly
- Food consumption: weekly from week 1 to 4, during week 8 and 13, for animals treated at 1000/5000 ppm also weekly from week 9-12 (sampling period of 2 days)
- Ophthalmoscopic examination: prior to study start and during week 13
- Haematology: during week 13 (from 5 animals/sex/treatment): erythrocyte count, (differential) leukocyte count, haemoglobin, haematocrit
- Biochemistry: during week 13(from 5 animals/sex/treatment):

sodium, potassium, calcium, chloride, glucose, blood urea nitrogen, creatinine, bilirubin, lactic dehydrogenase (LDH), alkaline phosphatase (ALP), SGPT (ALAT), SGOT (ASAT), total protein (albumin/globulin)
- Urinalysis: during week 5, 9 and 13(from 5 animals/sex/ treatment): specific gravity, glucose, protein, ketone bodies, blood, pH

ORGANS EXAMINED AT NECROPSY (MACROSCOPIC AND MICROSCOPIC):
- Organ weights: brain, liver, kidney, adrenals, spleen, lungs, heart, gonads
- Macroscopic: all tissues
- Microscopic: brain, pituitary, salivary gland, thyroid, parathyroid, heart, lung, liver, spleen, stomach, small intestine, large intestine, pancreas, kidney, urinary bladder, adrenals, gonads, lymph nodes, bone, bone marrow, muscle, lesions or masses

ANALYSES:
- Method: diets were analyzed for concentration of test article using Differential Scanning Calorimetry
- Sampling times: two samples after preparation of the diet

STATISTICAL METHODS: not indicated

Result : ANALYSES:
- Actual dose level (by sex): not reported
- Stability: stable for 1 week in diet
- Homogeneity: not reported

TOXIC RESPONSE/EFFECTS BY DOSE LEVEL:
- Mortality/clinical signs: none
- Body weight: at 1000/5000 ppm decreased in both sexes and at 3000 ppm in females during (part of) the last 6 weeks of treatment
- Food consumption: incidental differences from control values in all treatment groups
- Ophthalmoscopic examination: no treatment related effects
- Clinical chemistry: at 300 and 3000 ppm decreased ALAT in both sexes
- Haematology: at 3000 ppm increased number of white blood cells and a decreased number of neutrophils in both sexes
- Urinalysis: no treatment related effects
- Organ weights: no treatment related effects
- Gross pathology: reddish lungs in all treatment groups; incidental liver and kidney discoloration (sometimes with petechiae or mottled appearance)
- Histopathology: epithelial necrosis (females) and atrophy (both sexes) in the GI tract at 3000 ppm; laryngitis and peribronchial lymphoid infiltration were seen among animals;
congestion of the spleen at 3000 ppm (mainly in females)

STATISTICAL RESULTS: Effects on body weight and food consumption reached levels of statistical significance

Test substance : CAS 7775-27-1 (sodium persulfate), purity not indicated

Conclusion : Based on the findings on body weight and effects on the GI tract epithelium, it is concluded that the LOAEL is 3000 ppm. The effects on the GI-tract epithelium are seen after 13 weeks of treatment at 3000 ppm, but not after 7 weeks at 1000 ppm followed by 5000 ppm. Most probably 6 weeks treatment at the high dose level of 5000 ppm is not sufficient to evoke the effect. Therefore it is concluded that 3000 ppm is an effect level. Only 90 d study available.

Reliability : (2) valid with restrictions
1 Non-GLP
2 The analyses of the test diet are not included.
3 Considering initial body weights, the animals were very young at study

initiation (weanlings)
Flag : Critical study for SIDS endpoint
21.12.2004 (40) (41)

Type	:	
Species	:	rat
Sex	:	male
Strain	:	other: CR-CD
Route of admin.	:	oral feed
Exposure period	:	28 days
Frequency of treatm.	:	continuous
Post exposure period	:	
Doses	:	0, 13.9, 40.1, 137.2 mg/kg bw/day
Control group	:	yes
NOAEL	:	= 137.2 mg/kg bw
Method	:	other: not indicated
Year	:	
GLP	:	no
Test substance	:	

Method :
TEST ORGANISMS
- Age: weanlings
- Weight at study initiation: 42-45 g
- Number of animals: 10/treatment

ADMINISTRATION / EXPOSURE
- Exposure period: 28 days
- Route of administration: diet
- Post exposure period: not reported
- Doses: 0, 13.9, 40.1, 137.2 mg/kg/day

CLINICAL OBSERVATIONS: mortality, body weight (init. and terminal) and clinical signs

ORGANS EXAMINED AT NECROPSY:
- Macroscopic investigation (not specified)
- Organ weights: liver, kidneys, adrenals and testes

Result : TOXIC RESPONSE/EFFECTS BY DOSE LEVEL:
- Mortality: none
- Clinical signs: none
- Body weight gain: no treatment-related effects
- Organ weights: slight decrease in liver at 13.9 mg/ kg bw
- Gross pathology: no significant effects

Test substance : CAS 7775-27-1 (sodium persulfate), purity not indicated
Conclusion : Only 28-d study available
Reliability : (2) valid with restrictions
1. The information in the report is confined to the above.
2. Only males were tested. Animals were younger than required according to OECD407 (young adult).
Flag : Critical study for SIDS endpoint
07.01.2002 (23)

5.5 GENETIC TOXICITY 'IN VITRO'

Type	:	Ames test
System of testing	:	TA98, TA100, TA1535, TA1537 and TA1538
Test concentration	:	100, 333, 1000, 3333 and 10000 µg/plate
Cytotoxic concentr.	:	> 10000 µg/plate
Metabolic activation	:	with and without
Result	:	negative

Method : other: EPA 84-1
Year :
GLP : yes
Test substance :

Method : SYSTEM OF TESTING
- Species/cell type: TA98, TA100, TA1535, TA1537 and TA1538
- Deficiency: histidine
- Metabolic activation system: S9 from rat liver (Aroclor 1254 induced)

ADMINISTRATION:
- Dosing: 100, 333, 1000, 3333 and 10000 µg/plate
- Number of replicates: 3
- Application: plate incorporation
- Positive and negative control groups and treatment: water (negative); 2-aminoanthracene (all strains +S9); 2-nitrofluorene (TA98 and TA1538 -S9); sodium azide (TA100 and TA1535 -S9); 9-aminoacridine (TA1537 -S9)
- Incubation time: 48-72 h

CRITERIA FOR EVALUATING RESULTS:
Independent repeat of study.
Positive if at least a doubling of mean number of revertants per plate of at least one strain, accompanied by a dose-related response.

Result : GENOTOXIC EFFECTS:
- With metabolic activation: negative
- Without metabolic activation: negative

PRECIPITATION CONCENTRATION: > 10000 µg/plate

CYTOTOXIC CONCENTRATION:
- With metabolic activation: > 10000 µg/plate
- Without metabolic activation: > 10000 µg/plate

Test substance : CAS 7775-27-1 (sodium persulfate), purity not indicated
Conclusion : Only Ames test available.
Reliability : (1) valid without restriction
Flag : Critical study for SIDS endpoint
21.12.2004 (42)

Type : Unscheduled DNA synthesis
System of testing : Rat hepatocytes
Test concentration : 1.5-500 ug/mL
Cytotoxic concentr. : 400 ug/mL
Metabolic activation :
Result : negative
Method : EPA OPP 84-2
Year :
GLP : yes
Test substance :

Method : SYSTEM OF TESTING
- Species/cell type: rat hepatocytes
- No. of nuclei analyzed: 50/treatment with a colony counter

ADMINISTRATION:
- Dosing: 1.5, 5.0, 15, 50, 150, 250, 400 and 500 ug/mL
- Number of replicates: 3/treatment
- Application: incubation in presence of 3H-thymidine for 18-20 hours
- control groups:
positive 7,12-dimethylbenz(a)anthracene
negative William's Medium E

CRITERIA FOR EVALUATING RESULTS: increase of net nuclear grain count by at least 5 counts over control and/or a dose response effect with at least one dose with a 5 counts increase over control.

Result : EFFECTS:
No increase in number of nuclear grains up to 250 ug/mL
Controls were within expected ranges

CYTOTOXIC CONCENTRATION: at 250, 400 and 500 ug/mL relative toxicity compared to vehicle controls was 16%, 62% and 59%, respectively (measured as amount of LDH released after cell lysis)

Test substance : CAS 7775-27-1 (sodium persulfate), purity not indicated
Conclusion : Only unscheduled DNA synthesis available
Reliability : (1) valid without restriction
Only 3 cultures/treatment were counted (OECD 482 6).
Flag : Critical study for SIDS endpoint
21.12.2004 (43)

5.6 GENETIC TOXICITY 'IN VIVO'

Type : Micronucleus assay
Species : mouse
Sex : male/female
Strain : ICR
Route of admin. : i.p.
Exposure period : single
Doses : 85, 169 and 338 mg/kg bw
Result : negative
Method : other: no data
Year :
GLP : yes
Test substance :

Method : TEST ORGANISMS:
- Age: 6-8 weeks
- Weight at study initiation: 27-35 g (males), 21-27 g (females)
- No. of animals per dose: 5/sex/sampling time
- Source: Harlan Sprague Dawley, Inc. Frederick, MD

ADMINISTRATION:
- Vehicle: distilled water
- Duration of test: 72 hours
- Frequency of treatment: single dose i.p
- Sampling times: 24, 48 and 72 hours
- no. of slides: 2-4/animal
- Control groups:
vehicle control (5/sex/sampling time)
triethylenemelamine (0.25 mg/kg 5/sex/at 24 hours)

EXAMINATIONS:
- Clinical observations: frequency not indicated
- Analysis:
no. of miconucleated polychromatic erythrocytes (MPCE)/1000 polychromatic erythrocytes (PCE)
no. of normochromatic erythrocytes (NCE)/1000 polychromatic erythrocytes (PCE)
no. of PCE/total erythrocytes
- Criteria for evaluating results: significant treatment related increase relative to vehicle control either dose dependent or at a single dose at adjacent sacrifice times

- Criteria for selection of M.T.D.: doses were based on an acute toxicity test with an LD50 of 422 mg/kg bw

STATISTICAL METHOD: Kastenbaum-Bowman

Result : TOXIC RESPONSE/EFFECTS BY DOSE LEVEL:
- Mortality and time to death: 2 males and 4 females at 338 mg/kg bw died prior to their scheduled sacrifice and were replaced as far as possible (evaluated males/females at 24, 48 and 72 h: 5/5, 5/5, 4/3 respectively)
- Clinical signs: at 338 mg/kg bw lethargy, piloerection, prostration, tremor and irregular breathing

EFFECTS: PCE/total erythrocytes 0.37-0.65 for treated animals versus 0.48-0.62 for controls

GENOTOXIC EFFECTS: mean MPCE/1000 PCE 0.2-2.7 for treated animals versus 0.4-1.6 for controls

Positive controls were within expected ranges

Test substance : CAS 7775-27-1 (sodium persulfate), purity >99%.
Conclusion : negative
Only micronucleus available
Reliability : (1) valid without restriction
The number of polychromatic erythrocytes evaluated was 1000, which is in accordance with the existing OECD guideline at the time the study was performed.
Flag : Critical study for SIDS endpoint
21.12.2004 (44)

Type : Unscheduled DNA synthesis
Species : rat
Sex : male
Strain : Fischer 344
Route of admin. : gavage
Exposure period : 2-4 hours and 12-18 hours
Doses : 0, 41, 164 and 820 mg/kg bw
Result : negative
Method : other: not indicated
Year :
GLP : yes
Test substance :

Method : TEST ORGANISMS:
- Age: 10-11 weeks
- Animal body weight: 205-245 g
- No. of animals: 5 males/treatment
- Source: Harlan Sprague Dawley, Inc. Frederick, MD

ADMINISTRATION:
- Vehicle: distilled water
- Duration of test:
test 1: 2-4 hours
test 2: 12-18 hours
- Frequency of treatment: single dose
- Procedure: incubation of cultured hepatocytes in presence of 3H-thymidine for 17-20 hours; count of nuclear grains in 3 slides/treatment (50 nuclei/slide)
- Control groups and treatment:
negative controls: vehicle treated
positive controls: methylmethanesulfonate (test 1); 2-acetylaminofluorene (test 2)

EXAMINATIONS:
- Clinical observations: frequency not indicated
- Criteria for evaluating results: increase of net nuclear grain count by at least 5 counts over control and/or a dose response effect with at least one dose with a 5 counts increase over control
- Criteria for selection of M.T.D.: doses were based on an acute toxicity test with an LD50 of 820 mg/kg bw

Result : TOXIC RESPONSE/EFFECTS BY DOSE LEVEL:
- Mortality: none
- Clinical signs: diarrhoea and lethargy in 1 animal at 820 mg/kg bw

EFFECTS:
No significant increase in the number of nuclear grains up to 820 mg/kg bw in both tests.
Controls were within expected ranges.

Test substance : CAS 7775-27-1 (sodium persulfate), purity not indicated
Conclusion : Only in vivo unscheduled DNA synthesis available
Reliability : (1) valid without restriction
Flag : Critical study for SIDS endpoint
21.12.2004 (45)

5.7 CARCINOGENICITY

5.8.1 TOXICITY TO FERTILITY

5.8.2 DEVELOPMENTAL TOXICITY/TERATOGENICITY

5.8.3 TOXICITY TO REPRODUCTION, OTHER STUDIES

5.9 SPECIFIC INVESTIGATIONS

5.10 EXPOSURE EXPERIENCE

Type of experience : Human

Result : Two female hairdressers complaining of occupational asthma were tested with 11 individual ingredients in the commercial hair product. Skin prick test was positive for potassium persulfate. A simulated occupational test for inhalation was done using the bleach powder or potassium persulfate and clay. One patient gave positive skin reactions to sodium and potassium persulfate but not to other ingredients. She reacted so severely to inhalation of the product mixture, that no additional test was conducted. The other subject did not respond to the inhalation challenge.

Conclusion : Different subjects respond differently to the same chemicals.
15.12.2004 (46)

Type of experience : Human

Remark : case reports: Two workers developed dermatitis, rhinitis, bronchitis and asthma (no acute dyspnoea) after occupational exposure to dusts of Na, K and NH4-persulfates (relatively high exposure). The authors suggested that

chemically irritative or toxic effects of the persulfates play the predominant role in the pathogenesis of these case reports.
Literature could not be retrieved.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
09.12.2004 (47)

Type of experience : Human

Remark : case reports: after use of persulfates in bleaching of flour, skin eczema and asthmatic symptomes (baker's asthma) were fre- quently seen in bakers (since 1957 forbidden in Germany). The sensitive reaction to persulfates persisted more than 10 years, but verification is not reliable.
Literature could not be retrieved.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
09.12.2004 (48) (49) (50) (51)

Type of experience : Human

Remark : case reports: contact with bleach powder containing persulfates (exposure 2 - 5 years) let to urticaria, oedema, rhinitis, conjunctivitis following asthmatic symptoms.
Symptoms occurred between 2 and 5 years working as a hairdresser. Workplace related challenge tests with the bleach powders were positive (immediate and delayed reactions). Skin tests with hair bleaches or persulfates were not in all cases positive. Specific IgE antibody were not found in the RAST-test. The histamine reaction was pronounced. The pathophysiological mechanism is unclear.
Literature could not be retrieved.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
15.12.2004 (52) (53) (54) (55)

Type of experience : Human

Remark : case reports: several weeks after occupational exposure with persulfates (Na, K, NH4) rhinitis, cough, respiratory obstruction and dermatitis were observed in three workers.
The toxic irritative effect was predominant.
Literature could not be retrieved.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
15.12.2004 (56)

Type of experience : Human

Result : Ammonium, potassium, and sodium persulfate are used as oxidizing agents in hair bleaches and hair-coloring preparations. Persulfates are contained in hair lighteners, off-the-scalp products, bleaches and lighteners at concentrations of 60%, 25%, 22% and 16%, respectively. Much of the available safety test data are for ammonium persulfate, but these data are considered applicable to the other salts. The persulfates were reported to cause both delayed-type and immediate skin reactions, including irritant dermatitis, allergic eczematous dermatitis, localized contact urticaria, generalized urticaria, rhinitis, asthma, and syncope. The most common causes of allergic dermatitis in hairdressers are the active ingredients in hair dyes, and ammonium persulfate has been identified as a frequent

allergen. A sensitization study examined the incidence of urticarial reactions was performed with 17.5% ammonium, potassium, and sodium persulfate under occlusive patches. At this concentration and exposure conditions, a mixture of these persulfates was not sensitizing, and application of ammonium, potassium, and sodium persulfate did not result in an urticarial reaction. In normal use (i.e., not occluded and rinsed off), it is expected that a concentration greater than 17.5% would also be safe. Given the clinical reports of urticarial reactions, however, manufacturers and formulators should be aware of the potential for urticarial reactions at concentrations of persulfates greater than 17.5%. Based on the available data, the Cosmetic Ingredient Review (CIR) Expert Panel concluded that ammonium, potassium, and sodium persulfate are safe as used as oxidizing agents in hair colorants and lighteners designed for brief discontinuous use followed by thorough rinsing from the hair and skin.

Conclusion : This review article concludes that the persulfate salts have similar toxicity and data on ammonium persulfate can be used for the sodium and potassium salts. The review by the Cosmetic Ingredient Review Expert Panel also concludes that the three persulfates are safe in hair products at up to 17.5% based on a human skin sensitization study.

09.12.2004 (57)

Type of experience : Human

Result : Early report of dermal sensitization and occupational asthma reported in a single hairdresser. The patient experienced both utricaria and asthma. After ventilation equipment was installed in the salon, no asthma attachs occurred. The amount of persulfate in hair preparations is stated as being 30% of the total formulation.

Conclusion : Good industrial hygiene improves the prognosis of occupational asthma among hairdressers.

09.12.2004 (58)

Type of experience : Human

Result : A hairdresser developed rhinoconjunctivitis and bronchial asthma following a two-year apprenticeship. The patient reacted positively to a persultate prick test.

Conclusion : The case report indicates that persulfates can cause sensitization in the workplace to hairdressers.

09.12.2004 (59)

Type of experience : Human

Result : The main hazards for professional hairdressers are rhinitis, bronchitis, asthma and irritant and allergic contact dermatitis. The risk of respiratory effects is likely to be low among hairdressers using effective dust-free formulations, but considerably higher among those using powder formulations and ineffective dust-free formulations. Dermatitis due to persulfates is likely to affect up to 5% of hairdressers. Members of the general publich are not likely to have respiratory or skin conditions attributable to persulfates. The volume of persulftes imported for hair bleaching products in Australia is 6.5 tonnes/year of which 4.5 tonnes/year is formulated into consumer products. The content of persulfate in salon hair products ranged from 22% to 88% and the content of home-use hair products ranged from 45% to 82.5%.

Conclusion : Review of the literature for animal and human effects, particularly focused on hairdresser exposures. Immediate and delayed contact hypersensitivity, contact urticaria, rhinitis, bronchitis and asthma have been observed in hairdressers as a result of exposure to hair bleaching powders containing persulfates.

09.12.2004 (60)

Type of experience : Human

Result : Three workers at a persulfate production plant developed nasal mucosal inflammation, dry cough and dyspnea. Complaints were noted after many hours of exposure to persulfate dust in the workplace. Uncovered skin areas in two workers exhibited dermatitis. The three workers tested positive to 5% persulfate solution in patch tests. Bronchial obstruction occurred after prolonged exposure (8 hours).

Conclusion : Workers in a production plant developed symptoms that were related to exposure to persulfates. The paper does not include information on the amount of persulfate exposure (air level) or personal protective equipment used.

21.12.2004 (61)

Type of experience : Human

Result : Employees of the Buffalo plant of the FMC Corporation were included in an extensive industrial hygiene monitoring and clinical study. The clinical study evaluated pulmonary function for a full week in the summer of 1990 and for two weeks in the winter of 1991 using 14 subjects. Workers were directly exposed to persulfates in the packout area and caustic/crystallizer area and inside the laboratory. No workers had a history of asthma symptoms. Samples for breathing zone (608 hours) and area samples were made. Pre- and post-shift spirometry lung function to measure forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) on the first and last day of hte 7-day week were made. The mean level of exposure to persulfates was 0.5 mg/m3, mixed with a total dust level below a mean of 2.0 mg/m3. No clinically significant observations in the spirometry values were found.

Conclusion : Long-term exposure to 0.5 mg/m3 persulfate did not affect pulmonary function evaluated in 14 plant employees. The study related levels of persulfate in air to worker performance (lung function) and showed no deficits.

09.12.2004 (57)

Type of experience : Human

Result : A follow up study was conducted on workers examined in 1990-1991 to see if there were any changes in pulmonary function during 1990-1996. Follow-up data on the original study subjects and new employees involved checking medical records of the exposed employees. Medical records for 22, 17, 10 and 8 workers were available for the two, three, four and six year time periods of follow-up. Records for the five year follow-up were lost in a fire. The change over time in the pulmonary function tests was compared to actual and predicted ratios for years 2, 3, 4 and 6 after the 1990 assessment. Workers included in the study included material operators, crystallizer/caustic operators, lab technicians and workers from other areas. No statistically significant findings of pulmonary function test performance were found for any of the four work position categories. A total of 100 different t-test comparisons were conducted at a p value of 0.05. Two significant findings were found. but because they were less than the total of up to five findings allowed, the two findings were considered to be due to chance.

Conclusion : The study shows that continuous occupational exposure to persulfates over a period of six years did not result in any long term effects on pulmonary function.

09.12.2004 (62)

Type of experience : Human

Result : Fifteen employees in a persulfate production company were exposed to ammonium and potassium persulfate during production during the years 1976-1980. Up to 70% of new employees developed skin rashes. Many employees developed rashes within one month of employment. Not all employees followed the practice of wearing and washing gloves. Improved industrial hygiene practices were recommended. Since instituting improved practices (gloves, long sleeves, washing gloves), the number of reported incidences was significantly reduced.

Conclusion : Persulfates can induce rashes in an occupational workplace unless personal protective equipment is used properly.

09.12.2004 (63)

Type of experience : Human

Result : A study was conducted to example the prevalence of positive skin prick test reactions to ammonium and potassium persulfates (1% and 5% solutions) among 52 employees of a persulfate production plant. A group of 13 unexposed persons served as controls. Eight of the 52 employees showed a positive response to at least one persulfate solution: 2 were positive to potassium salt, three were positive to ammonium salt and three were positive to both salts. Lung function tests for the exposed population were generally normal but there was a trend showing a correlation between positive skin prick responders and slightly lower lung function for forced expiratory volume FEV1 ($p = 0.057$). Due to the small number of subjects the correlation need clarification.

Conclusion : There was a high response to ammonium and or potassium persulfate skin prick tests (8/52) associated with somewhat lower lung function in workers exposed to persulfates in a production facility. All 13 control subjects did not respond to the same skin prick test.

09.12.2004 (64)

Type of experience : Human

Remark : A well-documented review from the UK authority (HSE) was available.
Introduction
Persulphate salts (ammonium, potassium and sodium) are strong oxidising agents with wide industrial use. They are also used to enhance the action of peroxide hair bleaches, for which they are supplied as a powder to mix with liquid peroxide shortly before use. Persulphate hair bleaches have produced both irritant and allergic contact dermatitis, as well as urticarial and respiratory reactions (Fisher and Dooms-Goossens, 1976; Kellett and Beck, 1985; Kleinhans and Ranneberg, 1989). The contact urticaria is not immunologically-mediated, but thought to be due to the fact that persulphate is a weak histamine-releasing agent (Calnan and Schuster, 1963; Parsons et al., 1979). It is not known why only some individuals are sensitive to this action.

Evidence for work-related asthma
There have been a number of well-conducted studies of hairdressers with work-related asthmatic symptoms that have included specific bronchial challenge tests, performed blinded, using hair bleach or persulphate, either as powder or aerosolised solution. In some studies, controls who were either non-asthmatic, or asthmatic with hyperresponsive airways, were also challenged; none gave positive reactions.

Of 12 'tinters' from a hairdressing salon who used persulphate-containing bleach, 4 had work-related asthmatic and nasal symptoms, which had developed after a latent period of at least six months (Blainey et al., 1986). An affected individual from another salon was also included for investigation. All 5 were hyperresponsive to histamine, though other lung function parameters were normal. Only those with symptoms reacted at

specific challenge, giving late asthmatic responses, and controls (including asthmatics) failed to react. All 4 of the subjects who also underwent nasal challenge gave positive reactions.

Agustin reported the cases of two hairdressers who developed work-related rhinitis, conjunctivitis and, in one, asthma several years after first using bleaching powders (Agustin et al., 1992). Both had normal respiratory function, but the asthmatic subject was hyperresponsive to methacholine. At specific bronchial challenge, the person with asthma developed a late response, while the other suffered immediate severe nasal symptoms.

A young woman developed work-related respiratory symptoms about a year after starting work in a hairdressing salon (Parra et al., 1992). When she was investigated, after a month's absence from work, she was hyperresponsive to methacholine. On specific bronchial challenge, she developed a late, prolonged reaction followed by recurrent nocturnal falls in forced expiratory volume in one second, for 96 hours after the test.

Another case of work-related asthma, with associated sneezing and rhinoconjunctivitis, has been described, in which a young woman worked for 3 years before developing symptoms (Pankow et al., 1989). As in other cases, lung function was normal but the airways showed non-specific hyperresponsiveness. On unblinded bronchial challenge, she suffered an immediate asthmatic attack. Normal and asthmatic controls did not react.

A beautician with a history of mild seasonal rhinitis developed work-related asthma (Schwartz, 1989). Lung function was normal, and she was not hyperresponsive to methacholine. She underwent blinded bronchial challenges with a number of hair care preparations, and reacted only to a persulphate-containing bleach with an immediate reaction (it was unclear for how long measurements were continued). The patient declined challenge with persulphate itself.

All of these well-conducted studies provide evidence that persulphate salts are capable of inducing asthma and can cause specific reactions at bronchial challenge under conditions which do not induce a response in normal or previously non-exposed asthmatic people.

These studies are backed up by several case reports of occupational asthma associated with persulphate use, in which the bronchial challenge tests performed were not blinded and omitted controls. These include two cases, both positive at challenge (Pepys et al., 1976); 5 cases, 4 challenged - 2 positive, 1 negative, 1 equivocal (Therond et al., 1989); one case, positive (Gamboa et al., 1989); one case, positive (Schwaiblmair et al., 1990); three cases, one challenged - positive (Wallenstein et al., 1993).

There are also reports of persulphate effects in occupations other than hairdressing. One concerns an Italian factory that used ammonium and potassium persulphate during the manufacture of hydrogen peroxide, in which 12% of the workers suffered from asthma that usually developed within 6 months of starting work (Barsotti et al., 1951). Bronchial challenges were performed with an aerosol of a 1% ammonium persulphate solution; affected workers, but not controls, responded positively to challenge. In another study, 2 chemical factory workers who bagged persulphates developed work-related nasal and asthmatic symptoms within a few weeks of beginning work (Baur et al., 1979). Neither underwent bronchial challenge, and symptoms resolved on avoiding exposure.

Supporting data
Skin prick tests, and occasionally intradermal or scratch tests, have been performed on many of the people reported as having persulphate-related asthma or rhinitis. Either persulphate or bleach powder solutions have been used; negative controls have sometimes been included. The tests have been positive in most of those studied (Gaultier et al., 1966; Blandin, 1970; Fisher and Dooms-Goossens, 1976; Pepys et al., 1976; Baur et al., 1979; Blainey et al., 1986; Pankow et al., 1989; Agustin et al., 1992; Escudero Pastor et al., 1992; Parra et al., 1992; Wallenstein et al., 1993). There have also been some negative results reported (Baur et al., 1979; Blainey et al., 1986; Gamboa et al., 1989; Agustin et al., 1992; Wallenstein et al., 1993). In one study, the results of intradermal tests in 3 people correlated with bronchial challenge data (Wallenstein et al., 1993). Amongst employees manufacturing persulphates, work-related breathing difficulties were found more often (6/8) in those who were positive than in those who were negative (9/44) in skin prick tests (Wrbitzky et al., 1995). In an early study, a scratch test that was strongly positive triggered within minutes a "violent" attack of asthma (Blandin, 1970). While most people with persulphate asthma have given positive skin prick tests, this may be because of direct histamine release rather than an immunologically-mediated reaction.

In hairdressers with asthma, total immunoglobulin E (IgE) levels have generally been normal, though increased in two people, and decreased after avoidance of exposure in another (Gamboa et al., 1989; Pankow et al., 1989; Schwaiblmair et al., 1990; Agustin et al., 1992; Parra et al., 1992). No specific IgE to persulphates has been found in three separate cases tested (Gamboa et al., 1989; Schwaiblmair et al., 1990; Parra et al., 1992). However, the serum from an asthmatic patient was positive for both hair bleach and sodium persulphate in a Prausnitz-Kustner test for passive transfer of specific IgE (Escudero Pastor et al., 1992). Overall, these immunological data are scarce and inconclusive.

In peripheral blood studies, one person had eosinophilia, and another developed neutrophilia and eosinophilia following positive bronchial challenge (Schwaiblmair et al., 1990; Parra et al., 1992).

Source : HSE, UK authority.
30.05.2005 (65) (66) (47) (67) (68) (69) (70) (71) (72) (73) (74) (75) (76) (59) (77) (78) (46) (55) (79) (80) (81) (64)

5.11 ADDITIONAL REMARKS

Type : other: medical treatment with sodium persulphate

Remark : Literature could not be retrieved.
Therapy of postischaemic disorders of haemostatis in the tourniquet shock:
It was established in experiments on rats that the increase of survival in the animals after administration of sodium persulfate (in combination with cytochrome C, contrykal) before and after removing of tourniquets that were in place for 6 hours was noted. Injection of these drugs 30 min after removing the tourniquets in rabbits and dogs changed the severity of the haemodynamic and ECG parameters towards the third hour after decompression.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
01.02.1994 (82)

Type : other: pharmacokinetic

Remark : Literature could not be retrieved.
The reaction of 1,3-dimethyluracil with sodium persulfate in water (80 degree C) under nitrogen atmosphere gave 5-hydroxy-1,3- dimethyluracil (main product). Under similar conditions the oxidation of 5-fluoro-1,3-dimethyluracil gave a 6,6-dimeric compound together with other products.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
01.02.1994 (83)

Type : other: pharmacokinetic

Remark : Literature could not be retrieved.
Treatment of thymine with sodium persulfate in water (85 degree C, 7 h) resulted in the selective oxidation of the 5-methyl group of thymine.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
01.02.1994 (84) (85)

Type : other: pharmacokinetic

Remark : Literature could not be retrieved.
treatment of 1,3-dimethylthymine with sodium persulfate in water (reflux temp., 7 h) under nitrogen atmosphere gave 1,3-dimethyl- 5-hydroxymethyluracil and 1,3-dimethyl-5-formyluracil.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
01.02.1994 (85)

Type : other: pharmacokinetic

Remark : Literature could not be retrieved.
treatment of 5-methylpyrimidine nucleosides and nucleotides with sodium peroxodisulfate in sodium phosphate buffer solution (pH 7, 75 degree C) resulted in the selective oxidation of the methyl group.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
01.02.1994 (86)

Type : other: synergistic effects

Remark : Literature could not be retrieved.
Potentiator of the retinotoxic action of sodium fluoride: Sodium persulphate was tested as an adjuvant in rabbits (Dutch) treated with sodium fluoride. Sodium persulfate (75, 100 mg/kg) was injected intravenously first, followed immediately by the fluoride (50 mg/kg). Sodiumpersulphate gave a high incidence of typical fluoride lesions on the retina, death occurred (2/5). Sodium persulfate was suggested to be a potentia- tor of the retinotoxic action of sodium fluoride (test substance: no data; GLP: no data).

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (87)

(1) SPIN database 08-12-04.

(2) Degussa AG, Safety Data Sheet: Sodium persulphate, 13-12-2000.

(3) FMC Corporation, Material Safety Data Sheet: Sodium persulfate (02-02-01: date approved), 2001.

(4) Degussa AG, safety data sheet, 7.1.94.

(5) Merck Index, CD-ROM 1999.

(6) FMC, Toxicology Department, Princeton; letter of March 8, 1994 (1994).

(7) Peroxid-Chemie, unpublished report, 24.9.91 (1991).

(8) Breuer, M. M.; Jenkins, A. D.; Int. Wool Text Res. Conf., (Proc), 3rd., 447 - 456, 457 - 458 (1965).

(9) Koltoff I. and Miller I K (1951). The chemistry of persulfate. I. The kinetics and mechanism of the decomposition of the persulfate ion in aqueous medium. J. Am. Chem. Soc., 73, 3055-3059.

(10) House, D. A.; Chem. Rev. , vol. 62, 185 - 203 (1962).

(11) Kolthoff, I. M.; Miller, I. K.; J. Am. Chem. Soc., vol. 73, 3055 - 3059 (1951)

(12) FMC Corporation, Acute toxicity of sodium persulfate to rainbow trout (Onchorhynchus mykiss), Study no. I92-1251, 1993.

(13) FMC Corporation, Acute toxicity of sodium persulfate to bluegill (Lepomis macrochirus), Study no. I92-1250, 1993.

(14) FMC Corporation, Acute toxicity of sodium persulfate to the water flea (Daphnia Magna), Study no. I92-1252, 1993.

(15) FMC Corporation, Acute toxicity of sodium persulfate to grass shrimp (Palaemonetes pugio), Study no. I92-1253, 1993.

(16) FMC Corporation, Sodium persulfate: acute toxicity to the freshwater green alga, Selenastrum capricornutum, under static test conditions, Study no. I97-2228, 1998.

(17) Prabha, V. et al.; Can. J. Microbiol., vol. 35, 1076 - 1080 (1989).

(18) Takeda Chemical Industries Ltd., Japan (1966), 1302392, Fukuda et al. (1971).

(19) Tsai Y. L.; Tuovinen O. H.; Toxicity Assessment: An International Journal, vol. 4, 199 - 207 (1989).

(20) Tsai Y. L.; Tuovinen O. H.; FEMS Microbiology Letters, vol. 28, 11 - 14 (1985).

(21) Bacq, Z. M.; Bulletin de l'Academie Royale de Medecine de Belgique, VI series, vol. 7, Bruxelles Imprimerie Medicale et Scientifique, 108 - 134, 1942.

(22) Kunert, J.; Folia Microbiol., vol. 26, 196 - 200 (1981).

(23) FMC Corporation, Acute and 28-day subacute toxicity of sodium persulfate, Study no. ICG/T-79-029, 1979 (18).

(24) Degussa AG, unpublished, Report: Degussa AG - US-IT-Nr.: 79-0017-DKT (1979)

(25) FMC Corporation, Sodium persulfate: acute inhalation toxicity study in rats, Study no. I95-2017, 1995.

(26) FMC Corporation, Sodium persulfate: sensory irritation study in Swiss Webster mice, Study no. I93-1803, 1994.

(27) FMC Corporation, unpublished, FMC study no.: ICG/T-78-089 (1987).

(28) NIOSH; Toxic Substances List; HEW Pub., No. 73 - 134 (1974) in: Documentation of Threshold Limit Values and Biological Exposure Indices, ACGIH, vol. 5, 468 (1986).

(29) Nofre, C. et al.; Hebd. C. R. Sceances Acad. Sci., vol. 257, 791 - 794 (1963).

(30) Handbook of Toxicology, Spector, W. S., ed., vol. 1, 278 - 279, Saunders, Philadelphia (1956) in: The Merck Index. 11th. ed., 1366, Merck u. Co., Inc., USA, 1989.

(31) FMC Corporation, Acute and 28-day subacute toxicity of sodium persulfate, Study no. ICG/T-79-029, 1979.

(32) FMC Corporation, FMC study no.: I79-326 (1979).

(33) FMC Corporation, Sodium Persulfate: Skin Corrosion Study in Rabbits, FMC study no.: I80-403 (1980).

(34) Degussa AG, unpublished, Report: Degussa AG - US-IT-Nr.: 79-0016-DKT (1979)

(35) Degussa AG, unpublished, Report: Degussa AG - US-IT-Nr.: 79-0015-DKT (1979)

(36) FMC Corporation, Repeated insult patch study, Study no. I95-2037, 1996.

(37) FMC Corporation, FMC shock treatment: skin sensitization study in guinea pigs, Study no. I90-1113, 1990.

(38) Degussa AG, Natriumpersulfat; Prüfung auf sensibilisierende Eigenschaften an der Haut des Meerschweinchens (Optimierungs-Test), Study no. 85-0048-DKT, 1985.

(39) Wass, U. et al.; Scand. J. Work Environ. Health, vol. 16, 208 - 214 (1990).

(40) Cascieri, T.; Fletcher, M. J.; Weinberg, M. S.; The Toxicologist vol. 1, 149 (1981).

(41) FMC Corporation, Safety evaluation of sodium persulfate: a 90-day dietary feeding study in rats, Study no. I90-1151, 1979.

(42) FMC Corporation, Sodium persulfate: Salmonella/mammalian-microsome plate incorporation mutagenicity assay (Ames test), Study no. I90-1119, 1990.

(43) FMC Corporation, Unscheduled DNA synthesis in rat primary hepatocytes, Study no. I90-1121, 1990.

(44) FMC Corporation, Micronucleus cytogenetic assay in mice (sodium persulfate), Study no. I90-1120, 1990.

(45) FMC Corporation, In vivo - in vitro rat hepatocyte unscheduled DNA synthesis assay (sodium persulfate), Study no. I90-1173, 1991.

(46) Pepys, J., Hutchcroft, B.J. and Breslin, A.B.X., Asthma due to inhaled chemical agents-persulphate salts and henna in hairdressers. Clinical Allergy 6, 399-404, 1976.

(47) Baur X, Fruhmann G and von Liebe V (1979) Occupational asthma and dermatitis in two industrial workers after exposure to dusts of persulphate salts Respiration. 38; 144-150.

(48) Forck, G.; Berufsdermatosen, vol. 16, 84 - 92 (1968).

(49) Grosfeld, J. C. M.; Onderzoekingen over het ontstaan van eczeem bij bakkers. Thesis, Amsterdam (1951) in: Young, E.; Dermatologica, vol. 148, 39 - 60 (1974).

(50) Schulz, K. H.; Z. Haut- Geschl.- Krkh., vol. 42, 499 - 509 (1967).

(51) Young, E.; Dermatologica, vol. 148, 39 - 60 (1974).

(52) Hardel, P. J. et al.; La Nouvelle Presse Medicale, vol. 7, 4151 (1978).

(53) Pankow, W. et al., Persulfate-Asthma in the Hairdressing Trade, Pneumologie, vol. 43, 173 - 175 (1989).

(54) Pepys, J. et al.; Clinical Allergy, vol. 6, 399 - 404 (1976).

(55) Schwaiblmair, M.; Dtsch. med. Wschr., vol. 115, 695 - 697 (1990).

(56) Baur, X. et al., Bronchial Asthma of Allergic and Irritative Origin as an Occupational Disease Respiration, vol. 38, 144 - 150 (1979).

(57) Final Report on the Safety Assessment of Ammonium, Potassium, and Sodium Persulfate. International Journal of Toxicology 20 (Suppl. 3): 7-21, 2001. (Cosmetic Ingredient Review, Washington, DC, 20036, USA).

(58) K. Meindl and R. Meyer; Asthma and urtricaria in the hairdresser's trade due to bleaching agents containing persulfates. Zbl. Arbeitsmed. 19(3): 75-79, 1969.

(59) Pankow W, Hein H, Bittner K and Wichert P (1989) Persulphate-induced asthma in hairdressers Pneumologie. 43; 173-175.

(60) Priority Existing Chemical Assessment Report No. 18, Ammonium, Potassium and Sodium Persulfate. June 2001
National Industrial Chemicals Notification and Assessment Scheme, Commonwealth of Australia.

(61) Baur, X. et al.; Respiration, vol. 38, 144 - 150 (1979).

(62) Preliminary Report: Lung Function Assessment of Persulfate Workers: 1990-1996. FMC, Buffalo, NY. Unpublished report for FMC Corporation. By William W. Greaves, May 23, 1997.

(63) I.R. White, H.E. Catchpole, R.J.G. Rycroft; Rashes amongst persulphate workers. Contact Dermatitis: 8: 168-172, 1982.

(64) Wrbitzky R, Drexler H and Letzel S (1995) Early reaction type allergies and diseases of the respiratory passages in employees from persulphate production Int Arch Occup Environ Health. 67; 413-417.

(65) Agustin P, Martinez-Cocera C, Cimarra M et al (1992) Persulphate-induced occupational respiratory allergy Rev Esp Alergol Inmunol Clin. 7; 91-97.

(66) Barsotti M, Parmeggiani L and Sassi C (1951) Symptoms of bronchial asthma and eczema in workers assigned to hydrogen peroxide production units Med Lav. 42; 49-68.

(67) Blainey AD, Ollier S, Cundell D et al (1986) Occupational asthma in a hairdressing salon Thorax. 41; 42-50.

(68) Blandin G (1970) Desensitization among hairdressers (lacquer and bleach) Rev Franc Allergol. 10; 327-331.

(69) Calnan CD and Shuster S (1963) Reactions to ammonium persulphate Arch Dermatol. 88; 812-815.

(70) Escudero Pastor AI, Hernandez Garcia J, Lopez Sanchez JD et al (1992) Occupational asthma caused by persulphate inhalation Rev Esp Alergol Inmunol Clin. 7; 87-90.

(71) Fisher AA and Dooms-Goossens A (1976) Persulphate hair bleach reactions: cutaneous and respiratory manifestations Arch Dermatol. 112; 1407-1409.

(72) Gamboa PM, de la Cuesta CG, Garcia BE et al (1989) Late asthmatic reaction in a hairdresser, due to the inhalation of ammonium persulphate salts Allergol Immunopathol (Madr). 17; 109-111.

(73) Gaultier M, Gervaise P and Mellerio F (1966) Two causes of occupational asthma among hairdressers: persulphate and silk Arch Mal Prof. 27; 809-813.

(74) Kellett JK and Beck MH (1985) Ammonium persulphate sensitivity in hairdressers Cont Derm. 13; 26-28.

(75) Kleinhans D and Ranneberg KM (1989) Immediate-type reactions caused by ammonium persulphate hair bleaches Allergologie. 12; 353-354.

(76) Mahzoon S, Yamamato S and Greaves MW (1977) Response of skin to ammonium persulphate Acta Dermatovener. 57; 125-126.

(77) Parra FM, Igea JM, Quirce S et al (1992) Occupational asthma in a hairdresser caused by persulphate salts Allergy (Eur J Allergy Clin Immunol). 47; 656-660.

(78) Parsons JF, Goodwin BFJ and Safford RJ (1979) Studies on the action of histamine release by persulphates Food Cosmet Toxicol. 17; 129-135.

(79) Schwartz HJ (1989) Effect of chronic chromolyn sodium therapy in a beautician with occupational asthma J Occup Med. 31; 112-114.

(80) Therond M, Geraut C, Dupas D and Gayoux C (1989) Pathology of alkaline persulphates: concerning 19 recent cases Arch Mal Prof Med Trav Secur Soc. 50; 837-838.

(81) Wallenstein G, Wagner E and Schoneich R (1993) Airway symptoms in hairdressers with occupational contact eczema Arbeitsmed Sozialmed Praventivmed. 28; 441-444.

(82) Levandovsky, I. V.; Epishin, Y., N.; Anesteziol Reanimatol, no. 3, 60 - 63 (1981).

(83) Itahara, T. et al.; Symposium series, no. 21, 5 - 6 (1989).

(84) Itahara, T. et al.; J. Org. Chem., vol. 53, 3421 - 3424 (1988).

(85) Itahara, T. et al.; Symposium series, no. 16, 61 - 64 (1985).

(86) Itahara, T. et al.; Symposium series, no. 22, 9 - 10 (1990).

(87) Sorsby, A.; Harding, R.; Nature, vol. 210, 997 - 998 (1966).

S I D S

Dossier

Existing Chemical	:	ID: 7727-21-1
CAS No.	:	7727-21-1
EINECS Name	:	dipotassium peroxodisulphate
EC No.	:	231-781-8
Generic name	:	potassium persulfate
IUPAC Name	:	dipotassium peroxodisulphate

Producer related part

Company	:	Notox
Creation date	:	30.08.2001

Substance related part

Company	:	Notox
Creation date	:	30.08.2001
Status	:	
Memo	:	10 Category
Printing date	:	31.05.2005
Revision date	:	
Date of last update	:	31.05.2005
Number of pages	:	38
Chapter (profile)	:	Chapter: 1, 2, 3, 4, 5, 6, 7, 8, 10
Reliability (profile)	:	Reliability: without reliability, 1, 2, 3, 4
Flags (profile)	:	Flags: without flag, confidential, non confidential, WGK (DE), TA-Luft (DE), Material Safety Dataset, Risk Assessment, Directive 67/548/EEC, SIDS

1.0.1 APPLICANT AND COMPANY INFORMATION

Type : cooperating company
Name : Asahi Denka Kogyo K.K.
Contact person : Takanobu Ohshima
Date : 12.11.2004
Street : 8-6 Nihonbashi Kobunacho
Town : J-103 Chou-ku Tokyo
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Phone : 81 545 34 1032
Telefax : 81 545 34 0695
Telex :
Cedex :
Email : osima@adk.co.jp
Homepage :

Remark : Within CEFIC (European Chemical Industry Council) a Persulfate Working Group was formed to comply with the ICCA High Production Volume (HPV) initiative. Dominique de Halleux (CEFIC employee) is the secretary of this group. The members (cooperating companies) of the Persulfates Group are noted in this section.

19.11.2004

Type : cooperating company
Name : Degussa AG
Contact person : Werner Ponikwar
Date : 12.11.2004
Street : Dr-Gustav-Adolph-Strasse, 3
Town : D-82049 Pullach
Country : Germany
Phone : 49 89 744 22 421
Telefax : 49 89 744 22 6421
Telex :
Cedex :
Email : werner.ponikwar@degussa.com
Homepage :

19.11.2004

Type : cooperating company
Name : FMC Corporation
Contact person : Philip Block
Date : 12.11.2004
Street : 1735 Market Street
Town : PA 19103 Philadelphia
Country : United States
Phone : 215 299 6645
Telefax : 215 299 6272
Telex :
Cedex :
Email : philip_block@fmc.com
Homepage :

19.11.2004

Type : cooperating company
Name : Mitsubishi Gas Chemical Company, INC
Contact person : Toshikiyo Kurai

Date	:	12.11.2004
Street	:	Mitsubishi Building 5-2 Marunouchi 2 chome
Town	:	Chiyoda-ku
Country	:	Japan
Phone	:	81 33 283 4888
Telefax	:	81 33 287 2643
Telex	:	
Cedex	:	
Email	:	yamagishi@mgc.co.jp
Homepage	:	

19.11.2004

Type	:	cooperating company
Name	:	RheinPerChemie GmbH
Contact person	:	Dirk Ostwald
Date	:	12.11.2004
Street	:	Alex-Springer-Platz 2
Town	:	D-20354 Hamburg
Country	:	Germany
Phone	:	49 403 2509 512
Telefax	:	49 403 2509 510
Telex	:	
Cedex	:	
Email	:	ostwald@rheinperchemie.com
Homepage	:	

19.11.2004

1.0.2 LOCATION OF PRODUCTION SITE, IMPORTER OR FORMULATOR

Remark : In 2003 the estimated production amount of all three persulfates, in the countries represented by consortium members (North America, Europe, and Japan) is 65,400 tonnes per year. Europe accounts for about 42%, North America about 38% and Japan about 20%. There is also an estimated 10,000 tonnes of persulfates produced in China by a company affiliated with one of the European companies. There are no reported volumes for the individual Persulfate products.

15.12.2004

1.0.4 DETAILS ON CATEGORY/TEMPLATE

Comment : Persulfates

Remark : Each persulfate salt in this group consists of a dianion (persulfate) and two identical cations. Only the cation is different for each substance: Na, K or NH4. The persulfate salts are expected to display the same environmental, ecotoxicological and toxicological behaviour.

19.11.2004

1.1.0 SUBSTANCE IDENTIFICATION

IUPAC Name	:	dipotassium peroxodisulphate
Smiles Code	:	K O3-S-O-O-S-O3-K
Molecular formula	:	K2S2O8

Molecular weight : 270.3
Petrol class :

06.03.2002

1.1.1 GENERAL SUBSTANCE INFORMATION

Purity type :
Substance type : inorganic
Physical status : Solid
Purity : > 98 % w/w
Colour : White
Odour : odourless

Reliability : Only study available.

NOAEL = 131.5 mg/kg bw.
Potassium persulfate causes a release of histamine by degranulation of the mast cells without disruption of the membrane. The reaction is slow.

19.11.2004

1.1.2 SPECTRA

1.2 SYNONYMS AND TRADENAMES

Potassium peroxydisulfate

19.11.2004

1.3 IMPURITIES

Purity : Typical for marketed substance
CAS-No : 7778-80-5
EC-No : 231-915-5
EINECS-Name : potassium sulphate
Molecular formula : K2SO4
Value : <= .3 % v/v

08.12.2004

Purity : other
CAS-No : 7732-18-5
EC-No : 231-791-2
EINECS-Name : water
Molecular formula : H2O
Value : <= .3 % v/v

19.11.2004

1.4 ADDITIVES

Remark : Most products do not contain additives. Some producers may add proprietary drying agents.

19.11.2004

1.5 TOTAL QUANTITY

Quantity : - tonnes produced in

Remark : Ca. 75,400 tonnes are produced per year of all three persulfate salts. There are no reported values for the individual salts.

2003:
Europe: 27,200 t/y
Japan: 13,600 t/y
North America: 24,600 t/y
China: 10,000 t/y

15.12.2004

1.6.1 LABELLING

Labelling : as in Directive 67/548/EEC
Specific limits :
Symbols : O, Xn, Xi,
Nota : , ,
R-Phrases : (8) Contact with combustible material may cause fire
(22) Harmful if swallowed
(36/37/38) Irritating to eyes, respiratory system and skin
(42/43) May cause sensitization by inhalation and skin contact
S-Phrases : (2) Keep out of reach of children
(22) Do not breathe dust
(24) Avoid contact with skin
(26) In case of contact with eyes, rinse immediately with plenty of water and seek medical advice
(37) Wear suitable gloves

19.11.2004

1.6.2 CLASSIFICATION

Classified :
Class of danger : oxidizing
R-Phrases : (8) Contact with combustible material may cause fire
(22) Harmful if swallowed
(36/37/38) Irritating to eyes, respiratory system and skin
(42/43) May cause sensitization by inhalation and skin contact
Specific limits :

19.11.2004

1.6.3 PACKAGING

Memo : Fiber drums, poly bags or IBC (supersacks).

19.11.2004

1.7 USE PATTERN

Remark : Approximately 80% of all persulfates are used in two industrial applications, i.e., polymerization reactions (>60%; for example in manufacture of fluorocarbon elastomers and small scale production of electrophoretic gels) and printed circuit manufacture (about 20%). Persulfates are also used as an oxidant in cosmetics and hair bleaching products; non-biocidal shock treatment in swimming pools and other recreational waters; pulp and paper board manufacture; textile processing and in the photographic industry. Since persulfates are oxidants, they could have applications in other reactions requiring an oxidizing agent.

19.01.2005

1.7.1 DETAILED USE PATTERN

Industry category : 11 Polymers industry
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : not available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application : .6
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : Persulfates function as polymerization initiators and/or depolymerizers; and as an oxidant/bleaching agent in most other applications.

19.11.2004

Industry category : 4 Electrical/electronic engineering industry
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : not available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application : .2
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

19.11.2004

Industry category : 3 Chemical industry: chemicals used in synthesis
Use category :

Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application :
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : No reliable data available concerning tonnage for this application.
19.11.2004

Industry category : 12 Pulp, paper and board industry
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application :
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : No reliable data available concerning tonnage for this application.
19.11.2004

Industry category : 10 Photographic industry
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application :
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : No reliable data available concerning tonnage for this application.
19.11.2004

Industry category : 13 Textile processing industry
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : available
Product type/subgroup :

Tonnage for Application :
Year :
Fraction of tonnage for application :
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : No reliable data available concerning tonnage for this application.
19.11.2004

Industry category : 5 Personal / domestic use
Use category : 15 Cosmetics
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application : .03
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : Fraction of tonnage for application: 2-3%.
08.12.2004

Industry category : 15/0 other
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : not available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application : .01
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : Non-biocidal shock treatment of swimming pools and other recreational waters.
21.12.2004

Remark : In the Nordic Countries (Norway, Sweden and Denmark) the persulfates are used in the production of chemicals products, metal coating, the paper industry, the textile industry, the paint industry and in construction. The substances are mainly used as oxidizers and process regulators.
09.12.2004 (1)

1.7.2 METHODS OF MANUFACTURE

Origin of substance : Synthesis
Type : Production

Remark : Potassium persulfate is produced in electrolytic cells using potassium sulfate as starting material; crystallization of the potassium persulfate occurs in the electrolytic cell. An alternate method uses a displacement reaction whereby potassium ion replaces the sodium ion from sodium persulfate. In all cases the solids are dried to remove moisture, then packaged in polybags, fiber drums or IBCs (supersacks), ready for shipment.

16.12.2004

1.8 REGULATORY MEASURES

1.8.1 OCCUPATIONAL EXPOSURE LIMIT VALUES

Type of limit : TLV (US)
Limit value : .1 mg/m3
Short term exposure limit value
Limit value :
Time schedule : 8 hour(s)
Frequency : times

Remark : Belgium: TLV = 1.0 mg/m3
Germany: (MAK) OEL = 6 mg/m3

19.11.2004

1.8.2 ACCEPTABLE RESIDUES LEVELS

1.8.3 WATER POLLUTION

Classified by :
Labelled by :
Class of danger : 1 (weakly water polluting)

Remark : Weakly water polluting, product is expected to degrade in water forming sulfate salts.

19.11.2004

1.8.4 MAJOR ACCIDENT HAZARDS

1.8.5 AIR POLLUTION

1.8.6 LISTINGS E.G. CHEMICAL INVENTORIES

Remark : TSCA (USA), WHMIS (Canada), AICS (Australia), ENCS (Japan), KE Korea), PICCS (Philippines), EINECS (Europe).

09.12.2004

1.9.1 DEGRADATION/TRANSFORMATION PRODUCTS

Type : combustion products
CAS-No : 7790-62-7
EC-No : 232-216-8
EINECS-Name : dipotassium disulphate
IUCLID Chapter :

Remark : Gaseous oxides of sulfur and oxygen upon combustion (sulfur dioxide CAS 7446-09-5; oxygen CAS 7782-44-7)

1.9.2 COMPONENTS

1.10 SOURCE OF EXPOSURE

Source of exposure :
Exposure to the : Substance

Remark : Occupational exposure occurs in the manufacture of persulfates and in their use in hair dyes by professional hairdressers (CIR 2001, Leino T et al. 1999a, 1999b, Kellett and Beck. 1985). There are numerous well-documented literature reports of skin sensitisations and allergic responses by professional hairdressers (Fisher and Dooms-Goossens, 1976, Meindl and Meyer, 1969, Pankow et al, 1989). Workers in production facilities manufacturing persulfates have also reported clinical symptoms, but in most cases, these were controlled by improved occupational industrial hygiene practices (Baur and Fruhmann, 1979; Kanerva et al, 1999, Merget et al, 1997, White et al, 1982). Allergic contact dermatitis was reported on the hands of professional bakers or technicians handing flour containing persulfates and on the hands of professional hair dressers using hair products containing persulfates (CIR 2001, Veien et al, 2001). Exposure to persulfates from other applications is negligible.
For description of studies see section 5.10.

30.05.2005

1.11 ADDITIONAL REMARKS

1.12 LAST LITERATURE SEARCH

Type of search : Internal
Chapters covered : 3, 4, 5
Date of search : 18.08.2004

Remark : The databases searched were RTECS, Toxcenter, Biosis, Cancerlit, Medline and Embase.
The HSDB database had no listing for any of the three persulfates.

19.11.2004

1.13 REVIEWS

2.1 MELTING POINT

Decomposition : yes, at ca. 100 °C

Conclusion : Most reliable data available.
Reliability : (2) valid with restrictions
Handbook data are considered to be originated from a trusted source (=Sax). Therefore this secondary literature is provided with a reliability of 2 (according to Klimisch).
Flag : Critical study for SIDS endpoint
22.10.2001 (2) (3)

Decomposition : yes, at °C

Reliability : (4) not assignable
Secondary literature (MSDS).
11.11.2004 (4)

Value : > 170 °C
Decomposition : yes, at °C
Sublimation : No
Method : other
Year :
GLP : no data
Test substance :

Remark : Literature could not be retrieved.
Source : Peroxid Chemie GmbH Pullach
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
16.12.2004 (5)

2.2 BOILING POINT

2.3 DENSITY

Type : relative density
Value : = 2.48 at °C

Conclusion : Only data available.
Reliability : (2) valid with restrictions
Handbook data are considered to be originated from a trusted source (=Sax). Therefore this secondary literature is provided with a reliability of 2 (according to Klimisch).
Flag : Critical study for SIDS endpoint
11.11.2004 (2) (4)

Type : bulk density
Value : ca. 1 g/cm³ at 20 °C
Method : other
Year :
GLP : no data
Test substance :

Remark : Literature could not be retrieved.
Source : Peroxid Chemie GmbH Pullach
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
22.05.1995 (5)

2.3.1 GRANULOMETRY

2.4 VAPOUR PRESSURE

2.5 PARTITION COEFFICIENT

2.6.1 SOLUBILITY IN DIFFERENT MEDIA

Solubility in	:	Water
Value	:	= 60 g/l at 25 °C
pH value	:	= 5 - 8
concentration	:	1 other: %w/v at 25 °C
Temperature effects	:	
Examine different pol.	:	
pKa	:	at 25 °C
Description	:	
Stable	:	
Conclusion	:	Only data available.
Reliability	:	(4) not assignable Secondary literature (MSDS).
Flag	:	Critical study for SIDS endpoint

12.10.2001 (4)

Solubility in	:	
Value	:	ca. 50 g/l at 20 °C
pH value	:	ca. 2.5
concentration	:	50 g/l at 20 °C
Temperature effects	:	
Examine different pol.	:	
pKa	:	at 25 °C
Description	:	
Stable	:	
Remark	:	Literature could not be retrieved.
Source	:	Peroxid Chemie GmbH Pullach EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

22.05.1995 (5)

2.6.2 SURFACE TENSION

2.7 FLASH POINT

Method	:	other
Year	:	
GLP	:	
Test substance	:	
Remark	:	non-combustible

21.12.2004

2.8 AUTO FLAMMABILITY

Remark : No combustion up to 800 degrees C.
Reliability : (4) not assignable
Secondary literature (MSDS).

11.11.2004 (4)

2.9 FLAMMABILITY

2.10 EXPLOSIVE PROPERTIES

Remark : On decomposition releases oxygen which may intensify fire. Presence of water accelerates decomposition.
Reliability : (4) not assignable
Secondary literature (MSDS).

11.11.2004 (4)

2.11 OXIDIZING PROPERTIES

Method : other
Year :
GLP :
Test substance :

Remark : Test substance is an oxidizer.
Reliability : (4) not assignable
Secondary literature (MSDS).

11.11.2004 (4)

Result : maximum burning rate equal or higher than reference mixture
Method : Directive 84/449/EEC, A.17 "Oxidizing properties"
Year : 1984
GLP : no
Test substance :

Remark : Literature could not be retrieved.
max. burning rate:
Test substance: 1,8 mm/sec
Referencesubstance ($Ba(NO_3)_2$): 0,97 mm/sec
Source : Peroxid Chemie GmbH Pullach
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

23.05.1995 (6)

2.12 DISSOCIATION CONSTANT

2.13 VISCOSITY

2.14 ADDITIONAL REMARKS

3.1.1 PHOTODEGRADATION

3.1.2 STABILITY IN WATER

Type : abiotic
t1/2 pH4 : at °C
t1/2 pH7 : at °C
t1/2 pH9 : at °C

Remark : Hydrolysis: in alkaline, neutral and dilute acid solutions persulfate decomposes according to reaction (1) while in strongly acid solutions reactions (2) and (3) occur:
S2O8(-) + H2O --> 2HSO4(-) + 1/2 O2 (1)
H2S2O8 + H2O --> H2SO5 + H2SO4 (2)
H2SO5 + H2O --> H2O2 + H2SO4 (3)
Literature could not be retrieved.

Koltoff and Miller (1951) measured the rates of decomposition in water for potassium persulfate at various pH's. Since the decomposition (hydrolysis) rate is first order, the half life is independent of initial concentration. Half lives of potassium persulfate at 50 deg C as a function of pH were calculated from data in the Koltoff and Miller (1951) report, indicated below.

pH	1.0	1.6	3.0	7.0	10.0
Half Life (hours)	20	65	120	130	210

The mechanism of decomposition (hydrolysis), described in detail by Koltoff and Miller (1951) for dilute persulfate solutions, was also confirmed for saturated persulfate solutions using isothermal microwatt calorimetry. The main kinetic mechanism begins with homolytic cleavage of persulfate to form sulfate ion radicals. These radicals initiate a series of propagating reactions producing hydroxyl radicals, which ultimately produce hydrogen peroxide and a solution of acid sulfate. The net reaction is:
(S2O8)2- + H2O gives 1/2O2 + 2(SO4)2- + 2H+

The rate equation was described as having two terms once the solution became sufficiently acid:

-d[(S2O8)2-]/dt = k1(H2O)((S2O8)2-) + k2 (H+)((S2O8)2-)

Koltoff and Miller (1951) evaluated the rate constant for the acid-catalyzed term, k2, and it was determined to be 3.5 x 10-3 min-1 (m/l)-1. This term becomes dominant at low pH's.

Reliability : (2) valid with restrictions
Flag : Critical study for SIDS endpoint
21.12.2004 (7)

Deg. product :
Method : other
Year :
GLP :
Test substance :

Remark : An aqueous solution decomposes at ordinary temperature.
Conclusion : Most reliable data available.
Reliability : (2) valid with restrictions
21.12.2004 (3)

Deg. product :

Method : other
Year :
GLP :
Test substance :

Remark : Test substance becomes unstable in presence of heat, moisture and contamination.
Reliability : (4) not assignable
Secondary literature (MSDS).
21.12.2004 (4)

Type : abiotic
t1/2 pH4 : at °C
t1/2 pH7 : at °C
t1/2 pH9 : at °C

Remark : Decomposes to potassium sulfate and oxygen.
Literature could not be retrieved.
Source : Peroxid Chemie GmbH Pullach
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (8)

3.1.3 STABILITY IN SOIL

Remark : Decomposition of the crystals or powder occurs under moist conditions or at higher temperatures, and when heated to decomposition (120 degree C) toxic fumes of SOx are emitted.
Literature could not be retrieved.
15.12.2004

3.2.1 MONITORING DATA

3.2.2 FIELD STUDIES

3.3.1 TRANSPORT BETWEEN ENVIRONMENTAL COMPARTMENTS

3.3.2 DISTRIBUTION

3.4 MODE OF DEGRADATION IN ACTUAL USE

Remark : Literature could not be retrieved.
Result : Hydrolysis into potassium hydrogensulfate and H2O2, which decomposes to water and oxygen.
Source : Peroxid Chemie GmbH Pullach
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (8)

Remark : During use oxygen could be formed. Degradation produces sulfate and at elevated temperatures pyrosulfate.
Literature could not be retrieved.

15.12.2004

Remark : During use oxygen is transfered or can be released.
Degradation products in the environment are finally ammonium (NH4)+ and sulphate ions (for more references see data set on ammonium sulphate, CAS-no.: 7783-20-2).

15.12.2004

3.5 BIODEGRADATION

3.6 BOD5, COD OR BOD5/COD RATIO

3.7 BIOACCUMULATION

3.8 ADDITIONAL REMARKS

4.1 ACUTE/PROLONGED TOXICITY TO FISH

Type	:	
Species	:	Poecilia reticulata (Fish, fresh water)
Exposure period	:	
Unit	:	mg/l
LC50	:	= 845
Method	:	
Year	:	1983
GLP	:	no
Test substance	:	
Test substance	:	CAS 7727-21-1 (potassium persulfate), purity not indicated
Reliability	:	(4) not assignable

31.03.2005 (9)

4.2 ACUTE TOXICITY TO AQUATIC INVERTEBRATES

Type	:	
Species	:	Daphnia magna (Crustacea)
Exposure period	:	
Unit	:	mg/l
EC50	:	= 92 - 251
Method	:	
Year	:	1983
GLP	:	no
Test substance	:	
Test substance	:	CAS 7727-21-1 (potassium persulfate), purity not indicated
Reliability	:	(4) not assignable

31.03.2005 (9)

Type	:	
Species	:	other: Tubificidae
Exposure period	:	
Unit	:	mg/l
EC50	:	= 575
Method	:	
Year	:	1983
GLP	:	no
Test substance	:	
Test substance	:	CAS 7727-21-1 (potassium persulfate), purity not indicated
Reliability	:	(4) not assignable

31.03.2005 (9)

Type	:	
Species	:	other:Cyclops strenuus
Exposure period	:	
Unit	:	mg/l
EC50	:	= 1175
Method	:	
Year	:	1983
GLP	:	no
Test substance	:	
Test substance	:	CAS 7727-21-1 (potassium persulfate), purity not indicated

Reliability : (4) not assignable
31.03.2005 (9)

4.4	**TOXICITY TO MICROORGANISMS E.G. BACTERIA**
4.5.1	**CHRONIC TOXICITY TO FISH**
4.5.2	**CHRONIC TOXICITY TO AQUATIC INVERTEBRATES**
4.6.1	**TOXICITY TO SEDIMENT DWELLING ORGANISMS**
4.6.2	**TOXICITY TO TERRESTRIAL PLANTS**
4.6.3	**TOXICITY TO SOIL DWELLING ORGANISMS**
4.6.4	**TOX. TO OTHER NON MAMM. TERR. SPECIES**
4.7	**BIOLOGICAL EFFECTS MONITORING**
4.8	**BIOTRANSFORMATION AND KINETICS**
4.9	**ADDITIONAL REMARKS**

5.0 TOXICOKINETICS, METABOLISM AND DISTRIBUTION

5.1.1 ACUTE ORAL TOXICITY

Type	:	LD50
Value	:	= 1130 mg/kg bw
Species	:	rat
Strain	:	
Sex	:	male
Number of animals	:	6
Vehicle	:	other: corn oil
Doses	:	
Method	:	other: not indicated
Year	:	
GLP	:	no
Test substance	:	

Method :
TEST ORGANISMS:
- Number: 6/treatment
- Controls: none
- Weight at study initiation: 198 g (mean)

ADMINISTRATION:
- Doses: 500, 1000, 2500 mg/kg bw
- Concentration administered: 250 mg/ml corn oil

EXAMINATIONS: mortality, clinical signs, macroscopy

Result :
MORTALITY:
- Number of deaths at each dose: 1/6 (500), 2/6 (1000), 6/6 (2500)
- Time of death: within 24 hours

CLINICAL SIGNS: mild depression, weak and/or rapid breathing (recovered within 4 days)

NECROPSY FINDINGS: within normal limits

Test substance	:	CAS 7727-21-1 (potassium persulfate), purity not indicated
Conclusion	:	Only study available.
Reliability	:	(2) valid with restrictions 1. The information in the report is confined to the above. 2. Only males were tested. No effect on body weight reported.
Flag	:	Critical study for SIDS endpoint

21.12.2004 (10)

Type	:	LD50
Value	:	1162 mg/kg bw
Species	:	rat
Strain	:	
Sex	:	
Number of animals	:	
Vehicle	:	
Doses	:	
Method	:	other
Year	:	
GLP	:	
Test substance	:	

Remark	:	Literature could not be retrieved.
Source	:	Peroxid Chemie GmbH Pullach EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA) 19.11.2004 (11)
Type	:	LD50
Value	:	825 mg/kg bw
Species	:	rat
Strain	:	
Sex	:	
Number of animals	:	
Vehicle	:	
Doses	:	
Method	:	other
Year	:	
GLP	:	
Test substance	:	
Remark	:	Literature could not be retrieved.
Source	:	Peroxid Chemie GmbH Pullach EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA) 19.11.2004 (11)

5.1.2 ACUTE INHALATION TOXICITY

Type	:	LC50
Value	:	> 42.9 mg/l
Species	:	rat
Strain	:	
Sex	:	male
Number of animals	:	7
Vehicle	:	
Doses	:	
Exposure time	:	1 hour(s)
Method	:	other: not indicated
Year	:	
GLP	:	no
Test substance	:	
Method	:	TEST ORGANISMS: - Initial body weight: 116 g (mean) - Number of animals: 7/treatment - Controls: none ADMINISTRATION: - Exposure duration: 1 h - Concentration (nominal): 42.9 mg/L EXAMINATIONS: mortality, clinical signs, macroscopy
Result	:	MORTALITY: - Number of deaths: 0 CLINICAL SIGNS: hyperexcitability and slight irritation NECROPSY FINDINGS: enlarged liver and spleens in all animals
Test substance	:	CAS 7727-21-1 (potassium persulfate), purity not indicated
Conclusion	:	Only study available.
Reliability	:	(2) valid with restrictions 1. The information in the report is confined to the above.

2. Only males were tested.
3. Type of exposure not indicated and the exposure time is only 1 hour (OECD402: 4 hours).

Flag : Critical study for SIDS endpoint
21.12.2004 (10)

5.1.3 ACUTE DERMAL TOXICITY

Type	:	LD50
Value	:	> 10000 mg/kg bw
Species	:	rabbit
Strain	:	
Sex	:	male
Number of animals	:	4
Vehicle	:	
Doses	:	
Method	:	other: not indicated
Year	:	
GLP	:	no
Test substance	:	

Method : TEST ORGANISMS:
- Weight at study initiation: 2.5 kg
- Controls: none

ADMINISTRATION:
- Dose: 10000 mg/kg bw

EXAMINATIONS: mortality, clinical signs, macroscopy

Result : MORTALITY:
- Number of deaths: none

CLINICAL SIGNS: slight, reversible erythema

NECROPSY FINDINGS: few hemorrhagic areas between muscle and facia at the sight of application

Test substance : CAS 7727-21-1 (potassium persulfate), purity not indicated

Conclusion : Only study available.

Reliability : (2) valid with restrictions
1. The information in the report is confined to the above.
2. Only males were tested.

Flag : Critical study for SIDS endpoint
21.12.2004 (10)

5.1.4 ACUTE TOXICITY, OTHER ROUTES

5.2.1 SKIN IRRITATION

Species	:	rabbit
Concentration	:	
Exposure	:	no data
Exposure time	:	
Number of animals	:	6
Vehicle	:	
PDII	:	
Result	:	not irritating
Classification	:	
Method	:	other: not indicated

Year	:	
GLP	:	no
Test substance	:	
Method	:	ADMINISTRATION/EXPOSURE - Examinations time points: 24 and 72 h
Result	:	AVERAGE SCORE - Erythema: 0 - Edema: 0
Test substance	:	CAS 7727-21-1 (potassium persulfate), purity not indicated
Reliability	:	(2) valid with restrictions 1. The information in the report is confined to the above. 2. No information is given on the duration of exposure.

21.12.2004 (10)

5.2.2 EYE IRRITATION

Species	:	rabbit
Concentration	:	
Dose	:	
Exposure time	:	72 hour(s)
Comment	:	
Number of animals	:	8
Vehicle	:	
Result	:	not irritating
Classification	:	
Method	:	other: not indicated
Year	:	
GLP	:	no
Test substance	:	
Method	:	EXAMINATIONS - Ophthalmoscopic examination: cornea, iris, conjunctivae
Result	:	AVERAGE SCORE - Cornea: 0 - Iris: 0 (at 24 h score 1 in 1/8 animals) - Conjunctivae: 0 (at 24 h score 1 in 2/8 animals)
Test substance	:	CAS 7727-21-1 (potassium persulfate), purity not indicated
Reliability	:	(2) valid with restrictions 1. The information in the report is confined to the above.

21.12.2004 (10)

5.3 SENSITIZATION

5.4 REPEATED DOSE TOXICITY

Type	:	
Species	:	rat
Sex	:	male
Strain	:	other: CR-CD
Route of admin.	:	oral feed
Exposure period	:	28 days
Frequency of treatm.	:	continuous
Post exposure period	:	
Doses	:	0, 12.6, 41.2, 131.5 mg/kg bw/day
Control group	:	yes
NOAEL	:	= 131.5 mg/kg

Method	:	other: not indicated
Year	:	
GLP	:	no
Test substance	:	

Method :

TEST ORGANISMS
- Age: weanlings
- Weight at study initiation: 45-47 g
- Number of animals: 10/treatment

ADMINISTRATION / EXPOSURE
- Exposure period: 28 days
- Route of administration: diet
- Post exposure period: not reported
- Doses: 0, 12.6, 41.2, 131.5 mg/kg/day

BODY WEIGHT GAIN: no treatment-related effects

CLINICAL OBSERVATIONS: mortality, body weight (init. and terminal) and clinical signs

ORGANS EXAMINED AT NECROPSY:
- Macroscopic investigation (not specified)
- Organ weights: liver, kidneys, adrenals and testes

Result : TOXIC RESPONSE/EFFECTS BY DOSE LEVEL:
- Mortality: none
- Clinical signs: none
- Body weight gain: no treatment-related effects
- Organ weights: no treatment-related effects
- Gross pathology: no significant effects

Test substance	:	CAS 7727-21-1 (potassium persulfate), purity not indicated
Conclusion	:	Only study available.

NOAEL = 131.5 mg/kg bw.

Reliability	:	(2) valid with restrictions

1. The information in the report is confined to the above.
2. Only males were tested. Animals were younger than required according to OECD407 (young adult).

Flag	:	Critical study for SIDS endpoint

21.12.2004 (10)

5.5 GENETIC TOXICITY 'IN VITRO'

5.6 GENETIC TOXICITY 'IN VIVO'

5.7 CARCINOGENICITY

5.8.1 TOXICITY TO FERTILITY

5.8.2 DEVELOPMENTAL TOXICITY/TERATOGENICITY

5.8.3 TOXICITY TO REPRODUCTION, OTHER STUDIES

5.9 SPECIFIC INVESTIGATIONS

5.10 EXPOSURE EXPERIENCE

Type of experience : Human

Result : A 45-year old female laboratory assistant developed contact dermatitis on her hands. She washed her hands as often as ten times/day. Patch testing of chemicals from the workplace found that potassium persultate (2.5% in petroleum) gave a positive response. Twenty unexposed control subjects did not respond when with potassium persulfate.

Conclusion : Exposure to potassium persulfate induced an occupational allergic contact dermatitis in one individual who frequently was exposed to water and potassium persulfate.

11.11.2004 (12)

Type of experience : Human

Result : A study was conducted to evaluate the prevalence of positive skin prick test reactions to ammonium and potassium persulfates (1% and 5% solutions) among 52 employees of a persulfate production plant. A group of 13 unexposed persons served as controls. Eight of the 52 employees showed a positive response to at least one persulfate solution: 2 employees were positive to potassium salt, three employees were positive to ammonium salt and three employees were positive to both salts. Lung function tests for the exposed population were generally normal but there was a trend showing a correlation between positive skin prick responders and slightly lower lung function for forced expiratory volume FEV1 ($p = 0.057$). Due to the small number of subjects the correlation needs to be verified.

Conclusion : There was a high response to ammonium and or potassium persulfate skin prick tests (8/52) associated with somewhat lower lung function in workers exposed to persulfates in a production facility. All 13 control subjects did not respond to the same skin prick test. Exposure levels were not documented.

11.11.2004 (13)

Type of experience : Human

Result : A 36-year old laboratory technician in a potato flour facility exhibited dermatitis on her face and hands. She tested positively to 1, 2.5 and 5% aqueous solution of potassium persulfate. A prick test to 1% aqueous potassium persulfate was negative. A patch test to 2.5% ammonium persulfate produced a weaker response.

Conclusion : A single case of contact dermatitis is reported for a worker exposed to potassium persulfate in a potatoe flour factory.

11.11.2004 (14)

Type of experience : Human

Result : Ammonium, potassium, and sodium persulfate are used as oxidizing agents in hair bleaches and hair-coloring preparations. Persulfates are contained in hair lighteners, off-the-scalp products, bleaches and lighteners at concentrations of 60%, 25%, 22% and 16%, respectively. Much of the available safety test data are for ammonium persulfate, but these data are considered applicable to the other salts. The persulfates were reported to cause both delayed-type and immediate skin reactions, including irritant dermatitis, allergic eczematous dermatitis, localized contact urticaria,

generalized urticaria, rhinitis, asthma, and syncope. The most common causes of allergic dermatitis in hairdressers are the active ingredients in hair dyes, and ammonium persulfate has been identified as a frequent allergen. A sensitization study examined the incidence of urticarial reactions was performed with 17.5% ammonium, potassium, and sodium persulfate under occlusive patches. At this concentration and exposure conditions, a mixture of these persulfates was not sensitizing, and application of ammonium, potassium, and sodium persulfate did not result in an urticarial reaction. In normal use (i.e., not occluded and rinsed off), it is expected that a concentration greater than 17.5% would also be safe. Given the clinical reports of urticarial reactions, however, manufacturers and formulators should be aware of the potential for urticarial reactions at concentrations of persulfates greater than 17.5%. Based on the available data, the Cosmetic Ingredient Review (CIR) Expert Panel concluded that ammonium, potassium, and sodium persulfate are safe as used as oxidizing agents in hair colorants and lighteners designed for brief discontinuous use followed by thorough rinsing from the hair and skin.

Conclusion : This review article concludes that the persulfate salts have similar toxicity and data on ammonium persulfate can be used for the sodium and potassium salts. The review by the Cosmetic Ingredient Review Expert Panel also concludes that the three persulfates are safe in hair products at up to 17.5% based on a human skin sensitization study.

15.12.2004 (15)

Type of experience : Human

Result : Early report of dermal sensitization and occupational asthma reported in a single hairdresser. The patient experienced both utricaria and asthma. After ventilation equipment was installed in the salon, no asthma attachs occurred. The amount of persulfate in hair preparations is stated as being 30% of the total formulation.

Conclusion : Good industrial hygiene improves the prognosis of occupational asthma among hairdressers.

09.12.2004 (16)

Type of experience : Human

Result : A hairdresser developed rhinoconjunctivitis and bronchial asthma following a two-year apprenticeship. The patient reacted positively to a persultate prick test.

Conclusion : The case report indicates that persulfates can cause sensitization in the workplace to hairdressers.

09.12.2004 (17)

Type of experience : Human

Result : The main hazards for professional hairdressers are rhinitis, bronchitis, asthma and irritant and allergic contact dermatitis. The risk of respiratory effects is likely to be low among hairdressers using effective dust-free formulations, but considerably higher among those using powder formulations and ineffective dust-free formulations. Dermatitis due to persulfates is likely to affect up to 5% of hairdressers. Members of the general publich are not likely to have respiratory or skin conditions attributable to persulfates. The volume of persulftes imported for hair bleaching products in Australia is 6.5 tonnes/year of which 4.5 tonnes/year is formulated into consumer products. The content of persulfate in salon hair products ranged from 22% to 88% and the content of home-use hair products ranged from 45% to 82.5%.

Conclusion : Review of the literature for animal and human effects, particularly focused on hairdresser exposures. Immediate and delayed contact hypersensitivity, contact urticaria, rhinitis, bronchitis and asthma have been

observed in hairdressers as a result of exposure to hair bleaching powders containing persulfates.

09.12.2004 (18)

Type of experience : Human

Result : Three workers at a persulfate production plant developed nasal mucosal inflammation, dry cough and dyspnea. Complaints were noted after many hours of exposure to persulfate dust in the workplace. Uncovered skin areas in two workers exhibited dermatitis. The three workers tested positive to 5% persulfate solution in patch tests. Bronchial obstruction occurred after prolonged exposure (8 hours).

Conclusion : Workers in a production plant developed symptoms that were related to exposure to persulfates. The paper does not include information on the amount of persulfate exposure (air level) or personal protective equipment used.

09.12.2004 (19)

Type of experience : Human

Result : Employees of the Buffalo plant of the FMC Corporation were included in an extensive industrial hygiene monitoring and clinical study. The clinical study evaluated pulmonary function for a full week in the summer of 1990 and for two weeks in the winter of 1991 using 14 subjects. Workers were directly exposed to persulfates in the packout area and caustic/crystallizer area and inside the laboratory. No workers had a history of asthma symptoms. Samples for breathing zone (608 hours) and area samples were made. Pre- and post-shift spirometry lung function to measure forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) on the first and last day of hte 7-day week were made. The mean level of exposure to persulfates was 0.5 mg/m3, mixed with a total dust level below a mean of 2.0 mg/m3. No clinically significant observations in the spirometry values were found.

Conclusion : Long-term exposure to 0.5 mg/m3 persulfate did not affect pulmonary function evaluated in 14 plant employees. The study related levels of persulfate in air to worker performance (lung function) and showed no deficits.

09.12.2004 (20)

Type of experience : Human

Result : A follow up study was conducted on workers examined in 1990-1991 to see if there were any changes in pulmonary function during 1990-1996. Follow-up data on the original study subjects and new employees involved checking medical records of the exposed employees. Medical records for 22, 17, 10 and 8 workers were available for the two, three, four and six year time periods of follow-up. Records for the five year follow-up were lost in a fire. The change over time in the pulmonary function tests was compared to actual and predicted ratios for years 2, 3, 4 and 6 after the 1990 assessment. Workers included in the study included material operators, crystallizer/caustic operators, lab technicians and workers from other areas. No statistically significant findings of pulmonary function test performance were found for any of the four work position categories. A total of 100 different t-test comparisons were conducted at a p value of 0.05. Two significant findings were found. but because they were less than the total of up to five findings allowed, the two findings were considered to be due to chance.

Conclusion : The study shows that continuous occupational exposure to persulfates over a period of six years did not result in any long term effects on pulmonary function.

09.12.2004 (21)

Type of experience : Human

Result : A cross sectional study was performed in 32 of 33 employees of a persulfate production plant. Eighteen of 23 workmen from the same plant with no exposure to persulfates served as controls. Medical records of the seven subjects who had left the persulfate production for medical reasons since 1971 were collected. Data were recalled by a questionnaire, skin prick tests were performed with five environmental allergens, and ammonium and sodium persulfate (80 mg/ml). Specific IgE to the same environmental allergens as in the skin test, and total IgE were measured. Lung function and bronchial responsiveness to histamine were assessed by standard procedures. Workplace concentrations of ammonium and sodium persulfate were estimated by area and personal monitoring. Work-related rhinitis was reported by one subject with exposure to persulfates, conjunctivitis and bronchitis were reportedly related to work by two controls. There were no cutaneous reactions to persulfates in either group. Four non-atopic persulfate-exposed subjects and two workmen, one atopic and one non-atopic, were considered hyperresponsive to histamine. Three persulfate-exposed subjects with bronchial hyperresponsiveness did not show peak expiratory flow variability of 20%, the remainder refused peak flow measurements. None of the variables showed significant differences between the groups ($p > 0.05$). Six of the ex-workers left because of work related contact dermatitis, the remainder had complained of asthma. Mean values for workplace concentrations of ammonium and sodium persulfate within the bagging plant were below 1 mg/m3, and the maximal concentrations were 1.4 mg/m3 and 3.6 mg/m3, respectively. Exposure to workplace concentrations of ammonium and sodium persulfate of about 1 mg/m3 in this chemical plant was not associated with a relevant risk for occupational asthma.

Conclusion : A detailed study of 32 workers in a persulfate production facility indicated that exposure to persulfates in the plant (levels of about 1 mg/m3 with a peak of 3.6 mg/m3) was not associated with an increased risk of occupational asthma.

15.12.2004 (22)

Type of experience : Human

Remark : - Some hairdressers and their customers who were exposed to alkaline persulfate solutions showed symptoms like asthma, eczema, oedema (skin), and sporadically anaphylactic shock.
- Worker exposure to persulfates: < 15 mg/m3 as dust showed in 20 years no dermatitis in man.
- A standard text describes potassium persulfate as moderately irritating.
- A couple of weeks after professionnaly being exposed to persulfates (potassium, sodium, ammonium) three workers showed rhinitis, coughing, difficulties with respiration and dermatitis. The irritating effect dominated.
- Rashes were observed in 20-70% of newly appointed workers. Patch tests were not performed. No cases of sensitization are known.

Literature could not be retrieved.

Source : Peroxid Chemie GmbH Pullach
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

21.12.2004 (23) (24) (25) (26) (27)

Type of experience : Human

Remark : Eye contact: Only in one case burning of the eyes was reported, which had disappeared within 48 hours.
Literature could not be retrieved.

Source : Peroxid Chemie GmbH Pullach

EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
09.12.2004 (28)

Type of experience : Human

Remark : A well-documented review from the UK authority (HSE) was available.
Introduction
Persulphate salts (ammonium, potassium and sodium) are strong oxidising agents with wide industrial use. They are also used to enhance the action of peroxide hair bleaches, for which they are supplied as a powder to mix with liquid peroxide shortly before use. Persulphate hair bleaches have produced both irritant and allergic contact dermatitis, as well as urticarial and respiratory reactions (Fisher and Dooms-Goossens, 1976; Kellett and Beck, 1985; Kleinhans and Ranneberg, 1989). The contact urticaria is not immunologically-mediated, but thought to be due to the fact that persulphate is a weak histamine-releasing agent (Calnan and Schuster, 1963; Parsons et al., 1979). It is not known why only some individuals are sensitive to this action.

Evidence for work-related asthma
There have been a number of well-conducted studies of hairdressers with work-related asthmatic symptoms that have included specific bronchial challenge tests, performed blinded, using hair bleach or persulphate, either as powder or aerosolised solution. In some studies, controls who were either non-asthmatic, or asthmatic with hyperresponsive airways, were also challenged; none gave positive reactions.

Of 12 'tinters' from a hairdressing salon who used persulphate-containing bleach, 4 had work-related asthmatic and nasal symptoms, which had developed after a latent period of at least six months (Blainey et al., 1986). An affected individual from another salon was also included for investigation. All 5 were hyperresponsive to histamine, though other lung function parameters were normal. Only those with symptoms reacted at specific challenge, giving late asthmatic responses, and controls (including asthmatics) failed to react. All 4 of the subjects who also underwent nasal challenge gave positive reactions.

Agustin reported the cases of two hairdressers who developed work-related rhinitis, conjunctivitis and, in one, asthma several years after first using bleaching powders (Agustin et al., 1992). Both had normal respiratory function, but the asthmatic subject was hyperresponsive to methacholine. At specific bronchial challenge, the person with asthma developed a late response, while the other suffered immediate severe nasal symptoms.

A young woman developed work-related respiratory symptoms about a year after starting work in a hairdressing salon (Parra et al., 1992). When she was investigated, after a month's absence from work, she was hyperresponsive to methacholine. On specific bronchial challenge, she developed a late, prolonged reaction followed by recurrent nocturnal falls in forced expiratory volume in one second, for 96 hours after the test.

Another case of work-related asthma, with associated sneezing and rhinoconjunctivitis, has been described, in which a young woman worked for 3 years before developing symptoms (Pankow et al., 1989). As in other cases, lung function was normal but the airways showed non-specific hyperresponsiveness. On unblinded bronchial challenge, she suffered an immediate asthmatic attack. Normal and asthmatic controls did not react.

A beautician with a history of mild seasonal rhinitis developed work-related asthma (Schwartz, 1989). Lung function was normal, and she was not

hyperresponsive to methacholine. She underwent blinded bronchial challenges with a number of hair care preparations, and reacted only to a persulphate-containing bleach with an immediate reaction (it was unclear for how long measurements were continued). The patient declined challenge with persulphate itself.

All of these well-conducted studies provide evidence that persulphate salts are capable of inducing asthma and can cause specific reactions at bronchial challenge under conditions which do not induce a response in normal or previously non-exposed asthmatic people.

These studies are backed up by several case reports of occupational asthma associated with persulphate use, in which the bronchial challenge tests performed were not blinded and omitted controls. These include two cases, both positive at challenge (Pepys et al., 1976); 5 cases, 4 challenged - 2 positive, 1 negative, 1 equivocal (Therond et al., 1989); one case, positive (Gamboa et al., 1989); one case, positive (Schwaiblmair et al., 1990); three cases, one challenged - positive (Wallenstein et al., 1993).

There are also reports of persulphate effects in occupations other than hairdressing. One concerns an Italian factory that used ammonium and potassium persulphate during the manufacture of hydrogen peroxide, in which 12% of the workers suffered from asthma that usually developed within 6 months of starting work (Barsotti et al., 1951). Bronchial challenges were performed with an aerosol of a 1% ammonium persulphate solution; affected workers, but not controls, responded positively to challenge. In another study, 2 chemical factory workers who bagged persulphates developed work-related nasal and asthmatic symptoms within a few weeks of beginning work (Baur et al., 1979). Neither underwent bronchial challenge, and symptoms resolved on avoiding exposure.

Supporting data
Skin prick tests, and occasionally intradermal or scratch tests, have been performed on many of the people reported as having persulphate-related asthma or rhinitis. Either persulphate or bleach powder solutions have been used; negative controls have sometimes been included. The tests have been positive in most of those studied (Gaultier et al., 1966; Blandin, 1970; Fisher and Dooms-Goossens, 1976; Pepys et al., 1976; Baur et al., 1979; Blainey et al., 1986; Pankow et al., 1989; Agustin et al., 1992; Escudero Pastor et al., 1992; Parra et al., 1992; Wallenstein et al., 1993). There have also been some negative results reported (Baur et al., 1979; Blainey et al., 1986; Gamboa et al., 1989; Agustin et al., 1992; Wallenstein et al., 1993). In one study, the results of intradermal tests in 3 people correlated with bronchial challenge data (Wallenstein et al., 1993). Amongst employees manufacturing persulphates, work-related breathing difficulties were found more often (6/8) in those who were positive than in those who were negative (9/44) in skin prick tests (Wrbitzky et al., 1995). In an early study, a scratch test that was strongly positive triggered within minutes a "violent" attack of asthma (Blandin, 1970). While most people with persulphate asthma have given positive skin prick tests, this may be because of direct histamine release rather than an immunologically-mediated reaction.

In hairdressers with asthma, total immunoglobulin E (IgE) levels have generally been normal, though increased in two people, and decreased after avoidance of exposure in another (Gamboa et al., 1989; Pankow et al., 1989; Schwaiblmair et al., 1990; Agustin et al., 1992; Parra et al., 1992). No specific IgE to persulphates has been found in three separate cases tested (Gamboa et al., 1989; Schwaiblmair et al., 1990; Parra et al.,

1992). However, the serum from an asthmatic patient was positive for both hair bleach and sodium persulphate in a Prausnitz-Kustner test for passive transfer of specific IgE (Escudero Pastor et al., 1992). Overall, these immunological data are scarce and inconclusive.

In peripheral blood studies, one person had eosinophilia, and another developed neutrophilia and eosinophilia following positive bronchial challenge (Schwaiblmair et al., 1990; Parra et al., 1992).

Source : HSE, UK authority.
31.05.2005 (29) (30) (31) (32) (33) (34) (35) (36) (37) (38) (39) (40) (41) (42) (43) (44) (45) (46) (47) (17) (48) (13)

5.11 ADDITIONAL REMARKS

Type : Biochemical or cellular interactions

Method : Test 1: rat peritoneal mast cells were exposed to potassium persulfate (0.33-2.7 mg/mL cell suspension) under different conditions (temperature, pH and time). Histamine release was measured (corrected for spontaneous release) and cells were investigated for degranulation and/or membrane disruption.

Test 2: guinea pig skin slices (from the abdomen) were exposed to 0.2-16 mg/mL potassium persulfate or 0.2 mg/mL 48/80 for 30 minutes at 37 and 4 degC. Histamine release was measured (corrected for spontaneous release).

Test 3: guinea pigs were exposed intradermally to potassium persulfate at 4, 8 and 16 mg/mL saline. Animals were killed after 40 minutes and the skin was removed and assessed for lesions. The size of the lesion was recorded.

Result : Test 1: Histamine release increased dose dependently. Temperature, pH and incubation time influenced the reaction. At cellular level degranulation was observed.

Test 2: At 37 degC a dose related increase of histamine was seen. At 4 degC no effects were seen

Test 3: lesions were dose dependently increased in size and intensity.

Conclusion : Potassium persulfate causes a release of histamine by degranulation of the mast cells without disruption of the membrane. The reaction is slow.

30.05.2005 (43)

(1) SPIN database 08-12-04.

(2) CRC Handbook of chemistry and physics, CRC Press, 1999/2000.

(3) Merck Index, CD-ROM 1999.

(4) FMC Corporation, Material Safety Data Sheet: Potassium persulfate (02-05-01: date approved), 2001.

(5) Sicherheitsdatenblatt, Peroxid-Chemie GmbH, Ausgabe 2/95

(6) Peroxid-Chemie GmbH, unveröffentlicht

(7) Koltoff I. and Miller I K (1951). The chemistry of persulfate. I. The kinetics and mechanism of the decomposition of the persulfate ion in aqueous medium. J. Am. Chem. Soc., 73, 3055-3059.

(8) EUCLID-Datensatz Natriumpersulfat, CAS-Nr. 7775-27-1, Degussa AG, Hanau vom 31.05.1994

(9) Svobodova, Z., Machova, J., Faina, R., Stanek, P., Schneedorfer, J. (1983). Acute Toxicity of Peroxidisulphates to Aquatic Organisms. Buletin VURH Vodnany, 4, 17-24.

(10) FMC Corporation, Acute and 28-day subacute toxicity of potassium persulfate, Study no. ICG/T-79-024, 1979.

(11) LPT-Report 5918/90, 13. April 1994, unveröffentlicht

(12) Kanerva, L. et al., Occupational allergic contact dermatitis from potassium persulfate, Contact Dermatitis 40, 116-117, 1999.

(13) Wrbitzky, R., Drexler, H. and Letzel, S., Early reaction type allergies and diseases of the respiratory passages in employees from persulphate production, Int. Arch. Occup. Environ. Health 67, 413-417, 1995.

(14) Veine, N., Hattel, T. and Laurberg, G., Contact dermatitis due to potassium persulfate. Contact Dermatitis 45, 176, 2001.

(15) Final Report on the Safety Assessment of Ammonium, Potassium, and Sodium Persulfate, International Journal of Toxicology 20 (Suppl. 3): 7-21, 2001 (Cosmetic Ingredient Review (CIR), Washington, DC, 20036, USA).

(16) K. Meindl and R. Meyer; Asthma and urtricaria in the hairdresser's trade due to bleaching agents containing persulfates. Zbl. Arbeitsmed. 19(3): 75-79, 1969.

(17) W. Pankow, H. Hein, K. Bittner, P.v.Wichert; Persulfate-asthma in the hairdressing trade. Pneumologie 43, 173-175, 1989.

(18) Priority Existing Chemical Assessment Report No. 18, Ammonium, Potassium and Sodium Persulfate. June 2001. National Industrial Chemicals Notification and Assessment Scheme, Commonwealth of Australia.

(19) X. Baur and G. Fruhmann; Bronchial Asthma of Allergic and Irritative Origin as an Occupational Disease. Prax. Pneumol. 33, 317-322, 1979.

(20) Report of Persulfate Worker Study of the FMC Plant in Buffalo, New York 1990-1991. Unpublished report for FMC Corporation. FMC Study I1992-1713, Jan. 15, 1992.

(21) Preliminary Report: Lung Function Assessment of Persulfate Workers: 1990-1996. FMC, Buffalo, NY. Unpublished report for FMC Corporation. By William W. Greaves, May 23, 1997.

(22) Merget, R. et al.; Cross sectional study of chemical workers exposed to sodium and ammonium persulfate. Dermatosen in Beruf und Umwelt, (1997) 45/3 (130-131).

(23) Baur, X., Fruhmann, G.(1979), Bronchial Asthma of Allergic and Irritative Origin as an Occupational Disease. Prax. Pneumol., Vol. 33, 317-322.

(24) Documentation of The Treshold Limit Values and Biological Exposure Indices, 5 th Edition, ACGIH, Page 468, 1986

(25) Hardel et al. La Nouvelle Presse Médical, 7 (45), 4151, 1978
Davies R. and Blainey D., Dev Toxicol. Environ. Sci, 11, 219-228, 1983
Meindl K. und Meyer R. Zbl. Arbeitsmed 1969/3, 75-79

(26) Sax, N.I. (1975) Dangerous Properties of Industrial Materials 4 th Edition (Van Nostrand Reinhold Co., New York).

(27) White et al (1982), Rashes among Persulfate Workers, Contact Dermatitis 8 (3) 168-172.

(28) Grant, Toxicity of the eye page 853.

(29) Agustin P, Martinez-Cocera C, Cimarra M et al (1992) Persulphate-induced occupational respiratory allergy Rev Esp Alergol Inmunol Clin. 7; 91-97

(30) Barsotti M, Parmeggiani L and Sassi C (1951) Symptoms of bronchial asthma and eczema in workers assigned to hydrogen peroxide production units Med Lav. 42; 49-68.

(31) Baur X, Fruhmann G and von Liebe V (1979) Occupational asthma and dermatitis in two industrial workers after exposure to dusts of persulphate salts Respiration. 38; 144-150.

(32) Blainey AD, Ollier S, Cundell D et al (1986) Occupational asthma in a hairdressing salon Thorax. 41; 42-50.

(33) Blandin G (1970) Desensitization among hairdressers (lacquer and bleach) Rev Franc Allergol. 10; 327-331.

(34) Calnan CD and Shuster S (1963) Reactions to ammonium persulphate Arch Dermatol. 88; 812-815.

(35) Escudero Pastor AI, Hernandez Garcia J, Lopez Sanchez JD et al (1992) Occupational asthma caused by persulphate inhalation Rev Esp Alergol Inmunol Clin. 7; 87-90.

(36) Fisher AA and Dooms-Goossens A (1976) Persulphate hair bleach reactions: cutaneous and respiratory manifestations Arch Dermatol. 112; 1407-1409.

(37) Gamboa PM, de la Cuesta CG, Garcia BE et al (1989) Late asthmatic reaction in a hairdresser, due to the inhalation of ammonium persulphate salts Allergol Immunopathol (Madr). 17; 109-111.

(38) Gaultier M, Gervaise P and Mellerio F (1966) Two causes of occupational asthma among hairdressers: persulphate and silk Arch Mal Prof. 27; 809-813.

(39) Kellett JK and Beck MH (1985) Ammonium persulphate sensitivity in hairdressers Cont Derm. 13; 26-28.

(40) Kleinhans D and Ranneberg KM (1989) Immediate-type reactions caused by ammonium persulphate hair bleaches Allergologie. 12; 353-354.

(41) Mahzoon S, Yamamato S and Greaves MW (1977) Response of skin to ammonium persulphate Acta Dermatovener. 57; 125-126.

(42) Parra FM, Igea JM, Quirce S et al (1992) Occupational asthma in a hairdresser caused by persulphate salts Allergy (Eur J Allergy Clin Immunol). 47; 656-660.

(43) Parsons JF, Goodwin BFJ and Safford RJ (1979) Studies on the action of histamine release by persulphates Food Cosmet Toxicol. 17; 129-135.

(44) Pepys J, Hutchcroft BJ and Breslin ABX (1976) Asthma due to inhaled chemical agents-persulphate salts and henna in hairdressers Clin Allergy. 6; 399-404.

(45) Schwaiblmair M, Baur X and Fruhmann G (1990) Bronchial asthma caused by hair bleach in a hairdresser Dtsch Med Wochenschr. 115; 695-697.

(46) Schwartz HJ (1989) Effect of chronic chromolyn sodium therapy in a beautician with occupational asthma J Occup Med. 31; 112-114.

(47) Therond M, Geraut C, Dupas D and Gayoux C (1989) Pathology of alkaline persulphates: concerning 19 recent cases Arch Mal Prof Med Trav Secur Soc. 50; 837-838.

(48) Wallenstein G, Wagner E and Schoneich R (1993) Airway symptoms in hairdressers with occupational contact eczema Arbeitsmed Sozialmed Praventivmed. 28; 441-444.

S I D S

Dossier

Existing Chemical	:	ID: 7727-54-0
CAS No.	:	7727-54-0
EINECS Name	:	diammonium peroxodisulphate
EC No.	:	231-786-5
TSCA Name	:	Peroxydisulfuric acid ([(HO)S(O)2]2O2), diammonium salt
Generic name	:	ammonium persulfate
IUPAC Name	:	diammonium peroxodisulphate
Molecular Formula	:	H3N.1/2H2O8S2

Producer related part

Company	:	Notox
Creation date	:	30.08.2001

Substance related part

Company	:	Notox
Creation date	:	30.08.2001
Status	:	
Memo	:	20 Category
Printing date	:	06.06.2005
Revision date	:	
Date of last update	:	06.06.2005
Number of pages	:	77
Chapter (profile)	:	Chapter: 1, 2, 3, 4, 5, 6, 7, 8, 10
Reliability (profile)	:	Reliability: without reliability, 1, 2, 3, 4
Flags (profile)	:	Flags: without flag, confidential, non confidential, WGK (DE), TA-Luft (DE), Material Safety Dataset, Risk Assessment, Directive 67/548/EEC, SIDS

1.0.1 APPLICANT AND COMPANY INFORMATION

Type : cooperating company
Name : Asahi Denka Kogyo K.K.
Contact person : Takanobu Ohshima
Date : 12.11.2004
Street : 8-6 Nihonbashi Kobunacho
Town : J-103 Chou-ku Tokyo
Country : Japan
Phone : 81 545 34 1032
Telefax : 81 545 34 0695
Telex :
Cedex :
Email : osima@adk.co.jp
Homepage :

Remark : Within CEFIC (European Chemical Industry Council) a Persulfate Working Group was formed to comply with the ICCA High Production Volume (HPV) initiative. Dominique de Halleux (CEFIC employee) is the secretary of this group. The members (cooperating companies) of the Persulfates Group are noted in this section.

19.11.2004

Type : cooperating company
Name : Degussa AG
Contact person : Werner Ponikwar
Date : 12.11.2002
Street : Dr-Gustav-Adolph-Strasse, 3
Town : D-82049 Pullach
Country : Germany
Phone : 49 89 744 22 421
Telefax : 49 89 744 22 6421
Telex :
Cedex :
Email : werner.ponikwar@degussa.com
Homepage :

18.11.2004

Type : cooperating company
Name : FMC Corporation
Contact person : Philip Block
Date : 12.11.2004
Street : 1735 Market Street
Town : PA 19103 Philadelphia
Country : United States
Phone : 215 299 6645
Telefax : 215 299 6272
Telex :
Cedex :
Email : philip_block@fmc.com
Homepage :

18.11.2004

Type : cooperating company
Name : Mitsubishi Gas Chemical Company, INC
Contact person : Ken Yamagishi
Date : 12.11.2004

Street : Mitsubishi Building 5-2 Marunouchi 2 chome
Town : Chiyoda-ku
Country : Japan
Phone : 81 33 283 4888
Telefax : 81 33 287 2643
Telex :
Cedex :
Email : yamagishi@mgc.co.jp
Homepage :

18.11.2004

Type : cooperating company
Name : RheinPerChemie GmbH
Contact person : Dirk Ostwald
Date : 12.11.2004
Street : Alex-Springer-Platz 2
Town : D-20354 Hamburg
Country : Germany
Phone : 49 403 2509 512
Telefax : 49 403 2509 510
Telex :
Cedex :
Email : ostwald@rheinperchemie.com
Homepage :

18.11.2004

1.0.2 LOCATION OF PRODUCTION SITE, IMPORTER OR FORMULATOR

Remark : In 2003 the estimated production amount of all three persulfates, in the countries represented by consortium members (North America, Europe, and Japan) is 65,400 tonnes per year. Europe accounts for about 42%, North America about 38% and Japan about 20%. There is also an estimated 10,000 tonnes of persulfates produced in China by a company affiliated with one of the European companies. There are no reported volumes for the individual Persulfate products.

15.12.2004

1.0.3 IDENTITY OF RECIPIENTS

1.0.4 DETAILS ON CATEGORY/TEMPLATE

Comment : Persulfates

Remark : Each persulfate salt in this group consists of a dianion (persulfate) and two identical cations. Only the cation is different for each substance: Na, K or NH4. The persulfate salts are expected to display the same environmental, ecotoxicological and toxicological behaviour.

18.11.2004

1.1.0 SUBSTANCE IDENTIFICATION

IUPAC Name : diammonium peroxodisulphate

Smiles Code : NH4-O3-S-O-O-S-O3-NH4
Molecular formula : (NH4)2S2O8
Molecular weight : 228.3
Petrol class :

06.03.2002

1.1.1 GENERAL SUBSTANCE INFORMATION

Purity type :
Substance type : inorganic
Physical status : solid
Purity : > 98 % w/w
Colour : white
Odour : odourless

18.11.2004

1.1.2 SPECTRA

1.2 SYNONYMS AND TRADENAMES

ammonium peroxydisulfate

18.11.2004

1.3 IMPURITIES

Purity : typical for marketed substance
CAS-No : 7783-20-2
EC-No : 231-984-1
EINECS-Name : ammonium sulphate
Molecular formula : (NH4)2SO4
Value : <= .3 % v/v

08.12.2004

Purity : other
CAS-No : 7732-18-5
EC-No : 231-791-2
EINECS-Name : water
Molecular formula : H2O
Value : <= .3 % v/v

19.11.2004

1.4 ADDITIVES

Purity type : other
CAS-No :
EC-No :
EINECS-Name :
Molecular formula :
Value :

Function of additive :

Remark : Most products do not contain additives. Some producers may add proprietary drying agents.

18.11.2004

1.5 TOTAL QUANTITY

Quantity : - tonnes produced in

Remark : Ca. 75,400 tonnes are produced per year of all three persulfate salts. There are no reported values for the individual salts.

2003:
Europe: 27,200 t/y
Japan: 13,600 t/y
North America: 24,600 t/y
China: 10,000 t/y

15.12.2004

1.6.1 LABELLING

Labelling : as in Directive 67/548/EEC
Specific limits :
Symbols : O, Xn, Xi,
Nota : , ,
R-Phrases : (8) Contact with combustible material may cause fire
(22) Harmful if swallowed
(36/37/38) Irritating to eyes, respiratory system and skin
(42/43) May cause sensitization by inhalation and skin contact
S-Phrases : (2) Keep out of reach of children
(22) Do not breathe dust
(24) Avoid contact with skin
(26) In case of contact with eyes, rinse immediately with plenty of water and seek medical advice
(37) Wear suitable gloves

18.11.2004

1.6.2 CLASSIFICATION

Classified : as in Directive 67/548/EEC
Class of danger : oxidizing
R-Phrases : (8) Contact with combustible material may cause fire
(22) Harmful if swallowed
(36/37/38) Irritating to eyes, respiratory system and skin
(42/43) May cause sensitization by inhalation and skin contact
Specific limits :

15.12.2004

1.6.3 PACKAGING

Memo : Fiber drums, poly bags or IBC (supersacks)

18.11.2004

1.7 USE PATTERN

Remark : Approximately 80% of all persulfates are used in two industrial applications, i.e., polymerization reactions (>60%; for example in manufacture of fluorocarbon elastomers and small scale production of electrophoretic gels) and printed circuit manufacture (about 20%). Persulfates are also used as an oxidant in cosmetics and hair bleaching products; non-biocidal shock treatment in swimming pools and other recreational waters; pulp and paper board manufacture; textile processing and in the photographic industry. Since persulfates are oxidants, they could have applications in other reactions requiring an oxidizing agent.

19.01.2005

1.7.1 DETAILED USE PATTERN

Industry category : 11 Polymers industry
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : not available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application : .6
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : Persulfates function as polymerization initiators and/or depolymerizers; and as an oxidant/bleaching agent in most other applications.

18.11.2004

Industry category : 4 Electrical/electronic engineering industry
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : not available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application : .2
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

18.11.2004

Industry category : 3 Chemical industry: chemicals used in synthesis
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application :
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : No reliable data available concerning tonnage for this application.
18.11.2004

Industry category : 12 Pulp, paper and board industry
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application :
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : No reliable data available concerning tonnage for this application.
18.11.2004

Industry category : 10 Photographic industry
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application :
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : No reliable data available concerning tonnage for this application.
18.11.2004

Industry category : 13 Textile processing industry
Use category :
Extra details on use category : No extra details necessary

No extra details necessary
Emission scenario document : available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application :
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : No reliable data available concerning tonnage for this application.
18.11.2004

Industry category : 5 Personal / domestic use
Use category : 15 Cosmetics
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application : .03
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : Fraction of tonnage for application: 2-3%.
08.12.2004

Industry category : 15/0 other
Use category :
Extra details on use category : No extra details necessary
No extra details necessary
Emission scenario document : not available
Product type/subgroup :
Tonnage for Application :
Year :
Fraction of tonnage for application : .01
Fraction of chemical in formulation :
Production : :
Formulation : :
Processing : :
Private use :
Recovery :

Remark : Non-biocidal shock treatment of swimming pool and other recreational waters.
15.12.2004

Remark : In the Nordic Countries (Norway, Sweden and Denmark) the persulfates are used in the production of chemicals products, metal coating, the paper industry, the textile industry, the paint industry and in construction. The substances are mainly used as oxidizers and process regulators.
15.12.2004 (1)

1.7.2 METHODS OF MANUFACTURE

Origin of substance : Synthesis
Type : Production

Remark : Ammonium persulfate is produced in electrolytic cells using ammonium sulfate as starting material. The electrolyte removed from the cell containing the persulfate product is concentrated and crystallized in a proprietary vacuum crystallization process to produce the final solid persulfate product. The solid is dried to remove moisture, then packaged in polybags, fiber drums or IBCs (supersacks), ready for shipment.

16.12.2004

1.8 REGULATORY MEASURES

1.8.1 OCCUPATIONAL EXPOSURE LIMIT VALUES

Type of limit : TLV (US)
Limit value : .1 mg/m3
Short term exposure limit value
Limit value :
Time schedule : 8 hour(s)
Frequency : times

Remark : Belgium: TLV = 1.0 mg/m3
Germany: (MAK) OEL = 6 mg/m3

18.11.2004

1.8.2 ACCEPTABLE RESIDUES LEVELS

1.8.3 WATER POLLUTION

Classified by :
Labelled by :
Class of danger : 1 (weakly water polluting)

Remark : Weakly water polluting, product is expected to degrade in water forming sulfate salts.

18.11.2004

1.8.4 MAJOR ACCIDENT HAZARDS

18.11.2004

1.8.5 AIR POLLUTION

1.8.6 LISTINGS E.G. CHEMICAL INVENTORIES

Remark : TSCA (USA), WHMIS (Canada), AICS (Australia), ENCS (Japan), KE Korea), PICCS (Philippines), EINECS (Europe).

09.12.2004

1.9.1 DEGRADATION/TRANSFORMATION PRODUCTS

Type : combustion products
CAS-No :
EC-No :
EINECS-Name :
IUCLID Chapter :

Remark : Gaseous oxides of nitrogen, sulfur and oxygen upon combustion (nitrogen dioxide CAS 10102; sulfur dioxide CAS 7446-09-5; oxygen CAS 7782-44-7).

1.9.2 COMPONENTS

1.10 SOURCE OF EXPOSURE

Source of exposure :
Exposure to the : Substance

Remark : Occupational exposure occurs in the manufacture of persulfates and in their use in hair dyes by professional hairdressers (CIR 2001, Leino T et al. 1999a, 1999b, Kellett and Beck. 1985). There are numerous well-documented literature reports of skin sensitisations and allergic responses by professional hairdressers (Fisher and Dooms-Goossens, 1976, Meindl and Meyer, 1969, Pankow et al, 1989). Workers in production facilities manufacturing persulfates have also reported clinical symptoms, but in most cases, these were controlled by improved occupational industrial hygiene practices (Baur and Fruhmann, 1979; Kanerva et al, 1999, Merget et al, 1997, White et al, 1982). Allergic contact dermatitis was reported on the hands of professional bakers or technicians handing flour containing persulfates and on the hands of professional hair dressers using hair products containing persulfates (CIR 2001). Exposure to persulfates from other applications is negligible.
For description of studies see section 5.10.

30.05.2005

1.11 ADDITIONAL REMARKS

1.12 LAST LITERATURE SEARCH

Type of search : Internal
Chapters covered : 3, 4, 5
Date of search : 18.08.2004

Remark : The databases searched were RTECS, Toxcenter, Biosis, Cancerlit, Medline and Embase.
The HSDB database had no listing for any of the three persulfates.

18.11.2004

2.1 MELTING POINT

Decomposition : yes, at 120 °C

Conclusion : Most reliable data available.
Reliability : (2) valid with restrictions
Handbook data are considered to be originated from a trusted source (=SAX's). Therefore this secondary literature is provided with a reliability of 2 (according to Klimisch).
Flag : Critical study for SIDS endpoint
11.10.2001 (2)

Decomposition : yes, at > 160 °C

Reliability : (4) not assignable
Secondary literature (MSDS).
11.11.2004 (3)

Remark : Thermal decomposition may be lowered by moisture, contamination of heavy metals, dust etc. and container size (< 120 degree C).
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
17.05.1994

Remark : 120 degree C (decomposition)
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
17.05.1994 (4) (5)

2.2 BOILING POINT

Remark : not applicable
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
10.05.1994

2.3 DENSITY

Type : relative density
Value : 1.982 at °C

Conclusion : Most reliable data available.
Reliability : (2) valid with restrictions
Handbook data are considered to be originated from a trusted source (=Sax). Therefore this secondary literature is provided with a reliability of 2 (according to Klimisch).
Flag : Critical study for SIDS endpoint
11.10.2001 (6) (7) (2)

Type : relative density
Value : = 1.98 at 20 °C

Reliability : (4) not assignable
Secondary literature (MSDS).
11.11.2004 (3) (8)

Type : bulk density
Value : 950 - 1050 kg/m3 at °C

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
02.02.1994 (9)

2.3.1 GRANULOMETRY

2.4 VAPOUR PRESSURE

2.5 PARTITION COEFFICIENT

2.6.1 SOLUBILITY IN DIFFERENT MEDIA

Solubility in : Water
Value : = 850 g/l at 25 °C
pH value :
concentration : at °C
Temperature effects :
Examine different pol. :
pKa : at 25 °C
Description :
Stable :

Remark : pH of 1% solution is 4.0
Conclusion : Most relevant data available.
Reliability : (4) not assignable
Secondary literature (MSDS).
Flag : Critical study for SIDS endpoint
11.10.2001 (8)

Solubility in :
Value : at °C
pH value :
concentration : at °C
Temperature effects :
Examine different pol. :
pKa : at 25 °C
Description : other: decomposes in water forming oxygen
Stable :

Reliability : (2) valid with restrictions
Handbook data are considered to be originated from a trusted source (=Sax). Therefore this secondary literature is provided with a reliability of 2 (according to Klimisch).
11.11.2004 (2)

Solubility in : Water
Value : = 559 g/l at 20 °C

pH value :
concentration : at °C
Temperature effects :
Examine different pol. :
pKa : at 25 °C
Description :
Stable :

Remark : pH of 250 g/l solution is 2.3 at 20 C.
Reliability : (4) not assignable
Secondary literature (MSDS).
11.11.2004 (3)

Solubility in :
Value : = 559 g/l at 20 °C
pH value : = 2 - 2.5
concentration : 250 g/l at 20 °C
Temperature effects :
Examine different pol. :
pKa : at 25 °C
Description :
Stable :

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
16.05.1994 (9)

Solubility in :
Value : = 510 g/l at 25 °C
pH value :
concentration : at °C
Temperature effects :
Examine different pol. :
pKa : at 25 °C
Description :
Stable :

Remark : Literature could not be retrieved.
pH = 4 - 6 for 1 % solution
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
16.05.1994 (10)

2.6.2 SURFACE TENSION

2.7 FLASH POINT

Method : other
Year :
GLP :
Test substance :

Remark : non-combustible
21.12.2004

2.8 AUTO FLAMMABILITY

Method : other
Year :
GLP :
Test substance :

Remark : No combustion up to 800 degrees C.
Reliability : (4) not assignable
Secondary literature (MSDS).

11.11.2004 (11)

2.9 FLAMMABILITY

2.10 EXPLOSIVE PROPERTIES

Remark : On decomposition releases oxygen which may intensify fire.
Reliability : (4) not assignable
Secondary literature (MSDS).

11.11.2004 (3) (8)

2.11 OXIDIZING PROPERTIES

Remark : Test substance is an oxidizer.
Reliability : (4) not assignable
Secondary literature (MSDS).

11.11.2004 (3) (8)

Result : other: oxidizing properties

Remark : Literature could not be retrieved.
Yes, oxidizing properties (according to Dir. 67/548/EEC and amendments, EEC A17 test)
Yes, oxidizing properties (according to UN transportation regulation; UN-test)
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

29.05.1994 (12)

2.12 DISSOCIATION CONSTANT

2.13 VISCOSITY

2.14 ADDITIONAL REMARKS

Remark : Dangerous decomposition products: sulfur dioxide, sulfur trioxide, nitrogen oxide and nitrogen dioxide
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

16.05.1994 (9)

3.1.1 PHOTODEGRADATION

3.1.2 STABILITY IN WATER

Type : abiotic
t1/2 pH4 : at °C
t1/2 pH7 : at °C
t1/2 pH9 : at °C

Remark : Hydrolysis: in alkaline, neutral and dilute acid solutions persulfate decomposes according to reaction (1) while in strongly acid solutions reactions (2) and (3) occur:
S2O8(-) + H2O --> 2HSO4(-) + 1/2 O2 (1)
H2S2O8 + H2O --> H2SO5 + H2SO4 (2)
H2SO5 + H2O --> H2O2 + H2SO4 (3)
Literature could not be retrieved.

Koltoff and Miller (1951) measured the rates of decomposition in water for potassium persulfate at various pH's. Since the decomposition (hydrolysis) rate is first order, the half life is independent of initial concentration. Half lives of potassium persulfate at 50 deg C as a function of pH were calculated from data in the Koltoff and Miller (1951) report, indicated below.

pH	1.0	1.6	3.0	7.0	10.0
Half Life (hours)	20	65	120	130	210

The mechanism of decomposition (hydrolysis), described in detail by Koltoff and Miller (1951) for dilute persulfate solutions, was also confirmed for saturated persulfate solutions using isothermal microwatt calorimetry. The main kinetic mechanism begins with homolytic cleavage of persulfate to form sulfate ion radicals. These radicals initiate a series of propagating reactions producing hydroxyl radicals, which ultimately produce hydrogen peroxide and a solution of acid sulfate. The net reaction is:
(S2O8)2- + H2O gives 1/2O2 + 2(SO4)2- + 2H+

The rate equation was described as having two terms once the solution became sufficiently acid:

-d[(S2O8)2-]/dt = k1(H2O)((S2O8)2-) + k2 (H+)((S2O8)2-)

Koltoff and Miller (1951) evaluated the rate constant for the acid-catalyzed term, k2, and it was determined to be 3.5 x 10-3 min-1 (m/l)-1. This term becomes dominant at low pH's.

From its temperature-dependence of the rate constant for a sample of ammonium persulfate containing various amounts of water, the activation energy of 33.9 kcal/mole for this sample was determined to be identical to the value reported by Kolthoff and Miller (1951) for dilute solutions. This suggests that the kinetic mechanism is independent of the persulfate concentration and values measured for potassium persulfate are indicative for ammonium persulfate. (see also stability in water in potassium persulfate IUCLID data set).

Reliability : (2) valid with restrictions
Flag : Critical study for SIDS endpoint
21.12.2004 (13) (14)

Deg. product :
Method : other
Year :

GLP :
Test substance :

Remark : Aqueous solution decomposes at ambient temperature.
Conclusion : Most reliable data available.
Reliability : (2) valid with restrictions
21.12.2004 (7)

Deg. product :
Method : other
Year :
GLP :
Test substance :

Remark : Test substance becomes unstable in presence of heat, moisture and contamination.
Reliability : (4) not assignable
Secondary literature (MSDS).
21.12.2004 (3) (8)

3.1.3 STABILITY IN SOIL

Remark : Decomposition of the crystals or powder occurs under moist conditions or at higher temperatures, and when heated to decomposition (120 degree C) toxic fumes of SOx are emitted.
Literature could not be retrieved.
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (4) (5)

3.2.1 MONITORING DATA

3.2.2 FIELD STUDIES

3.3.1 TRANSPORT BETWEEN ENVIRONMENTAL COMPARTMENTS

3.3.2 DISTRIBUTION

3.4 MODE OF DEGRADATION IN ACTUAL USE

Remark : During use oxygen could be formed. Degradation produces sulfate and at elevated temperatures pyrosulfate.
Literature could not be retrieved.
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (10)

Remark : During use oxygen is transfered or can be released.
Degradation products in the environment are finally ammonium

(NH4)+ and sulphate ions (for more references see data set on ammonium sulphate, CAS-no.: 7783-20-2).

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

31.05.1994

3.5 BIODEGRADATION

3.6 BOD5, COD OR BOD5/COD RATIO

COD
Method : other: EEC 84/449, L251 (1984); NEN 6633
Year : 1987
COD : = 26 mg/g substance
GLP : yes

Remark : apparent COD-value due to oxidation of forming H2O2 in oxygen.
Literature could not be retrieved.
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
Test substance : at least 99 %
19.11.2004 (15)

BOD5
Method :
Year :
Concentration : related to
BOD5 : = 0 mg/l
GLP : no data

Remark : Literature could not be retrieved.
the test substance is an oxygen source itself, which could reduce BOD and COD.
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (16)

3.7 BIOACCUMULATION

Remark : Literature could not be retrieved.
The substance is not expected to bioaccumulate in cell systems (see 2.6; water solubility).
Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004

4.1 ACUTE/PROLONGED TOXICITY TO FISH

Type	:	static
Species	:	Oncorhynchus mykiss (Fish, fresh water)
Exposure period	:	96 hour(s)
Unit	:	mg/l
LC50	:	76.3
Limit test	:	
Analytical monitoring	:	yes
Method	:	EPA OPP 72-1
Year	:	
GLP	:	yes
Test substance	:	

Method :

TEST ORGANISMS
- Species: Oncorhynchus mykiss
- Supplier: Mt. Lassen Trout Farm, Red Bluff, CA
- Age/weight/loading: juveniles of 200-600 mg
- Feeding (pretreatment): Trout chow until 24-48 hours prior to testing
- Feeding during test: none

STOCK AND TEST SOLUTION AND THEIR PREPARATION
- Other procedures: test solutions were prepared from a stock solution of 10 g/L prepared in filtered deionised well water

DILUTION WATER
- Source: Well located near the test facility (Florida, USA)
- Chemistry (Alkalinity 264-273 mg CaCO3/L; Hardness 275 mg CaCO3/L; TOC 2.1 mg/L; TSS <4 mg/L; pH 7.0-8.0; Conductance 440 umhos/cm)

TEST SYSTEM
- Test type: static
- Concentrations: 0, 13, 22, 36, 60 and 100 mg/L (nominal)
- Exposure vessel type: 25 L glass exposure chambers (covered) containing 10 L of water or test solution
- Number of fish: 10 per replicate, 2 replicates/treatment
- Photoperiod: 16 hours light

PHYSICAL MEASUREMENTS
- Measuring times: Daily
- Test temperature: 13-14 C
- Dissolved oxygen: 78-93%
- pH: 7.9-8.5
- Adjustment of pH: no

DURATION OF THE TEST: 96 hours

TEST PARAMETER: mortality/behavioral changes
OBSERVATION TIMES: Daily

ANALYSES:
- Method: spectrophotometrically using CHEMets Kit No. K-7870. This kit consists of self-filling ampoules containing ammonium biocyanate and ferrous iron in an acidic solution. When reacted with persulphate a red-orange ferric thiocyanate complex was formed which has a maximum absorbance at 460 nm. A standard curve was generated with five concentrations ranging from 5-100 mg/L ammonium

persulphate in well water (r2 = 0.998). LOQ 5 mg/L.
Validation samples of 10 and 100 mg/L showed recoveries of respectively 110 and 96%
- Sampling times: At 0 h (replicate A) and at 96 hours (replicate B) for all concentrations.

STATISTICAL METHOD: Stephan, C.E., 1977 In Aquatic Toxicology and Hazard Evaluation, ASTM STP 634, Philadelphia, pp.65-84.

Remark : The study was also performed in agreement with ASTM 1980, Standard practice for conducting acute toxicity tests with fishes, macroinvertebrates, and amphibians, publication E729-80.

Result : RESULTS:
- Nominal concentrations (mg/L): 0, 13, 22, 36, 60, 100
- Measured concentrations (mg/L): ND*, 12, 22, 37, 61, 100
- Mortality [%]: 0, 30, 30, 40, 10, 95, respectively
- Other effects: erratic swimming behavior of several fish in 60 mg/L and loss of equilibrium of 1 fish in 100 mg/L at 96 hours
- Dose related effects: yes

*ND: not detected

Test substance : CAS 7727-54-0 (ammonium persulfate), purity 99.1%.

Conclusion : 96 h LC50 76.3 mg/L (95% CI 61-100 mg/L)
Most sensitive, reliable LC50.

Reliability : (1) valid without restriction
The test is performed under GLP with the following exception: periodic analyses of dilution water and trout food for the presence of pesticides, hydrocarbons and heavy metals was not carried out in complete compliance with GLP.

Flag : Critical study for SIDS endpoint

21.12.2004 (17)

Type : static
Species : Lepomis macrochirus (Fish, fresh water)
Exposure period : 96 hour(s)
Unit : mg/l
LC50 : 103
Limit test :
Analytical monitoring : yes
Method : EPA OPP 72-1
Year :
GLP : yes
Test substance :

Method : TEST ORGANISMS
- Species: Lepomis macrochirus
- Supplier: Shongaloo Fisheries, Waldo, FL
- Age/weight/loading: juveniles of 100-400 mg, 0.5 g/L
- Feeding (pretreatment): Combination of trout chow, brine shrimp, flake food until 24-48 hours prior to testing
- Feeding during test: none

STOCK AND TEST SOLUTION AND THEIR PREPARATION
- Other procedures: test solutions were prepared from a stock solution of 10 g/L prepared in filtered deionised well water

DILUTION WATER
- Source: Well located near the test facility (Florida, USA)
- Chemistry (Alkalinity 264 mg CaCO3/L; Hardness 275 mg CaCO3/L; TOC 2.1 mg/L; TSS <4 mg/L; pH 7.0-7.8; Conductance

520 umhos/cm)

TEST SYSTEM
- Test type: static
- Concentrations: 0, 13, 22, 36, 60 and 100 mg/L (nominal)
- Exposure vessel type: 12 L glass exposure chambers (covered) containing 5 L of water or test solution
- Number of fish: 10 per replicate, 2 replicates/treatment
- Photoperiod: 16 hours light
PHYSICAL MEASUREMENTS
- Measuring times: Daily
- Test temperature: 22 C
- Dissolved oxygen: 65-100% except for the 72 hour-value in one replicate of the highest dose group (53%). From 72 hours on all test vessels were aerated.
- pH: 7.7-8.4
- Adjustment of pH: no

DURATION OF THE TEST: 96 hours

TEST PARAMETER: mortality/behavioral changes
OBSERVATION TIMES: Daily

ANALYSES:
- Method: spectrophotometrically using CHEMets Kit No. K-7870. This kit consists of self-filling ampoules containing ammonium biocyanate and ferrous iron in an acidic solution. When reacted with persulphate a red-orange ferric thiocyanate complex was formed which has a maximum absorbance at 460 nm. A standard curve was generated with five concentrations ranging from 5-100 mg/L ammonium persulphate in well water (r2 = 0.998). LOQ 5 mg/L. Validation samples of 10 and 100 mg/L showed recoveries of respectively 110 and 96%
- Sampling times: At 0 h (replicate A) and at 96 hours (replicate B) for all concentrations.

STATISTICAL METHOD: Stephan, C.E., 1977 In Aquatic Toxicology and Hazard Evaluation, ASTM STP 634, Philadelphia, pp.65-84.

Remark : The study was also performed in agreement with ASTM 1980, Standard practice for conducting acute toxicity tests with fishes, macroinvertebrates, and amphibians, publication E729-80.

Result : RESULTS:
- Nominal concentrations (mg/L): 0, 13, 22, 36, 60, 100
- Measured concentrations (mg/L): ND*, 12, 22, 37, 63, 103
- Mortality [%]: 0, 0, 0, 0, 5, 50, respectively
- Other effects: lethargic or gyrating behaviour in 2 of 10 fish at 100 mg/L
- Dose related effects: yes

*ND: not detected

Test substance : CAS 7727-54-0 (ammonium persulfate), purity 99.1%.

Conclusion : 96-h LC50 103 mg/L (95% CI 63 mg/L-infinity)

Reliability : (1) valid without restriction
1. The oxygen level fell below 60% of air saturation at 72 hours in one replicate of the highest test concentration (53%). Thereafter all test vessels were aerated and the oxygen level increased to reach values above 60%.
2. The test is performed under GLP with the following exception: periodic analyses of dilution water and bluegill food for the presence of pesticides, hydrocarbons and heavy metals was not carried out in complete

compliance with GLP.

21.12.2004 (18)

Type	:	semistatic
Species	:	Poecilia reticulata (Fish, fresh water)
Exposure period	:	96 hour(s)
Unit	:	mg/l
LC50	:	323
Method	:	OECD Guide-line 203 "Fish, Acute Toxicity Test"
Year	:	1988
GLP	:	yes
Test substance	:	

Method :

TEST ORGANISMS
- Species: Poecilia reticulata
- Supplier: Bred at test facility NOTOX, The Netherlands
- size: 10-30 mm
- Feeding (pretreatment): Once a day with Tetramin and Tetraphyl (1:1) discontinued 24 hours prior to the start of the test
- Feeding during test: no

STOCK AND TEST SOLUTION AND THEIR PREPARATION
- Vehicle, solvent: None
- Other procedures: Test substance was dissolved in water with the aid of ultra sonication

DILUTION WATER
- Source: Dutch standard water according to Adema, 1980.
- Chemistry: Alkalinity; Hardness 199 mg CaCO3/L;pH 8.2 (before aeration)

TEST SYSTEM
- Test type: semi-static
- Concentrations: 0, 100, 180, 320, 560, 1000
- Renewal of test solution: at 24, 48 and 72 hours
- Exposure vessel type: 1 L glass vessels
- Number of fish: 5 per replicate, 2 replicates/treatment
- Photoperiod: Probably 14 hours

PHYSICAL MEASUREMENTS
- Measuring times: At 0 h (fresh); at 24, 48 and 72 h (fresh and aged) and at 96 h (aged)
- Test temperature: Probably 23+/-2 C (not measured)
- Dissolved oxygen: >=72%
- pH: 7.6-8.4
- Adjustment of pH: no

DURATION OF THE TEST: 96 hours

TEST PARAMETER: mortality and behavioral changes
OBSERVATION TIMES: 2, 24, 48, 72, 96 hours

ANALYSES: not performed

STATISTICAL METHOD: Probit analysis (Finney, 1971)

Result : RESULTS:
- Nominal concentrations (mg/L): 0, 100, 180, 320, 560, 1000
- Mortality [%]: 0, 0, 0, 40, 100, 100, respectively
- Other effects: Increased pigmentation (>=180 mg/L), incidental decreased swimming ability (>=320 mg/L), only reaction when touching the caudal peduncle (1 fish at 320

mg/L and 1 fish at 1000 mg/L)
- Dose related effects: yes

Test substance : CAS 7727-54-0 (ammonium persulfate), purity >=99%.
Conclusion : 96 h LC50 323 mg/L (95% CI 285-405 mg/L)
Reliability : (2) valid with restrictions
No analyses were performed to confirm the nominal test concentrations. This lowers the study reliability.

21.12.2004 (19)

4.2 ACUTE TOXICITY TO AQUATIC INVERTEBRATES

Type : static
Species : Daphnia magna (Crustacea)
Exposure period : 48 hour(s)
Unit : mg/l
EC50 : 120
Analytical monitoring : yes
Method : EPA OPP 72-2
Year :
GLP : yes
Test substance :

Method : TEST ORGANISMS
- Species: Daphnia magna
- Source/supplier: Environmental Science & Engineering, Inc., Gainesville, Florida, USA
- Breeding method: laboratory bred
- Age: <24 hours
- Feeding (pretreatment): Synthetic food composed of yeast, trout chow, cereal leaves
- Feeding during test: no

STOCK AND TEST SOLUTION AND THEIR PREPARATION
- Other procedures: test solutions were prepared from a stock solution of 10 g ammonium persulfate/L in filtered, dionized, well water.

DILUTION WATER
- Source: Reconstituted well water (Gainesville, Florida)
- Chemistry: Hardness 169 mg CaCO3/L; Alkalinity 119 mg CaCO3/L; Conductivity 560 umhos/cm; pH 8.4

TEST SYSTEM
- Test type: static
- Concentrations: 0, 39, 65, 108, 180, 300 mg/L
- Exposure vessel type: (covered) glass cylinders (d 100 mm, h 50 mm) containing 250 mL dilution water or test solution
- Number of individuals: 10 per replicate, 2 replicates/treatment
- Photoperiod (intensity of irradiation): 16 hours (1183 lux)

PHYSICAL MEASUREMENTS
- Measuring times: 0, 24, 48 h
- Test temperature: 21-22 C
- Dissolved oxygen: 96-101%
- pH: 8.0-8.4
- Adjustment of pH: no

DURATION OF THE TEST: 48 hours

TEST PARAMETER: Immobility/behavioral changes
OBSERVATION TIMES: 24, 48 h

ANALYSES:
- Method: spectrophotometrically using CHEMets Kit No. K-7870. This kit consists of self-filling ampoules containing ammonium biocyanate and ferrous iron in an acidic solution. When reacted with persulphate a red-orange ferric thiocyanate complex was formed which has a maximum absorbance at 460 nm. A standard curve was generated with five concentrations ranging from 5-100 mg/L ammonium persulphate in well water (r2 = 0.998). LOQ 5 mg/L. Validation samples of 10 and 100 mg/L showed recoveries of respectively 110 and 96%
- Sampling times: At 0 h (replicate A) and at 48 hours (replicate B) for all concentrations.

STATISTICAL METHOD: Stephan, C.E., 1977 In Aquatic Toxicology and Hazard Evaluation, ASTM STP 634, Philadelphia, pp.65-84.

Result : RESULTS:
- Nominal concentrations (mg/L): 0, 39, 65, 108, 180, 300
- Measured concentrations (mg/L): ND*, 41, 68, 109, 185, 313
- Immobility [%]: 0, 0, 15, 20, 95, 100, respectively
- Other effects: Lethargic behavior at 108-300 mg/L
- Dose related effects: yes

Test substance : CAS 7727-54-0 (ammonium persulfate), purity 99.89%.

Conclusion : 48 h EC50 120 mg/L (95% CI 103-139 mg/L)
Most sensitive, reliable EC50.

Reliability : (1) valid without restriction
1. The test is performed under GLP with the following exception: periodic analyses of dilution water and daphnid food for the presence of pesticides, hydrocarbons and heavy metals was not carried out in complete compliance with GLP.

Flag : Critical study for SIDS endpoint

21.12.2004 (20)

Type : static
Species : Daphnia magna (Crustacea)
Exposure period : 24 hour(s)
Unit : mg/l
EC50 : 357
Analytical monitoring : no
Method : OECD Guide-line 202
Year : 1984
GLP : yes
Test substance :

Method : TEST ORGANISMS
- Species: Daphnia magna
- Source/supplier: NOTOX, The Netherlands
- Breeding method: laboratory bred (19+/-1 C, 16 h light, batches start with Daphnids of <3 days old and cultures >4 weeks were discarded).
- Age: <24 hours
- Feeding (pretreatment): Daily with a suspension of Chlorella pyrenoidosa
- Feeding during test: no

STOCK AND TEST SOLUTION AND THEIR PREPARATION
Ammonium persulfate was dissolved directly in water within 3 hours before

start of the test.

DILUTION WATER
- Source: Dutch Standard Water formulated according to Adema, 1980.
- Chemistry: Hardness 199 mg CaCO3/L; sum Mg and Ca 2.1 mmol/L; Ca/Mg ratio 1.9:1; Na/K ratio 6:1; pH 8.2 +/- 0.2

TEST SYSTEM
- Test type: static
- Concentrations: 0, 100, 180, 320, 560, 1000 mg/L
- Exposure vessel type: 100 mL glass vessels
- Number of individuals: 10 per replicate, 2 replicates/treatment
- Photoperiod: 16 hours
PHYSICAL MEASUREMENTS
- Measuring times: 0, 24 h
- Test temperature: 19-20 C
- Dissolved oxygen: 90-102%
- pH: 7.7-8.3
- Adjustment of pH: no

DURATION OF THE TEST: 24 hours

TEST PARAMETER: immobilisation
OBSERVATION TIMES: 24 hours

ANALYSES: not performed

REFERENCE SUBSTANCE: 48 h immobilisation test with K2Cr2O7 at concentrations 0-3.2 mg/L was performed in parallel with the test with ammonium persulphate.

STATISTICAL METHOD: Probit analysis (Finney, 1971)

Result : RESULTS:
- Nominal concentrations (mg/L): 0, 100, 180, 320, 560, 1000
- Immobility [%]: 0, 0, 0, 20, 100, 100, respectively
- Dose related effects: yes

RESULTS: TEST WITH REFERENCE SUBSTANCE
24 h EC50 1.1 mg/L
48 h EC50 0.6 mg/L

Test substance : CAS 7727-54-0 (ammonium persulfate), purity not specified.
Conclusion : 24 h EC50 357 mg/L (95% CI 312-448 mg/L)
Reliability : (2) valid with restrictions
No analyses were performed during this test to confirm the nominal test concentrations. OECD 202 does not require analyses, but since there is also no information on the purity of the test substance, the study reliability is lowered.

21.12.2004 (21)

Type : static
Species : Palaemonetes pugio (Crustacea)
Exposure period : 96 hour(s)
Unit : mg/l
EC50 : 391
Analytical monitoring : yes
Method : EPA OPP 72-3
Year :

GLP : yes
Test substance :

Method : TEST ORGANISMS
- Species: Palaemonetes pugio (0.06-0.15 g at test end)
- Supplier: Aquatic Indicators, St. Augustine, FL
- Feeding during test: no

STOCK AND TEST SOLUTION AND THEIR PREPARATION
- A stock solution containing 10 g/L test substance was prepared in filtered deionized well water.

DILUTION WATER
- Source: Atlantic Ocean water near Whitney Laboratory, Marineland, FL (salinity adjusted with well water to 20 ppt)
- Chemistry: alkalinity 183 mg/L CaCO3

TEST SYSTEM
- Test type: static
- Concentrations: 78, 130, 216, 360, 600 mg/L (no vehicle), untreated controls.
- Exposure vessel type: 25 L glass jars (covered, shrimps were individually caged in screen cups) and containing 10 L of solution
- No. of shrimps: 1/screen cup, 10 screen cups/replicate, 2 replicates/treatment.
- Photoperiod: 16 h light

PHYSICAL MEASUREMENTS
- Measuring times: daily for all test vessels
- Test temperature: 20-21°C
- Dissolved oxygen: 87-98%
- pH: 7.9-8.3
- Salinity: 20-21 ppt

DURATION OF THE TEST: 96 h

TEST PARAMETER: Mortality/symptoms

OBSERVATION TIMES: 24, 48, 72, 96 h

ANALYSES: At 0 (repl. A) and 96 h (repl. B) from all concentrations by colorimetric reaction followed by spectrophotometrical analysis.

STATISTICAL METHOD: Stephan, C.E., 1977 In Aquatic Toxicology and Hazard Evaluation, ASTM STP 634, Philadelphia, pp.65-84.

Remark : The study was also performed in agreement with ASTM 1980, Standard practice for conducting acute toxicity tests with fishes, macroinvertebrates, and amphibians, publication E729-80.

Result : Mortality at the measured concentrations 0, 79, 137, 224, 348 and 584 mg/L were respectively 0, 15, 5, 10, 30 and 100%. No behavioral changes were reported.

Analytical results: Calibration curve with r2=0.999.
Validation samples of 10 and 100 mg/L showed recoveries of 102-105%.
Mean measured test concentrations were 97-101% of nominal.

Test substance : CAS 7727-54-0 (ammonium persulfate), purity 99.89%.
Conclusion : 96 h LC50 391 mg/L (95% CI 348-584 mg/L)
Reliability : (1) valid without restriction

1. Non-key study (saltwater organism).
2. GLP-study with the following exception: the periodic analysis of dilution water and shrimp food was not carried out in complete compliance with GLP.
3. Two version of page 8 were included. One provided the theoretical purity of the test substance (=99.1%) and the other provided the experimental purity (=99.89%). In this summary the measured value is included.

21.12.2004 (22)

Type	:	
Species	:	Daphnia magna (Crustacea)
Exposure period	:	48
Unit	:	mg/l
EC50	:	ca. 120
Method	:	other
Year	:	
GLP	:	
Test substance	:	

Remark : Literature could not be retrieved.
Type of test : static
Test substance: no data
Method : Bringmann, Kuehn (1959)
pH: 7,5; temp.: 23 degree C
GLP : no

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (23)

4.3 TOXICITY TO AQUATIC PLANTS E.G. ALGAE

Species	:	Selenastrum capricornutum (Algae)
Endpoint	:	biomass
Exposure period	:	120 hour(s)
Unit	:	mg/l
NOEC	:	39.2
72h-EC50	:	= 83.7
Limit test	:	
Analytical monitoring	:	yes
Method	:	OECD Guide-line 201 "Algae, Growth Inhibition Test"
Year	:	1984
GLP	:	yes
Test substance	:	

Method : TEST ORGANISMS
- Species: Selenastrum capricornutum
- Source/supplier: University of Texas, Austin (1989)
- Laboratory culture: yes, since 1989 until study (1998) kept at performing lab
- Method of cultivation: cultured on freshwater algal medium (ASTM, 1990), continuous illumination (~3333 lux), 24+/-2 C
- Pretreatment: 5 day old inoculum culture
- Initial cell concentration: 3000 cells/mL

STOCK AND TEST SOLUTION AND THEIR PREPARATION
Direct addition of test substance to the 600 mL volumes of freshwater algal media.

DILUTION WATER
- Source: deionised water (reconstituted)

GROWTH/TEST MEDIUM CHEMISTRY
- Chemistry: not specified, reported to be reconstituted in accordance with ASTM (1990)
- pH: 7.5+/-0.1

TEST SYSTEM
- Test type: static
- Concentrations: 0, 23, 39, 65, 108, 180, 300 mg/L
- Exposure vessel type: 250 mL glass Erlenmeyer flasks containing 100 mL of medium
- Number of replicates: 3 for treatments, 6 for control
- Photoperiod (intensity of irradiation): continuous illumination (2567-3947 lux)
PHYSICAL MEASUREMENTS
- Test temperature: 23-25 C (daily, 1 parallel uninoc. flask)
- pH: 7.4-7.5* (start), 7.2-7.3 (72 h), 6.5-6.8 (120 h, 300 mg/L), 6.9-7.5 (120 h, 39-180 mg/L), 7.4-7.8 (120 h, 23 mg/L), 8.1-9.7 (120 h, control)
* The pH was adapted from 6.9-7.5 to 7.4-7.5 at t=0

DURATION OF TEST: 120 hours

TEST PARAMETER: cell counts (electronic particle counter)
OBSERVATION TIMES: 24, 48, 72, 96, 120 h

ANALYSES:
- Method: Colorimetric analysis at 460 nm with a spectrophotometer (corrected for blank values). A calibration curve was generated with five concentrations ranging from 5-59 mg/L ammonium persulphate in algae medium (r2 = 0.999). LOD/LOQ 1.56/4.11 mg/L. Validation samples of 10 and 592 mg/L showed recoveries of respectively 98 and 104%. QCs spiked at 20 and 300 mg/L showed recoveries of 98-101%.
- Sampling times: 0, 72 (extra inoculated flasks (parallel)), 120 h

STATISTICAL METHOD: Probit analyses, ANOVA, Dunnett's procedure

Result : RESULTS:
- Nominal concentrations (mg/L): 0, 23, 39, 65, 108, 180, 300
- Measured concentrations (mg/L): <1.6, 24, 39, 64, 106, 185, 313
- Cell density data: see attached document
- Inh. growth rate (% of control-120 h): 0, -2, 21, 28, 41, 50, 71
- Inh. biomass (AUC-72 h) (% of control): 0, 20, 24, 50, 52, 70, 83

GROWTH FACTOR CONTROL: 52 after 72 h; 687 after 120 h

STATISTICAL RESULTS: At 72 hours the cell numbers at treatments 65-300 mg/L are significantly reduced when compared to the control treatment. At 120 hours significant reduction is seen at all test concentrations except for the lowest test concentration (23 mg/L).

Test substance : CAS 7727-54-0 (ammonium persulfate), purity 98.7%.

Attached document : see ref14.xls and ref14A.xls

Conclusion	:	72 h EbC50 83.7 mg/L (95% CI 72-98 mg/L) 120 h ErC50 154 mg/L (95% CI 125-201 mg/L) Only study available.
Reliability	:	(1) valid without restriction 1. Because the calculation of the inhibition on growth rate and biomass was not in accordance with the method used by OECD 201, the reviewer recalculated the EC50 values using log-linear regression analysis. This resulted in 120 h EbC50 of 114 mg/L (95% CI 61-212 mg/L) and 120 h ErC50 >296 mg/L. In the attached document the percentages of inhibition calculated in accordance with OECD 201 and used for the recalculation of the EC50 values are included. The values for 72 hours exposure are presented, because these are the standard values according to OECD 201. 2. Rises in pH of maximal 2 units in the control were probably associated with CO2 depletion from test media due to cell growth and do not invalidate the test. 3. The pH was elevated before the start of the test from 6.9-7.3 to 7.4. Since the adaptation was limited the study reliability was not lowered. 4. There was insufficient information on the composition of the algae medium (reported to be in accordance with ASTM, 1990). Since however an adequate control growth was observed, the study reliability was not lowered.
Flag	:	Critical study for SIDS endpoint

21.12.2004 (24)

Species	:	Scenedesmus quadricauda (Algae)
Endpoint	:	growth rate
Exposure period	:	96
Unit	:	mg/l
EC10	:	= 33
Method	:	other: Bringmann, Kuehn
Year	:	1959
GLP	:	no
Test substance	:	no data
Remark	:	Literature could not be retrieved.
Source	:	Degussa AG Frankfurt am Main EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
Test condition	:	pH 7.5; 24 degree C; type of test: static

19.11.2004 (23)

Species	:	other aquatic plant: Myriophyllum spicatum (Eurasian watermilfoil)
Endpoint	:	growth rate
Exposure period	:	
Unit	:	mg/l
EC50	:	= 13.2 - 16.2
Limit test	:	
Analytical monitoring	:	no data
Method	:	other: no data
Year	:	
GLP	:	no data
Test substance	:	no data
Remark	:	IC50 (root-weight/length; stem-weight/length): 13.2 - 16.2 mg/l (as NH4); no further data Literature could not be retrieved.
Source	:	Degussa AG Frankfurt am Main EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (25)

4.4 TOXICITY TO MICROORGANISMS E.G. BACTERIA

Type	:	aquatic
Species	:	Pseudomonas putida (Bacteria)
Exposure period	:	18 hour(s)
Unit	:	mg/l
EC10	:	36
Analytical monitoring	:	no
Method	:	other: Umweltsbundesamt (UBA) Guidelines: Bewertung wassergefaehrdender Stoffe, III Bestimmung der akuten Bakterientoxizitaet, Ad-hoc-Arbeidsgruppe I (Obmann Dr. Niemitz), LTwS, Nr. September 1979.
Year	:	1979
GLP	:	yes
Test substance	:	
Method	:	A stock solution of ammonium persulphate was prepared in water (conc. 100 mg/l, pH 7.0). Test solutions (100 mL) were prepared by adding together the required volume of (diluted) stock solution, nutrient medium, water and 10 ml of inoculum of Pseudomonas putida. Test concentrations were 6E-6, 2E-5, 9E-5, 4E-4, 2E-3, 6E-3, 0.02, 0.1, 0.4, 1.6, 6.3, 25 and 100 mg/L. Three parallel series of 13 flasks (one flask for each concentration), 10 blank flasks (without test substance), 13 abiotic control flasks (without inoculum) and positive control (5 flasks: 4938, 9875, 19750, 39500, 79000 mg methanol/L) were incubated for 18±2 h at 25°C. At the end of the test, the extinction (436 nm) was measured.
Result	:	Inhibition [%] at 6E-6-25 mg/L <=2% and at 100 mg/L 66% Reference substance: EC10 20611 mg/L (literature: 6600 mg/L).
Test substance	:	CAS 7727-54-0 (ammonium persulfate), purity not indicated.
Conclusion	:	18-h EC10 36 mg/L.
Reliability	:	(3) invalid 1. There was no information on the pH during the test, the test medium used differed slightly from the medium described in DIN 38412 Teil 8 (1991). 2. The growth factor could not be deduced from the report (DIN 38 412 Teil 8: 100 after 18 h). The positive control was reported to fall within the acceptable range (EC10 20611 mg/L; literature EC10 6600 mg/L). The study reliability was lowered, because it cannot be excluded that the growth factor was sub-optimal (DIN 38412 Teil 8). 3. The study was probably conducted in accordance with the guidelines at that time, but is not in compliance with the current standards.

21.12.2004 (26)

Type	:	
Species	:	Escherichia coli (Bacteria)
Exposure period	:	24
Unit	:	mg/l
EC10	:	= 1000
NOEC	:	< 1000
Method	:	other
Year	:	
GLP	:	
Test substance	:	
Remark	:	Literature could not be retrieved.

Remark : EC10 (48 h) = 1000 mg/l
NOEC (48 h) < 1000 mg/l
Test substance: no data
Type of test : static
Method : Bringmann, Kuehn (1959)
pH: 7,5, temp.: 27 degree C
GLP : no

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (23)

Type :
Species : other bacteria: Brevibacterium thiogenitalis (ATCC 19240)
Exposure period : 48
Unit : mg/l
NOEC : = 20
Method : other
Year :
GLP :
Test substance :

Remark : Literature could not be retrieved.
Remark: L-glutamic acid forming bacterium
Effect: increased formation of L- glutamic acid
Test substance: purity = no data
Method : Fukuda et al. Year: 1971
GLP : no data

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (27)

4.5.1 CHRONIC TOXICITY TO FISH

4.5.2 CHRONIC TOXICITY TO AQUATIC INVERTEBRATES

4.6.1 TOXICITY TO SEDIMENT DWELLING ORGANISMS

4.6.2 TOXICITY TO TERRESTRIAL PLANTS

Species : other terrestrial plant: Vicia faba (bean)
Endpoint : other: damage to foliage and stem
Exposure period :
Unit :
Method : other: irrigation (soil covered)
Year :
GLP : no data
Test substance : no data

Remark : Concentration : 1.0 % (irrigation water)
Exposure period: 10 days
Effect : damage to foliage (approx. 45 %)
slight damage to stem (approx. 2 %)
Literature could not be retrieved.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (28)

Species	:	other terrestrial plant: Solanum tuberosum (potatoes)
Endpoint	:	other: damage to foliage, stem
Exposure period	:	
Unit	:	
Method	:	other: irrigation (soil covered)
Year	:	
GLP	:	no data
Test substance	:	no data
Remark	:	Concentration : 1.0 % (irrigation water) Exposure period: 10 days Effect : strong damage to foliage (approx. 90 %) slight damage to stem (approx. 6 - 8 %) Literature could not be retrieved.
Source	:	Degussa AG Frankfurt am Main EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (28)

4.6.3 TOXICITY TO SOIL DWELLING ORGANISMS

4.6.4 TOX. TO OTHER NON MAMM. TERR. SPECIES

Species	:	other not soil dwelling arthropod: Tyrophagus putrescentiae (mold mite)/ arachnid
Endpoint	:	other: reproduction
Exposure period	:	
Unit	:	
Method	:	other: Ammoniumpersulfate was mixed with a wheat germ diet; tests were conducted at 25 degree C and 85 % relative humidity; control group: yes
Year	:	
GLP	:	no data
Test substance	:	no data
Remark	:	Concentration : 1.5, 3, 6 % by weight Exposure period: 17 days Effect : 3 % and 6 % concentration of ammoniumpersulfate strongly reduced fertility. The egg viability was only slightly affected. Literature could not be retrieved.
Source	:	Degussa AG Frankfurt am Main EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (29) (30)

4.7 BIOLOGICAL EFFECTS MONITORING

4.8 BIOTRANSFORMATION AND KINETICS

4.9 ADDITIONAL REMARKS

5.0 TOXICOKINETICS, METABOLISM AND DISTRIBUTION

5.1.1 ACUTE ORAL TOXICITY

Type	:	LD50
Value	:	= 700 mg/kg bw
Species	:	rat
Strain	:	Sprague-Dawley
Sex	:	male/female
Number of animals	:	10
Vehicle	:	water
Doses	:	300, 500, 660 and 750 mg/kg bw
Method	:	TEST ORGANISMS: - Source: Charles River Laboratories - Age: young adults - Number: 5/sex/treatment (except at 300 mg/kg only male) - Weight at study initiation: 215-266 g (male); 151-186 g (female) ADMINISTRATION: - Doses: 300, 500, 660 and 750 mg/kg bw - Doses per time period: single - Volume administered or concentration: 25% w/v - Post dose observation period: 14 days EXAMINATIONS: mortality and clinical symptoms at 0.5, 1, 2, 3, 4 and 6 hours after dosing and daily thereafter for 14 days, body weight on days 0, 7 and 14 and necropsy on day 14 STATISTICAL METHOD: modified Logit-Linear Regression
Result	:	MORTALITY: - Number of deaths at each dose: Male: 0/5 (300 mg/kg), 2/5 (500 mg/kg), 0/5 (660 mg/kg), 3/5 (750 mg/kg) Female: 1/5 (500 mg/kg), 2/5 (660 mg/kg), 3/5 (750 mg/kg) - Time of death: within three days CLINICAL SIGNS: abdominal gripping, abdominogenital staining, ataxia, anorexia, chromodacryorrhea, chromorhinorrhea, diarrhoea, decreased feces, decreased locomotion, dehydration, dyspnea, hypothermia lacrimation, no faeces, oral discharge, tremors and unthriftiness. All rats recovered within 8 days. NECROPSY FINDINGS: no gross lesions
Test substance	:	CAS 7727-54-0 (ammonium persulfate), purity 99%.
Conclusion	:	LD50 = 700 (502-898) mg/kg bw for females and 742 (237-1247) mg/kg bw for males Most reliable study.
Reliability	:	(1) valid without restriction 1. Only draft report was available.
Flag	:	Critical study for SIDS endpoint

21.12.2004 (31)

Type	:	LD50
Value	:	= 600 mg/kg bw
Species	:	rat
Strain	:	
Sex	:	male
Number of animals	:	6

Vehicle	:	water
Doses	:	
Method	:	other: not indicated
Year	:	
GLP	:	no
Test substance	:	

Method	:	TEST ORGANISMS: - Number: 6/treatment - Controls: none ADMINISTRATION: - Doses: 100, 500 and 1000 mg/kg bw - Post dose observation period: not reported EXAMINATIONS: mortality, clinical signs, macroscopy
Result	:	MORTALITY: - Number of deaths at each dose: 0/6 (100), 0/6 (500), 5/6 (1000) - Time of death: within 24 hours CLINICAL SIGNS: depressed; drooping eyes NECROPSY FINDINGS: within normal limits
Test substance	:	CAS 7727-54-0 (ammonium persulfate), purity not indicated
Reliability	:	(2) valid with restrictions The information in the report was confined to the above.

21.12.2004 (32)

Type	:	LD50
Value	:	= 820 mg/kg bw
Species	:	rat
Strain	:	
Sex	:	
Number of animals	:	
Vehicle	:	
Doses	:	
Method	:	other: strain: Wistar (m); Smyth et al.
Year	:	1962
GLP	:	no
Test substance	:	no data

Remark	:	Literature could not be retrieved.
Source	:	Degussa AG Frankfurt am Main EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (33)

Type	:	LD50
Value	:	= 495 mg/kg bw
Species	:	rat
Strain	:	
Sex	:	
Number of animals	:	
Vehicle	:	
Doses	:	
Method	:	OECD Guide-line 401 "Acute Oral Toxicity"
Year	:	1991
GLP	:	yes
Test substance	:	no data

Remark	:	Literature could not be retrieved.

Method:
female rats; strain: Sprague-Dawley; APS administered as 25 % (w/v) solution in tap water; observation period: 14 days
Effects:
Clinical signs included tremors, salivation, lacrimation, pallor, splayed hindlimbs, stilted gait, decreased locomotion and loss of muscle control. All clinical signs subsided by day 5.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (34)

5.1.2 ACUTE INHALATION TOXICITY

Type	:	LC50
Value	:	> 2.95 mg/l
Species	:	rat
Strain	:	Sprague-Dawley
Sex	:	male/female
Number of animals	:	10
Vehicle	:	
Doses	:	
Exposure time	:	4 hour(s)
Method	:	EPA OPP 81-3
Year	:	
GLP	:	yes
Test substance	:	

Method :
TEST ORGANISMS:
- Source: Charles River Breeding Laboratories, North Carolina
- Age: 45 days
- Weight at study initiation: 222-255 g (male); 161-193 g (female)
- Number of animals: 5/sex/treatment
- Controls: none

ADMINISTRATION:
- Type of exposure: whole body
- Exposure duration: 4 hours
- Concentrations(nominal/measured): 5.0/2.95 mg/L
- Particle size (MMAD): 97% < 10 micron
- Type or preparation of particles: Spengler dust feeder
- Air changes: 12.4 per hour

EXAMINATIONS: mortality and clinical signs hourly during exposure and at 30, 240 min thereafter and twice daily until day 14; body weight prior to exposure and on days 2, 5, 8 and 15, necropsy on day 15

ANALYSES:
- Method: gravimetrically
- Sampling times: 30, 35, 90, 133, 138, 143, 153, 158, 206 and 211 minutes

Result : MORTALITY:
- Number of deaths at each dose: none

CLINICAL SIGNS: on day 1 after exposure: respiratory distress, crusts about the face, increased secretory response, languid behaviour, squinted eye(s), substance on

fur; during observation period: crusts, urine stains, rough haircoat and alopecia

BODY WEIGHT GAIN: yes, except on day 2 as minimal response to the treatment

NECROPSY FINDINGS: one animal with alopecia

Test substance : CAS 7727-54-0 (ammonium persulfate), purity assumed to be 100%

Conclusion : Most reliable study.

Reliability : (1) valid without restriction
1. Sedimentation and/or impaction of the dust in the exposure chamber was observed. The dust generator was stopped and filled twice during the exposure.
2. Oral uptake from the fur cannot be excluded.

Flag : Critical study for SIDS endpoint

21.12.2004 (35)

Type : LC50
Value : = 520 mg/l
Species : rat
Strain :
Sex : male
Number of animals : 7
Vehicle : water
Doses :
Exposure time : 1 hour(s)
Method : other: not indicated
Year :
GLP : no
Test substance :

Method : TEST ORGANISMS:
- Number of animals: 7/treatment
- Controls: none

ADMINISTRATION:
- Type of exposure: aerosol of 25% ammonium persulfate suspension in water
- Exposure duration: 1 h
- Concentrations(nominal): 283.5, 443.9 and 696.3 mg/L

EXAMINATIONS: mortality, clinical signs, macroscopy

Result : MORTALITY:
- Number of deaths at each dose: 1/7 (283.5), 1/7 (443.9), 7/7 (696.3)
- Time of death: within 2 days (highest dose); 8-14 days (other two doses)

CLINICAL SIGNS: instability and lethargy at all doses, convulsions at highest dose only

NECROPSY FINDINGS: black liver, distended stomach and hemorrhagic lungs at 696.3 mg/L, thickened spleen at 443.9 mg/L

Test substance : CAS 7727-54-0 (ammonium persulfate), purity not indicated

Reliability : (2) valid with restrictions
1. Type of exposure not indicated and the exposure time is only 1 hour (OECD402: 4 hours).
2. Only males were tested.

3. The information in the report was confined to the above.

21.12.2004 (32)

5.1.3 ACUTE DERMAL TOXICITY

Type	:	LD50
Value	:	> 2000 mg/kg bw
Species	:	rat
Strain	:	Sprague-Dawley
Sex	:	male/female
Number of animals	:	10
Vehicle	:	
Doses	:	
Method	:	OECD Guide-line 402 "Acute dermal Toxicity"
Year	:	1987
GLP	:	yes
Test substance	:	

Method :

TEST ORGANISMS:
- Source: Taconic Farms, Germantown, NY
- Age: young adult
- Weight at study initiation: 237-270 g (male) and 228-249 g (female)
- Number: 5/sex/treatment
- Controls: none

ADMINISTRATION:
- Area covered: 5.0 x 5.0 cm
- Occlusion: yes
- Total amount applied: 18-21 mg/cm2 (moistened with physiol. saline)
- Dose: 2000 mg/kg bw
- Removal of test substance: wiped with gauze moistened with methanol and rinsed with tap water

EXAMINATIONS: mortality and clinical signs at 0.5, 1, 2, 3, 4 and 6 hours and twice daily thereafter until day 14; local irritation on days 1, 3, 7 and 14; body weights on day 0, 7 and 14; necropsy on day 14

Result :

MORTALITY:
- Number of deaths: none

CLINICAL SIGNS: abdominogenital staining, chromorhinorrhea, chromodacryorrhea and lacrimation (recovery within 2 days).

LOCAL IRRITATION: erythema in 2/5 males on day 1

BODY WEIGHT: no treatment-related effects

NECROPSY FINDINGS: no gross internal lesions

Test substance	:	CAS 7727-54-0 (ammonium persulfate), purity 99%.
Conclusion	:	Most reliable study.
Reliability	:	(1) valid without restriction
Flag	:	Critical study for SIDS endpoint

21.12.2004 (36)

Type	:	LD50
Value	:	> 10000 mg/kg bw
Species	:	rabbit
Strain	:	

Sex	:	male
Number of animals	:	4
Vehicle	:	
Doses	:	
Method	:	other: not indicated
Year	:	
GLP	:	no
Test substance	:	

Method :
TEST ORGANISMS:
- Weight at study initiation: 2376 g
- Controls: none

ADMINISTRATION:
- Dose: 10000 mg/kg bw (undiluted)

EXAMINATIONS: mortality, clinical signs, macroscopy

Result :
MORTALITY:
- Number of deaths at each dose: none

CLINICAL SIGNS: skin irritation, erythema and eschar formation on accidently damaged skin

NECROPSY FINDINGS: few small hemorrhagic areas between muscle and facia

Test substance	:	CAS 7727-54-0 (ammonium persulfate), purity not indicated
Reliability	:	(2) valid with restrictions The information in the report was confined to the above.

21.12.2004 (32)

5.1.4 ACUTE TOXICITY, OTHER ROUTES

5.2.1 SKIN IRRITATION

Species	:	rabbit
Concentration	:	undiluted
Exposure	:	Semiocclusive
Exposure time	:	4 hour(s)
Number of animals	:	6
Vehicle	:	
PDII	:	
Result	:	not irritating
Classification	:	not irritating
Method	:	OECD Guide-line 404 "Acute Dermal Irritation/Corrosion"
Year	:	1981
GLP	:	yes
Test substance	:	

Method :
TEST ANIMALS:
- Strain: New Zealand White
- Sex: male/female
- Source: Hazleton Research Animals, Inc. Denver, Pennsylvania
- Age: young adult
- Weight at study initiation: 2.6-2.8 kg
- Number of animals: 3/sex/treatment

ADMINISTRATION/EXPOSURE
- Preparation of test substance: application as granular

		solid - Area of exposure: 5x5 cm2 - Occlusion: yes - Amount applied: 0.5 g moistened with physiol. saline - Removal of test substance: wiped with gauze moistened with methanol and rinsed with tap water EXAMINATIONS - Scoring system: Draize - Examination time points: 4.5, 24, 48 and 72 hours
Result	:	AVERAGE SCORE - Erythema: 0 at all observation times - Edema: 0 at all observation times OTHER EFFECTS: none
Test substance	:	CAS 7727-54-0 (ammonium persulfate), purity 99.5%.
Conclusion	:	Exposure time in accordance with the guideline.
Reliability	:	(1) valid without restriction The exposure area was larger than required by the OECD guideline - 25 cm2 instead of 6 cm2 - while the amount applied was according to guideline requirements.
21.12.2004		(37)

Species	:	rabbit
Concentration	:	
Exposure	:	no data
Exposure time	:	
Number of animals	:	6
Vehicle	:	
PDII	:	
Result	:	not irritating
Classification	:	
Method	:	other: not indicated
Year	:	
GLP	:	no
Test substance	:	

Method	:	ADMINISTRATION/EXPOSURE - Examination time points: 24 and 72 h
Remark	:	The information in the report is very limited.
Result	:	AVERAGE SCORE - Erythema: 0 - Edema: 0
Test substance	:	CAS 7727-54-0 (ammonium persulfate), purity not indicated
Reliability	:	(2) valid with restrictions
21.12.2004		(32)

Species	:	rabbit
Concentration	:	
Exposure	:	
Exposure time	:	
Number of animals	:	
Vehicle	:	
PDII	:	
Result	:	not irritating
Classification	:	
Method	:	other: Patch-test
Year	:	
GLP	:	
Test substance	:	

Remark	:	Literature could not be retrieved. Test substance: > 99 % Method : OECD (1981) GLP : no
Source	:	Degussa AG Frankfurt am Main EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (38)

5.2.2 EYE IRRITATION

Species	:	rabbit
Concentration	:	
Dose	:	.1 other: gram
Exposure time	:	72 hour(s)
Comment	:	
Number of animals	:	9
Vehicle	:	
Result	:	slightly irritating
Classification	:	
Method	:	OECD Guide-line 405 "Acute Eye Irritation/Corrosion"
Year	:	1987
GLP	:	yes
Test substance	:	

Method :

TEST ANIMALS:
- Strain: New Zealand White
- Sex: male/female
- Source: Hazleton Research Animals, Inc. Denver, Pennsylvania
- Age: young adult
- Weight at study initiation: 2.4-3.0 kg
- Number of animals: 3 males and 6 females

ADMINISTRATION/EXPOSURE
- Amount of substance instilled: 0.1 g (local anaesthetic (tetracaine hydrochloride) was used before the treatment)
- Removal of substance: 3 male and 3 female not washed and 3 female washed with tap water after 30 sec

EXAMINATIONS
- Scoring system: Draize
- Observation times: 1, 24, 48 and 72 h (at 24 h also by fluorescein)

Result :

AVERAGE SCORE
not washed:
- Cornea: 0.0 for all observation times
- Iris: 0.33 (1 h); 0.0 (24, 48 and 72 h)
- Conjuntivae (Redness): 1.2 (1 h); 1.0 (24 h); 0.7 (48 h); 0.0 (72 h)
- Conjuntivae (Chemosis): 0.0 for all observation times

DESCRIPTION OF LESIONS: slight to mild conjunctivitis during first 48 h

Test substance	:	CAS 7727-54-0 (ammonium persulfate), purity 99.5%.
Conclusion	:	Most reliable study.
Reliability	:	(1) valid without restriction

21.12.2004 (39)

Species	:	rabbit
Concentration	:	
Dose	:	

Exposure time	:	72 hour(s)
Comment	:	
Number of animals	:	8
Vehicle	:	
Result	:	not irritating
Classification	:	
Method	:	other: not indicated
Year	:	
GLP	:	no
Test substance	:	

Method	:	EXAMINATIONS - cornea, iris, conjunctivae - Scoring system: Draize - Observation period: 72 h
Remark	:	The information in the report was very limited. The method used is not at all clear.
Result	:	AVERAGE SCORE - Cornea: 0 - Iris: 0 - Conjunctivae: 0 - Overall irritation score: 0
Test substance	:	CAS 7727-54-0 (ammonium persulfate), purity not indicated
Reliability	:	(2) valid with restrictions The information in the report was confined to the above.

21.12.2004 (32)

Species	:	rabbit
Concentration	:	
Dose	:	
Exposure time	:	
Comment	:	
Number of animals	:	
Vehicle	:	
Result	:	
Classification	:	
Method	:	other: Draize-test
Year	:	
GLP	:	
Test substance	:	

Remark	:	Literature could not be retrieved. Result : slightly irritating Test substance: > 99 % Method : OECD (1981) GLP : no
Source	:	Degussa AG Frankfurt am Main EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (40)

5.3 SENSITIZATION

Type	:	Guinea pig maximization test
Species	:	guinea pig
Concentration	:	1st: Challenge .1 % intracutaneous 2nd: Challenge 1 % occlusive epicutaneous 3rd:
Number of animals	:	20

Vehicle	:	other: physiolog. saline for intracutaneous and water for epicutaneous application
Result	:	ambiguous
Classification	:	
Method	:	OECD Guide-line 406 "Skin Sensitization"
Year	:	1981
GLP	:	no data
Test substance	:	

Method :

TEST ANIMALS:
- Strain: Pirbright White (Bor: DHPW)
- Sex: male/female
- Source: Winkelmann, Borchen
- Age: males 7-10 weeks; females 5-8 weeks
- Weight at study initiation: 310-468 g
- Number of animals: 20
- Controls: 20

ADMINISTRATION/EXPOSURE
- Study type: guinea pig maximization
- Test substance for induction/challenge: 0.1 ml 0.1% in physiol. saline solution
- Preparation of test substance for second challenge: 0.2 ml 1% in water
- Induction schedule: day 1, 3 and 5 (test substance); day 8, 10, 12, 15, 17 and 19 (test substance + FCA)
- Challenge schedule: day 36 intracutaneous
- Second challenge: day 50 epicutaneous

EXAMINATIONS
- Grading system: thickness of skin crease at day 1, 2, 3, 4, 5 and 6 (induction) and day 36 and 37 (challenge); Draize system at day 52 and 53 (second challenge)

STATISTICAL METHOD: Fisher test

Result : RESULTS OF TEST
- Sensitization reaction first challenge: 20/20 animals
- Sensitization reaction second challenge: 3/20 animals at 24 h; control 0/20

Test substance : CAS 7727-54-0 (ammonium persulfate), purity >99%.

Conclusion : Intradermal challenge: positive
Epidermal challenge: negative

Reliability : (2) valid with restrictions
1. No pilot study was performed to determine the highest non-irritant dose. It is reported that the 1% solution used is sub-irritant.
2. The induction/challenge schedule is more thorough than that required by OECD 406. The challenging schedule is also different, but appropriate to test sensitizing properties of the test substance.
3. From the results of the intradermal challenge the test substance would be categorised as sensitizing. According to the OECD 406 method (Magnusson and Kligman) only 10% of the animals tested is positive in the epidermal challenge and therefore the substance would not be sensitizing.

06.06.2005 (41)

5.4 REPEATED DOSE TOXICITY

Type	:	Sub-chronic
Species	:	rat
Sex	:	male/female

Strain	:	Sprague-Dawley
Route of admin.	:	inhalation
Exposure period	:	13 weeks
Frequency of treatm.	:	6 hours/day, 5 days/week
Post exposure period	:	6 and 13 weeks
Doses	:	5, 10 and 25 mg/m3
Control group	:	yes, concurrent no treatment
NOAEL	:	= 10.3 mg/m³
Method	:	OECD Guide-line 413 "Subchronic Inhalation Toxicity: 90-day Study"
Year	:	1981
GLP	:	yes
Test substance	:	

Method :

TEST ORGANISMS
- Age: 52 days
- Weight at study initiation: 204-269 g (males), 146-192 g (females)
- Number of animals: 20/sex/treatment (10/sex/treatment for main study and 5/sex/treatment for both recovery periods)

ADMINISTRATION / EXPOSURE
- Exposure period: 13 weeks
- Route of administration: inhalation (whole body)
- Post exposure period: 6 and 13 weeks
- Doses: 0, 5, 10 and 25 mg/m3
- Particle size: MMAD 2.5-2.7 um
- Type or preparation of particles: dust aerosol generated with an air micronizer
- Air changes: 13.5/hour

SATELLITE GROUPS AND REASONS THEY WERE ADDED: recovery animals to assess reversibility of the effects

CLINICAL OBSERVATIONS AND FREQUENCY:
- Clinical signs: at least once daily during the treatment period, once daily during the recovery period
- Mortality: twice daily
- Body weight: weekly
- Food consumption: weekly
- Ophthalmoscopic examination: prior to the test and during week 12
- Haematology: during week 3 and 13:
leukocytes (total and differential), erythrocytes, hemoglobin, hematocrit, MCV, MCH, MCHC, platelet count, prothrombin time, activated partial thromboplastin time, methemoglobin
- Biochemistry: during week 3 and 13;
albumin, total protein, globulin, A/G ratio, total bilirubin, urea nitrogen, creatinine, ALP, ALAT, ASAT, GGT, glucose, cholesterol, calcium, chloride, phosphorus, potassium, sodium

ORGANS EXAMINED AT NECROPSY (MACROSCOPIC AND MICROSCOPIC):
- Organ weights: adrenals, brain, kidneys, lungs, liver, ovaries, testes
- Macroscopic: complete on all animals
- Microscopic:
For control and high dose animals necropsied during week 13:
adrenals, aorta, bone(marrow), brain, eyes with optic nerve, GI-tract, heart, kidneys, liver, lungs, lymphnodes, mammary gland, nasal tissues, ovaries, pancreas, parathyroids, peripheral nerve, pituitary, prostate, salivary glands, seminal vesicles, skeletal muscle, skin, spinal cord, spleen, testes, epididymides, thymus, thyroids, trachea, urinary bladder, uterus with vagina, gross lesions
For intermediate dose groups necropsied at week 13:

lungs, trachea, nasal tissues, liver, kidneys and gross lesions
For control and high dose animals at week 19 (6 weeks recovery): lungs and trachea

ANALYSES:
actual concentration
- Method: gravimetrically
- Sampling times: 4 samples/exposure during day 0-28, 2 samples/exposure thereafter

STATISTICAL METHODS: ANOVA, Dunnett's test

Remark : Following the 6-week recovery period, inflammation of the trachea and bronchi/bronchioles, decreased body weights and increased lung weights noted in high dose animals after 13 weeks of exposure, were no longer evident and reversed to normal. Rales persisted in females at 25 mg/m3 during the 6 week recovery period

Result : ANALYSES:
- Actual concentration: 5.0, 10.3 and 25 mg/m3
- Stability: stated to be stable during the study
- Homogeneity: 79-105% of mean (assessed during pretest)

TOXIC RESPONSE/EFFECTS BY DOSE LEVEL:
- Mortality and time to death: 1 male at 10 and 25 mg/m3 during week 8; 1 female during week 17
- Clinical signs: rales and increased respiration during and after exposure in males and females at 25 mg/m3 and in females at 10 mg/m3. Rales persisted in females at 25 mg/m3 during the 6 weeks recovery. Incidental wet or dried material was reported around the nose and in the facial area of high dosed animals after exposure.
- Body weight: decreased in both sexes until week 19 at 25 mg/m3
- Body weight gain: decreased during week 0-3 in both sexes at 25 mg/m3
- Food consumption: decreased during week 1-3 in both sexes at 25 mg/m3 (and occasionally thereafter)
- Ophthalmoscopic examination: no treatment related effects
- Clinical chemistry: incidental effects were seen on glucose, albumin, total protein, ALP, ALAT and ASAT
- Haematology: increased hemoglobin and hematocrit after 3 weeks in females at 25 mg/m3
- Organ weights: increased absolute and relative lung weights after 13 weeks at 25 mg/m3 in both sexes, increased relative brain weight in males at 13 and 26 weeks and in both sexes after 19 weeks at 25 mg/m3
- Gross pathology: pale lungs with white areas in both sexes at 25 mg/m3 after 13 weeks
- Histopathology: inflammation of the bronchi and excessive mucus secretion in the bronchi in both sexes at 25 mg/m3, increased severity of alveolar hysticytosis and inflammation of the trachea in females at 25 mg/m3

No effects on male and female gonads were found.

STATISTICAL RESULTS: The effects on body weight (gain), lung and brain weight (in males) and food consumption reached the level of statistical significance

Test substance : CAS 7727-54-0 (ammonium persulfate), purity 98.7%.

Conclusion : Based on the effects on body weight, lung weight, food consumption, clinical effects on respiration and microscopic findings in lung and trachea, it is concluded that the NOAEL is 10 mg/m3. Findings in the 10 mg/m3 group are sporadic or are found in just one of the sexes.
Only 90 d study available.

Reliability : (1) valid without restriction
1. Clinical pathology findings could be related to one or two

animals/treatment or were seen in just one of the sexes. Therefore these findings were considered to be biologically irrelevant.
2. The effects on the brain weight can be attributed to the lower body weight found in animals treated at 25 mg/m3.
3. The elevation of hemoglobin and hematocrit levels of the females at 25 mg/m3 observed after 3 weeks was not observed at 13 weeks and was not seen in males. Therefore, the effect was not considered relevant.

Flag : Critical study for SIDS endpoint
25.03.2005 (42)

Type	:	
Species	:	rat
Sex	:	male
Strain	:	other: CR-CD
Route of admin.	:	oral feed
Exposure period	:	28 days
Frequency of treatm.	:	continuous
Post exposure period	:	
Doses	:	0, 13.3, 41.1, 82.1 mg/kg/day
Control group	:	yes
NOAEL	:	= 41.1 mg/kg bw
Method	:	other
Year	:	
GLP	:	no
Test substance	:	

Method :
TEST ORGANISMS
- Age: weanlings
- Weight at study initiation: 42-45 g
- Number of animals: 10/treatment

ADMINISTRATION / EXPOSURE
- Exposure period: 28 days
- Route of administration: diet
- Doses: 0, 13.3, 41.1, 82.1 mg/kg/day

CLINICAL OBSERVATIONS: mortality, body weight (init. and terminal)
ORGANS EXAMINED AT NECROPSY:
- Macroscopic investigation (not specified)
- Organ weights: liver, kidneys, adrenals and testes

Result :
TOXIC RESPONSE/EFFECTS BY DOSE LEVEL:
- Mortality: none
- Clinical signs: not reported
- Body weight gain: no treatment-related effects
- Organ weights: significant decrease in relative adrenal weight at 13.3 and 82.1 mg/kg/day
- Gross pathology: no findings

Test substance : CAS 7727-54-0 (ammonium persulfate), purity not indicated

Conclusion : NOAEL based on decreased weight of adrenals is 82.1 mg/kg/day.
Only 28-d study available.

Reliability : (2) valid with restrictions
1. Only males were tested. Animals were younger than required according to OECD407 (young adult).
2. The information in the report is confined to the above.

Flag : Critical study for SIDS endpoint
21.12.2004 (32)

Type	:	
Species	:	rat

Sex	:	male
Strain	:	other: Sprague Dawley
Route of admin.	:	inhalation
Exposure period	:	7 days
Frequency of treatm.	:	23,5 h/day
Post exposure period	:	
Doses	:	1, 4, 9, 17, 20 mg/m3
Control group	:	yes
NOAEL	:	1
Method	:	other: see remark
Year	:	
GLP	:	no data
Test substance	:	no data
Remark	:	Effects: 4 mg/m3 and above: decrease of body weight gain; lung wet weight, total lung protein, total lung DNA levels were increased (indicative of inflammation and/or edema); no death in the high dose group. Method: animals per group and sex: 6 mass median aero-dynamic diameter: 0,8 - 1,3 um (aerosol) Literature could not be retrieved.
Source	:	Degussa AG Frankfurt am Main EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

15.12.2004 (43)

Type	:	
Species	:	other: rat, dog
Sex	:	no data
Strain	:	no data
Route of admin.	:	oral feed
Exposure period	:	16 months
Frequency of treatm.	:	permanent
Post exposure period	:	
Doses	:	"high proportion" of flour treated with 0.02 - 0.81 % ammonium persulphate
Control group	:	no data specified
Method	:	other: no data
Year	:	
GLP	:	no
Test substance	:	no data
Remark	:	As the amount of residual ammonium persulphate (if any) that was actually ingested is not known, the relevance of these studies to an assessment of the chemical's toxicity must be considered highly questionable. Literature could not be retrieved.
Result	:	No overt toxicity was observed. Weight gain was normal, as was the appearance of the major organs on gross and microscopic examination.
Source	:	Degussa AG Frankfurt am Main EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (44) (45)

5.5 GENETIC TOXICITY 'IN VITRO'

Type	:	Ames test
System of testing	:	TA98, TA100, TA1535, TA1537, TA1538 and WP2 uvrA
Test concentration	:	1, 5, 10, 50, 100, 500, 1000 and 5000 µl/plate
Cytotoxic concentr.	:	> 5000 µl/plate

Metabolic activation : with and without
Result : negative
Method : other: not indicated
Year :
GLP : no data
Test substance :

Method : SYSTEM OF TESTING
- Species/cell type: TA98, TA100, TA1535, TA1537, TA1538 and WP2 uvrA
- Deficiency: histidine for S. typhimurium and tryptophan for E. coli
- Metabolic activation system: S9 from rat liver

ADMINISTRATION:
- Dosing: 1, 5, 10, 50, 100, 500, 1000 and 5000 µl/plate
- Number of replicates: 2
- Application: preincubation method
- Positive and negative control groups and treatment: water as negative control; positive controls: 2-(2-furyl)-3-(5-nitro-2-furyl)acrylamide (TA98, TA100 and WP2 uvrA all -S9), N-ethyl-N'-nitro-N-nitrosoguanidine (TA1535 - S9), 9-aminoacridine (TA1537 -S9), 4-nitroquinoline-1-oxide (TA1538 - S9), benzo[a]pyrene (TA98, TA100, TA1537, TA1538 all +S9) and 2-aminoanthracene (TA1535 and WP2 uvrA both +S9)
- Pre-incubation time: 20 min.
- Incubation time: 48 hours

Result : GENOTOXIC EFFECTS:
- With metabolic activation: none
- Without metabolic activation: none

CYTOTOXIC CONCENTRATION:
- With metabolic activation: >5000 µl/plate
- Without metabolic activation: >5000 µl/plate

Test substance : CAS 7727-54-0 (ammonium persulfate), purity 98%.
Conclusion : Most reliable Ames test available.
Reliability : (2) valid with restrictions
1. Initial number of cells is not given.
2. Review article: the information is limited to the above mentioned; only mean plate counts/doses were reported.
Flag : Critical study for SIDS endpoint
21.12.2004 (46)

Type : Chromosomal aberration test
System of testing : Chinese hamster fibroblast
Test concentration : 3 doses with a maximum of 0.25 mg/mL
Cytotoxic concentr. : > 0.25 mg/mL
Metabolic activation : without
Result : negative
Method : other: not indicated
Year :
GLP : no data
Test substance :

Method : SYSTEM OF TESTING
- Species/cell type: Chinese hamster fibroblast
- No. of metaphases analyzed: ~100

ADMINISTRATION:
- Dosing: 3 doses with a maximum of 0.25 mg/ml

- Number of replicates: 1
- Positive and negative control groups and treatment: physiological saline (vehicle)
- Exposure period: 24 and 48 hours (colcemid added two hours before cell harvesting)

DEVIATIONS FROM GUIDELINE: The test was only performed without metabolic activation.

CRITERIA FOR EVALUATING RESULTS:
incidence < 4.9% is negative; 5.0%<incidence<9.9% is equivocal; >10.0% is positive

Result : GENOTOXIC EFFECTS:
- Without metabolic activation: negative

FREQUENCY OF EFFECTS: 2.0% polyploid; 4.0% structural aberrations

CYTOTOXICITY: 50% growth inhibition at 0.25 mg/mL

Test substance : CAS 7727-54-0 (ammonium persulfate), purity 99.2%.
Conclusion : Only chromosome aberration test available
Reliability : (4) not assignable
1. The information in the report is confined to the above.
2. Only the maximum dose used, the end result and the % of polyploid cells and structural chromosomal aberrations after 48 h exposure are reported. No positive controls are reported, but from positive results found with some other test substances it can be concluded that the test system was adequate.
Flag : Critical study for SIDS endpoint
21.12.2004 (47)

Type : Ames test
System of testing : TA92, TA94, TA98, TA100, TA1535 and TA1537
Test concentration : max. 10 mg/plate
Cytotoxic concentr. : > 10 mg/plate
Metabolic activation : with and without
Result : negative
Method : other: not indicated
Year :
GLP : no data
Test substance :

Method : SYSTEM OF TESTING
- Species/cell type: TA92, TA94, TA98, TA100, TA1535 and TA1537
- Deficiency: histidine
- Metabolic activation system: S9 from rat liver

ADMINISTRATION:
- Dosing: maximum 10 mg/plate
- Number of replicates: 2
- Application: preincubation method
- Positive and negative control groups and treatment: negative control: DMSO
- Pre-incubation time: 20 min.
- Incubation time: 2 days

CRITERIA FOR EVALUATING RESULTS: positive if number of colonies was twice the number in the negative control

Result : GENOTOXIC EFFECTS:
- With metabolic activation: negative

- Without metabolic activation: negative

Test substance : CAS 7727-54-0 (ammonium persulfate), purity 99.2%.

Reliability : (4) not assignable
1. Only the maximum concentration which gave a negative result is reported.
2. No separate numbers of reverted colonies for the individual strains as well as for the duplicates are reported.
3. In this review article no standard positive controls were included, but from positive results found with other test substances it can be concluded that the test system was adequate.

21.12.2004 (47)

Type : Ames test
System of testing : Salmonella typhimurium, TA 97
Test concentration :
Cytotoxic concentr. :
Metabolic activation : no data
Result : negative
Method :
Year :
GLP :
Test substance :

Remark : Literature could not be retrieved.
Test substance: no data
Method : Maron u. Ames (1983)
GLP : no data

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (48)

Type : other: Mutation test
System of testing : Bacteria (species not specified)
Test concentration :
Cytotoxic concentr. :
Metabolic activation : no data
Result : negative
Method :
Year :
GLP :
Test substance :

Remark : Literature could not be retrieved.
no further information

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (49)

5.6 GENETIC TOXICITY 'IN VIVO'

5.7 CARCINOGENICITY

Species : other: mice
Sex : female
Strain : Sencar
Route of admin. : dermal
Exposure period : 51 weeks
Frequency of treatm. : twice a week

Post exposure period	:	
Doses	:	0.2 ml of a 200 mg/ml solution
Result	:	negative
Control group	:	yes
Method	:	other: see remark
Year	:	1984
GLP	:	no
Test substance	:	no data

Remark : Literature could not be retrieved.
This is not a formal guideline study.
Method: skin painting (test for promoting activities); single application of 20 mmol DMBA (dimethylbenzanthracene), one week later application of TPA (tumor promoter), acetone or ammoniumpersulfate (200 mg/ml); 20 animals

Controls: DMBA (20 nmol in 0.2 ml acetone and DMBA, Dimethyl benz[a]anthracene, followed by TPA (Tetradecanoly phorbol acetate) in acetone were the promotion controls; Acetone was the negative control for complete carcinogenesis.

Effect: squamous cell carcinoma (1/20); epidermal hyperplasia (1/20). Positive control group with TPA and DMBA had 20/20 mice with skin tumors. Acetone alone treated animals had 0/15 skin tumors. Maximum skin tumors per mouse was 0, 40.1 and 0.3 for the negative control, positive control and ammonium persulfate groups, respectively.

Reliability : (2) valid with restrictions
21.12.2004 (50)

Species	:	other: mice
Sex	:	female
Strain	:	Sencar
Route of admin.	:	dermal
Exposure period	:	51 weeks
Frequency of treatm.	:	twice a week
Post exposure period	:	
Doses	:	0.2 ml of 200 mg/ml ammonium persulfate solution or 0.2 ml acetone
Result	:	
Control group	:	yes
Method	:	other: See remark
Year	:	1984
GLP	:	no
Test substance	:	

Remark : Literature could not be retrieved.
Method: skin painting (test for complete carcinogenic activities); 20 animals
Controls:acetone as a negative control
Effect: epidermal hyperplasia (2/20), no animals with squamous cell carcinoma.
Test substance: no data
GLP : no data

Test substance : ammonium persulfate

Reliability : (3) invalid
1. no positive control
2. number of animals per group was too low.
3. Lenght of experiment was not long enough (51 weeks). Pathology methods were incomplete.

21.12.2004 (51)

5.8.1 TOXICITY TO FERTILITY

Type	:	other
Species	:	rat
Sex	:	no data
Strain	:	no data
Route of admin.	:	oral feed
Exposure period	:	6 months
Frequency of treatm.	:	permanent
Premating exposure period		
Male	:	
Female	:	
Duration of test	:	
No. of generation studies	:	
Doses	:	"high proportion" of flour treated with 0.02 % and 0.1 % ammonium persulfate
Control group	:	no data specified
Method	:	other: no data
Year	:	
GLP	:	no data
Test substance	:	no data
Remark	:	As the amount of residual ammonium persulphate (if any) that was actually ingested is not known, the relevance of these studies to an assessment of the chemical's toxicity must be considered highly questionable. Literature could not be retrieved.
Result	:	Reproductive performance was reported to be normal. Microscopic examination of "representative" tissues of the offspring did not reveal any adverse effects and their growth was apparently normal.
Source	:	Degussa AG Frankfurt am Main EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (44) (45)

5.8.2 DEVELOPMENTAL TOXICITY/TERATOGENICITY

Species	:	rat
Sex	:	male/female
Strain	:	other: Crl:CD (SD)IGS BR
Route of admin.	:	oral feed
Exposure period	:	pre-mating, mating, gestation, lactation
Frequency of treatm.	:	ad libitum in diet
Duration of test	:	
Doses	:	0, 40, 100 and 250 mg/kg/day
Control group	:	yes, concurrent no treatment
NOAEL teratogen.	:	= 250 mg/kg bw
LOAEL Teratogenicity	:	> 250 mg/kg bw
Method	:	other: OECD 421
Year	:	2004
GLP	:	yes
Test substance	:	
Method	:	TEST ORGANISMS - Age: 11 weeks at exposure - Weight at study initiation: 359-436 g (males), 212-280 g (females) - Number of animals: 12/sex/group

ADMINISTRATION / EXPOSURE
- Exposure period: two weeks prior to mating, mating for both sexes; three and a half additional weeks for males. Females were exposed following mating, throughout gestation until lactation day 4.
- Route of administration: diet
- Doses: 0, 40, 100 and 250 mg/kg/day, the dietary concentrations were adjusted weekly based on body weight until initiation of mating in females. Female diets were not adjusted after breeding. Male diets were adjusted for the remaining weeks of food consumption after the breeding interval.
- Vehicle: untreated diet (Powdered PMI Certified Rodent Diet #5002)

CLINICAL OBSERVATIONS AND FREQUENCY: ADULTS
- Mortality: twice daily for mortality, pain and distress
- Clinical signs: once daily
- Body weight: Males were weighed on days 0, 4, 7 and weekly during treatment and at termination. Females were weighted on days 0, 4, 7 and weekly thereafter during the premating phase. During gestation, females were weighed on gestation days 0, 7, 14,17 and 20. Dams producing litters were weighed on lactation days 0 and 4.
- Food consumption: Food consumption for males was measured on days 0, 4 and 7 and weekly thereafter, except during mating, and at termination. Food consumption for females was measured on days 0, 4 7 and 21 during gestation and on days 0 and 4 during lactation. Food consumption was measured during gestation and lactation on body weight days.

MATING
-One male and one female from the same dose group were placed together. A record of the mating pairs was maintained. Once mating was confirmed by copulatory plug or vaginal sperm, gestation day 0 recorded and, the male and female pair were separated.
-Observations of mating time, pregnancy rate and day of pregnancy following mating, date of delivery.

OBSERVATIONS OF LITTERS
-At birth and on lactation day 4, litter size (number born live and dead), sex (number of males and females per litter), body weight on day 0 and 4, and abnormal observations of individual offspring, gross external obnormalities; daily observations of all pups for abnormal behavior and any mortality.

ORGANS EXAMINED AT NECROPSY (MACROSCOPIC):
- Macroscopic: necropsy of all abnormal pups and examination for cervical, thoracic and abdominal viscera abnormalities

ANALYSES OF DIET:
- Method: Diets were prepared fresh weekly from a fresh concentrated stock containing test article in the diet. Concentrations ranged from 4141 to 4668 ppm for males and 3411 to 3864 for females. Stablity of the diet at use level was determined for up to 14 days following preparation. Differential Scanning Calorimetry was used for sample analysis, using delta H (enthalpy) responses. The method was validated in the concentration range of the diets used on the study. Homogeneity of low and high dose levels was determined for week 1 and 14-day stability was determined at room temperature. Sample verification was done for the top, middle and bottom of the batch for low and high dose levels for weeks 1, 3, 6, and 8.
- Sampling times: Week 1, 3, 6 and 8 diets

STATISTICAL METHODS:
-ANOVA was used for body weight/weight gain, food consumption data and natural delivery data one-way analysis of variance. Levene's test was used to analyze homogeneity of variances, i.e. organ weights. Dunnett's t-test

was served as post-hoc group comparison test. Group comparisons were performed at the 1% and 5% two-tailed probability levels. Mean live pup weights were analyzed by one-way analysis of covariance (ANCOVA) with litter size as the covariant.

Result : ANALYSES:
- Actual dose level (by sex): Verification was done on the middle level sample of the control and treated diet batches for week 1 and from the middle of all samples prepared for weeks 3, 6 and 8. There were some minor deviations of concentration in groups 2 and 4 on weeks 1, 3 or 6 (ranging from 0.4% to 2.6% below target concentration) which did not impact the study.
- Stability: stable for 2 week in diet. Concentrations were within + 10% of the target concentrations. Day 14 stability was similar to day 1 stability (125% vs. 120% of target concentrations, respectively). Several animals received diet 15 days, instead of up to 14 days, after preparation. These minor deviations did not impact the study.
- Homogeneity: homogeneity analyses indicate that the low and high dose diets were within + 7% of the overall mean.
-Compound consumption: Mean values for compound consumption were generally within 10% of the target doses during premating and generally increased over the target during the first two weeks of gestation (7.6-22.5%) and the first four days of lactation (30%-50%).

TOXIC RESPONSE/EFFECTS BY DOSE LEVEL:
- Mortality/clinical signs: no treatment-related clinical signs or mortality among pups.
- Body weight:: a dose-dependent decrease in mean pup body weight for both sexes on lactation day 0 and 4 which reached statistical significance at 250 mg/kg on lactation day 0 only.
-Necropsy Findings: no treatment-related findings among pups.
Indices of Survival: Livebirth and viability incides were similar across all groups. The mean number of live pups and mean number of live pups surviving to day 4 were similar across all groups.
STATISTICAL RESULTS: decreased pup body weight on lactation day 0 in male and female pups at 250 mg/kg/day. This transient effects resolved after lactation day 0.

Test substance : CAS 7727-54-0 (ammonium persulfate), purity 99.2%.
Conclusion : Not a developmental toxicant, NOEL for embryo/fetal viability = 250 mg/kg/day.
Reliability : (1) valid without restriction
Flag : Critical study for SIDS endpoint
21.12.2004 (52)

5.8.3 TOXICITY TO REPRODUCTION, OTHER STUDIES

Type : other: reproductive/developmental toxicity/repeated dose toxicity
In vitro/in vivo : In vivo
Species : rat
Sex : male/female
Strain : other: Crl:CD (SD)IGS BR
Route of admin. : oral feed
Exposure period : pre-mating, mating, gestation. Lactation
Frequency of treatm. : ad libitum in diet
Duration of test :
Doses : 0, 40, 100 and 250 mg/kg/day
Control group : yes, concurrent no treatment
Method : other: OECD 421
Year : 2004
GLP : yes
Test substance :

Method : TEST ORGANISMS
- Age: 11 weeks at time of exposure
- Weight at study initiation: 359-436 g (males), 212-280 g (females)
- Number of animals: 12/sex/group

ADMINISTRATION / EXPOSURE
- Exposure period: two weeks prior to mating, mating for both sexes; three and a half additional weeks for males. Females were exposed following mating, throughout gestation until lactation day 4.
- Route of administration: diet
- Doses: 0, 40, 100 and 250 mg/kg/day, the dietary concentrations were adjusted weekly based on body weight until initiation of mating in females. Female diets were not adjusted after breeding. Male diets were adjusted for the remaining weeks of food consumption after the breeding interval.
- Vehicle: untreated diet (Powdered PMI Certified Rodent Diet #5002)

CLINICAL OBSERVATIONS AND FREQUENCY: ADULTS
- Mortality: twice daily for mortality, pain and distress
- Clinical signs: once daily
- Body weight: Males were weighed on days 0, 4, 7 and weekly during treatment and at termination. Females were weighed on days 0, 4, 7 and weekly thereafter during the premating phase. During gestation, females were weighed on gestation days 0, 7, 14,17 and 20. Dams producing litters were weighed on lactation days 0 and 4.
- Food consumption: Food consumption for males was measured on days 0, 4 and 7 and weekly thereafter, except during mating, and at termination. Food consumption for females was measured on days 0, 4 7 and 21 during gestation and on days 0 and 4 during lactation. Food consumption was measured during gestation and lactation on body weight days.

MATING
-One male and one female from the same dose group were placed together. A record of the mating pairs was maintained. Once mating was confirmed by copulatory plug or vaginal sperm, gestation day 0 was recorded and, the male and female pair were separated.
-Observations of mating time, pregnancy rate and day of pregnancy following mating, date of delivery.

OBSERVATIONS OF LITTERS
-Daily observations of all pups for abnormal behavior and any mortality.
-At birth and on lactation day 4, litter size (number born live and dead), sex (number of males and females per litter),
-Body weight on day 0 and 4
-Abnormal observations of individual offspring
-Gross external abnormalities, necropsy of all abnormal pups and examination for cervical, thoracic and abdominal viscera abnormalities

ORGANS EXAMINED AT NECROPSY (MACROSCOPIC AND MICROSCOPIC): ADULTS
- Organ weights: brain, liver, kidney, prostate with seminal vesicles, testes, epididymides, ovaries, uterus with cervix.
- Macroscopic: all tissues checked at gross necropsy in adults
- Microscopic: testes, ovaries, epididymides.

STAGING OF SPERMATOGENESIS
-The right testes of all control and high-dose males will be prepared and stined with Periodic Acid Schiff's Hematoxylin stain for evaluation of spermatogenic stages.

ANALYSES OF DIET:
- Method: Diets were prepared fresh weekly from a fresh concentrated stock containing test article in the diet. Concentrations ranged from 4141 to 4668 ppm for males and 3411 to 3864 for females. Stablity of the diet at use level was determined for up to 14 days following preparation. Differential Scanning Calorimetry was used for sample analysis, using delta H (enthalpy) responses. The method was validated in the concentration range of the diets used on the study. Homogeneity of low and high dose levels was determined for week 1 and 14-day stability was determined at room temperature. Sample verification was done for the top, middle and bottom of the low and high dose levels for weeks 1, 3, 6, and 8.
- Sampling times: Week 1, 3, 6 and 8 diets

STATISTICAL METHODS:
-ANOVA was used for body weight/weight gain, food consumption data and natural delivery data isomg pme=way analysis of variance. Levene's test was used to analyze homogeneity of variances, i.e. organ weights. Dunnett's t-test was served as a post-hoc group comparison test. Group comparisons were performed at the 1% and 5% two-tailed probability levels. Mean live pup weights were analyzed by one-way analysis of covariance (ANCOVA) with litter size as the covariant.

Result : ANALYSES:
- Actual dose level (by sex): Verification was done on the middle level sample of the control and treated batches of diet for week 1 and from the middle of all samples prepared for weeks 3, 6 and 8. There were some minor deviations of concentration in groups 2 and 4 on weeks 1, 3 or 6 (ranging from 0.4% to 2.6% below target concentration) which did not impact the study.
- Stability: stable for 2 week in diet. Concentrations were within + 10% of the target concentrations. Day 14 stability was similar to day 1 stability (125% vs. 120% of target concentrations, respectively). Several animals received diet 15 days, instead of up to 14 days, after preparation. These minor deviations did not impact the study.
- Homogeneity: homogeneity analyses indicate that the low and high dose diets were within + 7% of the overall mean.
-Compound consumption: Mean values for compound consumption were generally within 10% of the target doses during premating and generally increased over the target level during the first two weeks of gestation (7.6-22.5%) and the first four days of lactation (30%-50%).

TOXIC RESPONSE/EFFECTS BY DOSE LEVEL:
- Mortality/clinical signs: no treatment-related clinical signs or mortality among parental animals.
- Body weight: there were no statistically significant effects on parental body weight. There was a slight trend to reduced body weight among mid- and high- dose males during the study and high-dose females during gestation.
- Food consumption: Decreased food consumption was noted among high-dose males and females for the day 0-4 interval (significant for males) which resolved as the animals continue to feed on the treated diet. This effect was attributed to the palatability of the test diet.
-Organ weights: no treatment-related effects on organ weights.
-Gross pathology: There were no treatment-related findings among parents. Necropsy observations in males included small and/or soft testes in one male each in the 100 and 250 mg/kg/day groups and small epididymis in the same 250 mg/kg/day male, and a liver mass in one 100 mg/kg/day male. In females, findings included sores and/or alopecia in females across all treatment groups and a small mammary mass in one 100 mg/kg/day female. These findings were not considered treatment-related.
-Histopathology: One high-dose male had a hypoplastic testicle and

aspermia of the epididymides and the female mated to this animal did not become pregnant. Two other males had minimal degeneration of the testicle. Minimal testicular degeneration was also noted in two control animals. The sporadic occurrence in both control and high-dose groups establishes this finding as unrelated to treatment. There were no microscopic changes in the ovaries in the high dose group compared to the control.

-Sperm Staging: There was a normal progression of spermatogenesis; all stages of the spermatogenic cycle were present and associations of the stages were not unusual in any respects.
-Indices of Fertility and Reproduction: Pregnancy rates were 100% for the control and 40 mg/kg groups and 92% for the 100 and 250 mg/kg groups. The duration of gestation was similar across all groups.

STATISTICAL RESULTS: Decreased food consumption and body weight change during study days 0-4 in high dose males. The transient effects resolved after the period of significance. Increased food consumption for days 4-7 in high dose females. This effect may reflect a rebound since the food consumption in this group was slightly, but not siginficantly, reduced during days 0-4.

Test substance : CAS 7727-54-0 (ammonium persulfate), purity 99.2%.
Conclusion : Not a reproductive toxicant, NOEL for male and female fertility indices, reproductive performance = 250 mg/kg/day,
NOAEL for male and female toxicity = 250 mg/kg/day
Reliability : (1) valid without restriction
Flag : Critical study for SIDS endpoint
31.05.2005 (52)

5.10 EXPOSURE EXPERIENCE

Type of experience : Human

Result : A number of patients with previous experiences of reactions (erythema, oedema, itching, wheals, headache, loss of conciousness) after the use of hair bleach containing ammonium persulfate, were challenged with solutions of ammonium persulfate (epidermal and intradermal).
In general ammonium persulfate treatment gave a positive response (appearance of wheals within 10-30 minutes).
Pretreatment with an antihistamine or a histamine depleting agent (48/80), reduced the reaction in most of the patients.
This suggests a histamine related response, although an antibody mediated response can not be fully excluded.
Conclusion : Ammonium persulfate can cause generalised histamine reactions in susceptible persons by releasing histamine from skin. It is a weak histamine liberator. The mechanism of action could be either direct histamine liberation or antibody mediated.
13.01.2005 (53)

Type of experience : Human

Remark : Three years after starting working as a hairdresser a 33 years old woman developed urticaria on contact with hairbleach. After a further 4 years rhinoconjunctivitis set in and later also bronchial asthma on contact with such bleaches. Tests revealed hypersensitivity to widely used persulphate-containing bleaching liquids. The causative role of this group of chemicals was proven by positive skin tests and specific workplace related provocation tests. Specific IgE antibodies could not be demonstrated. The findings suggest a pseudoallergic reaction.

Test substance : Platineclair, hair bleach containing persulfates (probably ammonium persulfate)

11.11.2004 (54)

Type of experience : Human

Result : Ammonium, potassium, and sodium persulfate are used as oxidizing agents in hair bleaches and hair-coloring preparations. Persulfates are contained in hair lighteners, off-the-scalp products, bleaches and lighteners at concentrations of 60%, 25%, 22% and 16%, respectively. Much of the available safety test data are for ammonium persulfate, but these data are considered applicable to the other salts. The persulfates were reported to cause both delayed-type and immediate skin reactions, including irritant dermatitis, allergic eczematous dermatitis, localized contact urticaria, generalized urticaria, rhinitis, asthma, and syncope. The most common causes of allergic dermatitis in hairdressers are the active ingredients in hair dyes, and ammonium persulfate has been identified as a frequent allergen. A sensitization study examined the incidence of urticarial reactions was performed with 17.5% ammonium, potassium, and sodium persulfate under occlusive patches. At this concentration and exposure conditions, a mixture of these persulfates was not sensitizing, and application of ammonium, potassium, and sodium persulfate did not result in an urticarial reaction. In normal use (i.e., not occluded and rinsed off), it is expected that a concentration greater than 17.5% would also be safe. Given the clinical reports of urticarial reactions, however, manufacturers and formulators should be aware of the potential for urticarial reactions at concentrations of persulfates greater than 17.5%. Based on the available data, the Cosmetic Ingredient Review (CIR) Expert Panel concluded that ammonium, potassium, and sodium persulfate are safe as used as oxidizing agents in hair colorants and lighteners designed for brief discontinuous use followed by thorough rinsing from the hair and skin.

Conclusion : This review article concludes that the persulfate salts have similar toxicity and data on ammonium persulfate can be used for the sodium and potassium salts. The review by the Cosmetic Ingredient Review Expert Panel also concludes that the three persulfates are safe in hair products at up to 17.5% based on a human skin sensitization study.

11.11.2004 (55)

Type of experience : Human

Result : Working conditions in hairdressing salons were assessed. Twenty randomly sampled hairdressing salons in the Helsinki, Finland, metropolitan area were studied. The study, performed in winter 1994-1995, included a survey of hairdressing chemicals used, measurement of physical and chemical working conditions, and a self-administered questionnaire of the work environment and health of workers. Air concentrations persulfates were 2.9 g/m3 in small salons and 0.9 g/m3 in large size salons. The breathing zone concentration of persulfate reached 30 g/m3 during mixing of bleaching powder. Good general ventilation decreased health complaints caused by hairdressing chemicals. Although effective general ventilation alleviated the effect of air pollutants, it could not completely solve the problem; therefore, local exhaust ventilation is recommended at hairdressing chemical mixing sites and wherever they are applied to the hair. Results showed increasing the air exchange rate up to 5-7 times/hour during high exposure jobs improved the situation.

Conclusion : This paper documents the average air concentration of persulfates in 20 randomly-selected hairdressing salons to be 0.9 - 2.9 g/m3 for persulfates with peak levels of 30 g/m3 at the breathing zone during mixing of bleaching powder.

11.11.2004 (56)

Type of experience : Human

Result : The occurrence and causes of hairdressers' occupational skin and respiratory diseases were studied in a random sample of 355 female hairdressers aged 15-54 years. Of the 189 reporting work-related skin and respiratory symptoms in telephone interviews on exposure and health, 130 hairdressers underwent a physical examination, lung function tests, prick and patch testing, and nasal and lung provocation tests. An occupational disease was diagnosed when the causality between exposure and disease was probable and the clinical tests supported the diagnosis. The telephone interview revealed a life-time prevalence of 16.9% for hand dermatoses, 16.9% for allergic rhinitis, and 4.5% for asthma among the hairdressers. In the clinical investigations, the prevalence was 2.8% for occupational dermatoses, 1.7% for occupational rhinitis, and 0.8% for occupational asthma. Ammonium persulfate caused 90% of the respiratory diseases and 27% of the hand dermatoses. It is concluded that work-related skin and respiratory symptoms are common among hairdressers. Often a specific cause (eg, ammonium persulfate) can be found if occupational diseases are suspected and diagnosed. Hairdressers with atopic diseases are at risk of developing occupational skin and respiratory diseases.

Conclusion : A study of 355 female hairdressers indicated that skin and respiratory were common with an incidence of 16.9% for hand dermatoses and 0.8% for occupational asthma. Persulfate is alleged to be associated with 27% of the hand dermatoses and 90% of the respiratory complaints. The article does not include levels of exposure to persulfates.

15.12.2004 (57)

Type of experience : Human

Result : Four hair dressers showing reactions to hair dye products were tested for sensitivity to ammonium persulfate using a patch test with 2% to 5% aqueous solution. Two woman were nonreactive and two woman reacted positively to ammounium persulfate. One woman stopped working as a hairdresser and the other had no additional problems after avoiding use of persulfate hair bleaches.

Conclusion : Occupational use of persulfates in hair products can produce skin sensitization reactions in some workers.

11.11.2004 (58)

Type of experience : Human

Result : Four cases are reported of occupational exposure to persulfate hair products which resulted in rashes. Patients tested positiveily when patch tested with 2% ammounium persulfate.

Conclusion : Ammonium persulfate can induce sensitization in exposed hair dressers.

11.11.2004 (59)

Type of experience : Human

Result : Early report of dermal sensitization and occupational asthma reported in a single hairdresser. The patient experienced both utricaria and asthma. After ventilation equipment was installed in the salon, no asthma attachs occurred. The amount of persulfate in hair preparations is stated as being 30% of the total formulation.

Conclusion : Good industrial hygiene improves the prognosis of occupational asthma among hairdressers.

18.11.2004 (60)

Type of experience : Human

Result : This study evaluated 118 patients at a dermatology clinic. Patients were patch tested with 2.5% ammonium persulfate in petroleum or water. There were 49 hairdressers among the 118 patients. 12/49 (24.5%) hairdressers gave positive reactions to ammonium persulfate. All of the hairdressers had hand eczema and had been employed as hairdressers for an average time of 21 months. Only 1 of the total population of 118 patients who was not a hairdresser tested positive to ammonium persulfate.
Conclusion : In a sample of 49 hairdressers, 24.5% tested positive in a patch test with 2.5% ammonium persulfate.

11.11.2004 (61)

Type of experience : Human

Result : A hairdresser developed rhinoconjunctivitis and bronchial asthma following a two-year apprenticeship. The patient reacted positively to a persultate prick test.
Conclusion : The case report indicates that persulfates can cause sensitization in the workplace to hairdressers.

11.11.2004 (62)

Type of experience : Human

Result : The main hazards for professional hairdressers are rhinitis, bronchitis, asthma and irritant and allergic contact dermatitis. The risk of respiratory effects is likely to be low among hairdressers using effective dust-free formulations, but considerably higher among those using powder formulations and ineffective dust-free formulations. Dermatitis due to persulfates is likely to affect up to 5% of hairdressers. Members of the general publich are not likely to have respiratory or skin conditions attributable to persulfates. The volume of persulftes imported for hair bleaching products in Australia is 6.5 tonnes/year of which 4.5 tonnes/year is formulated into consumer products. The content of persulfate in salon hair products ranged from 22% to 88% and the content of home-use hair products ranged from 45% to 82.5%.
Conclusion : Review of the literature for animal and human effects, particularly focused on hairdresser exposures. Immediate and delayed contact hypersensitivity, contact urticaria, rhinitis, bronchitis and asthma have been observed in hairdressers as a result of exposure to hair bleaching powders containing persulfates.

11.11.2004 (63)

Type of experience : Human

Result : Three workers at a persulfate production plant developed nasal mucosal inflammation, dry cough and dyspnea. Complaints were noted after many hours of exposure to persulfate dust in the workplace. Uncovered skin areas in two workers exhibited dermatitis. The three workers tested positive to 5% persulfate solution in patch tests. Bronchial obstruction occurred after prolonged exposure (8 hours).
Conclusion : Workers in a production plant developed symptoms that were related to exposure to persulfates. The paper does not include information on the amount of persulfate exposure (air level) or personal protective equipment used.

18.11.2004 (64)

Type of experience : Human

Result : Fifteen employees in a persulfate production company were exposed to ammonium and potassium persulfate during production during the years 1976-1980. Up to 70% of new employees developed skin rashes. Many employees developed rashes within one month of employment. Not all

employees followed the practice of wearing and washing gloves. Improved industrial hygiene practices were recommended. Since instituting improved practices (gloves, long sleeves, washing gloves), the number of reported incidences was significantly reduced.

Conclusion : Persulfates can induce rashes in an occupational workplace unless personal protective equipment is used properly.

19.11.2004 (65)

Type of experience : Human

Result : Employees of the Buffalo plant of the FMC Corporation were included in an extensive industrial hygiene monitoring and clinical study. The clinical study evaluated pulmonary function for a full week in the summer of 1990 and for two weeks in the winter of 1991 using 14 subjects. Workers were directly exposed to persulfates in the packout area and caustic/crystallizer area and inside the laboratory. No workers had a history of asthma symptoms. Samples for breathing zone (608 hours) and area samples were made. Pre- and post-shift spirometry lung function to measure forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) on the first and last day of hte 7-day week were made. The mean level of exposure to persulfates was 0.5 mg/m3, mixed with a total dust level below a mean of 2.0 mg/m3. No clinically significant observations in the spirometry values were found.

Conclusion : Long-term exposure to 0.5 mg/m3 persulfate did not affect pulmonary function evaluated in 14 plant employees. The study related levels of persulfate in air to worker performance (lung function) and showed no deficits.

19.11.2004 (66)

Type of experience : Human

Result : A follow up study was conducted on workers examined in 1990-1991 to see if there were any changes in pulmonary function during 1990-1996. Follow-up data on the original study subjects and new employees involved checking medical records of the exposed employees. Medical records for 22, 17, 10 and 8 workers were available for the two, three, four and six year time periods of follow-up. Records for the five year follow-up were lost in a fire. The change over time in the pulmonary function tests was compared to actual and predicted ratios for years 2, 3, 4 and 6 after the 1990 assessment. Workers included in the study included material operators, crystallizer/caustic operators, lab technicians and workers from other areas. No statistically significant findings of pulmonary function test performance were found for any of the four work position categories. A total of 100 different t-test comparisons were conducted at a p value of 0.05. Two significant findings were found. but because they were less than the total of up to five findings allowed, the two findings were considered to be due to chance.

Conclusion : The study shows that continuous occupational exposure to persulfates over a period of six years did not result in any long term effects on pulmonary function.

19.11.2004 (67)

Type of experience : Human

Result : A cross sectional study was performed in 32 of 33 employees of a persulfate production plant. Eighteen of 23 workmen from the same plant with no exposure to persulfates served as controls. Medical records of the seven subjects who had left the persulfate production for medical reasons since 1971 were collected. Data were recalled by a questionnaire, skin prick tests were performed with five environmental allergens, and ammonium and sodium persulfate (80 mg/ml). Specific IgE to the same

environmental allergens as in the skin test, and total IgE were measured. Lung function and bronchial responsiveness to histamine were assessed by standard procedures. Workplace concentrations of ammonium and sodium persulfate were estimated by area and personal monitoring. Work-related rhinitis was reported by one subject with exposure to persulfates, conjunctivitis and bronchitis were reportedly related to work by two controls. There were no cutaneous reactions to persulfates in either group. Four non-atopic persulfate-exposed subjects and two workmen, one atopic and one non-atopic, were considered hyperresponsive to histamine. Three persulfate-exposed subjects with bronchial hyperresponsiveness did not show peak expiratory flow variability of 20%, the remainder refused peak flow measurements. None of the variables showed significant differences between the groups ($p > 0.05$). Six of the ex-workers left because of work related contact dermatitis, the remainder had complained of asthma. Mean values for workplace concentrations of ammonium and sodium persulfate within the bagging plant were below 1 mg/m3, and the maximal concentrations were 1.4 mg/m3 and 3.6 mg/m3, respectively. Exposure to workplace concentrations of ammonium and sodium persulfate of about 1 mg/m3 in this chemical plant was not associated with a relevant risk for occupational asthma.

Conclusion : A detailed study of 32 workers in a persulfate production facility indicated that exposure to persulfates in the plant (levels of about 1 mg/m3 with a peak of 3.6 mg/m3) was not associated with an increased risk of occupational asthma.

15.12.2004 (68)

Type of experience : Human

Result : A study was conducted to example the prevalence of positive skin prick test reactions to ammonium and potassium persulfates (1% and 5% solutions) among 52 employees of a persulfate production plant. A group of 13 unexposed persons served as controls. Eight of the 52 employees showed a positive response to at least one persulfate solution: 2 were positive to potassium salt, three were positive to ammonium salt and three were positive to both salts. Lung function tests for the exposed population were generally normal but there was a trend showing a correlation between positive skin prick responders and slightly lower lung function for forced expiratory volume FEV1 ($p = 0.057$). Due to the small number of subjects the correlation need clarification.

Conclusion : There was a high response to ammonium and or potassium persulfate skin prick tests (8/52) associated with somewhat lower lung function in workers exposed to persulfates in a production facility. All 13 control subjects did not respond to the same skin prick test.

19.11.2004 (69)

Remark : case reports: two workers developed dermatitis, rhinitis, bronchitis and asthma (no acute dyspnoea) after occupational exposure to dusts of Na, K, and NH4-persulfates (relatively high exposure). The authors suggested that chemically irritative or toxic effects of the persulfates play the predominant role in the pathogenesis of these reports.
Literature could not be retrieved.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

18.11.2004 (70)

Remark : contact with bleach powder containing persulfates let to irritant dermatitis, urticaria, oedema, rhinitis,

conjunctivitis, asthma and syncope. Allergic eczematous contact dermatitis (delayed type) are rare. Workplace related challenge tests with the bleach powders were positive (immediate and delayed reactions). Skin tests with hair bleaches or persulfates were in rare cases positive. Specific IgE antibody were not found in the RAST-test. Provocation tests with histamine were positive. The pathophysiological mechanism is unclear.
Literature could not be retrieved.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
21.12.2004 (71) (72) (73) (74) (53) (75) (76) (77) (78) (79) (80) (81) (59) (60) (82) (83) (84) (54) (85) (62) (86)

Remark : in 242 patients with one or more positive reactions to a routine battery, NH4- and K-persulfates were tested. In 17 cases a delayed type reaction was seen.
Literature could not be retrieved.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
01.02.1994 (87)

Remark : Literature could not be retrieved.
over 5 years (1986 - 1990) 2320 patients with reactions to one or more allergens of the European standard series were additionally tested with NH4- (2.5 %) and K-persulphate (2 %). In 22 female patients (0.9 %) positive reactions were obtained (all had hand dermatitis only). 14 patients were hairdressers. Six persons reacted only to ammonium persulphate, 16 to ammonium and potassium persulphate. 15 patients were also positive to other tested allergens.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (88)

Remark : Literature could not be retrieved.
the evaluation of 116 hairdressers (1984-1987) with eczema gave in 77.6 % of all patients positive results in testing typical substances occuring at the working place of hairdressers. In 90 of 160 hairdressers there were occuring symptoms during the first three years. 26.7 % were positive to ammonium persulfate.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (89)

Remark : Case report:
Two cases have been described of redness and slight crusting of the scalp and forehead, some hours after application of a hair bleach containing ammonium persulfate. The investigators attributed this to an irritant rather than a sensitzation effect. Standard 24/48 h covered patch tests with 2.5 or 5 % ammonium persulfate produced no local reactions in these two patients.
Literature could not be retrieved.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (90) (58)

Remark : Allergic contact dermatitis was observed on the hands of bakers and hairdressers.
Literature could not be retrieved.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)

19.11.2004 (91) (92) (93)

Result : A 36-year old laboratory technician in a potato flour facility exhibited dermatitis on her face and hands. She tested positively to 1, 2.5 and 5% aqueous solution of potassium persulfate. A prick test to 1% aqueous potassium persulfate was negative. A patch test to 2.5% ammonium persulfate produced a weaker response.

Conclusion : A single case of contact dermatitis is reported for a worker exposed to persulfate in a potato flour factory.

15.12.2004 (94)

Remark : A well-documented review from the UK authority (HSE) was available.
Introduction
Persulphate salts (ammonium, potassium and sodium) are strong oxidising agents with wide industrial use. They are also used to enhance the action of peroxide hair bleaches, for which they are supplied as a powder to mix with liquid peroxide shortly before use. Persulphate hair bleaches have produced both irritant and allergic contact dermatitis, as well as urticarial and respiratory reactions (Fisher and Dooms-Goossens, 1976; Kellett and Beck, 1985; Kleinhans and Ranneberg, 1989). The contact urticaria is not immunologically-mediated, but thought to be due to the fact that persulphate is a weak histamine-releasing agent (Calnan and Schuster, 1963; Parsons et al., 1979). It is not known why only some individuals are sensitive to this action.

Evidence for work-related asthma
There have been a number of well-conducted studies of hairdressers with work-related asthmatic symptoms that have included specific bronchial challenge tests, performed blinded, using hair bleach or persulphate, either as powder or aerosolised solution. In some studies, controls who were either non-asthmatic, or asthmatic with hyperresponsive airways, were also challenged; none gave positive reactions.

Of 12 'tinters' from a hairdressing salon who used persulphate-containing bleach, 4 had work-related asthmatic and nasal symptoms, which had developed after a latent period of at least six months (Blainey et al., 1986). An affected individual from another salon was also included for investigation. All 5 were hyperresponsive to histamine, though other lung function parameters were normal. Only those with symptoms reacted at specific challenge, giving late asthmatic responses, and controls (including asthmatics) failed to react. All 4 of the subjects who also underwent nasal challenge gave positive reactions.

Agustin reported the cases of two hairdressers who developed work-related rhinitis, conjunctivitis and, in one, asthma several years after first using bleaching powders (Agustin et al., 1992). Both had normal respiratory function, but the asthmatic subject was hyperresponsive to methacholine. At specific bronchial challenge, the person with asthma developed a late response, while the other suffered immediate severe nasal symptoms.

A young woman developed work-related respiratory symptoms about a year after starting work in a hairdressing salon (Parra et al., 1992). When she was investigated, after a month's absence from work, she was hyperresponsive to methacholine. On specific bronchial challenge, she developed a late, prolonged reaction followed by recurrent nocturnal falls in forced expiratory volume in one second, for 96 hours after the test.

Another case of work-related asthma, with associated sneezing and rhinoconjunctivitis, has been described, in which a young woman worked for 3 years before developing symptoms (Pankow et al., 1989). As in other cases, lung function was normal but the airways showed non-specific hyperresponsiveness. On unblinded bronchial challenge, she suffered an immediate asthmatic attack. Normal and asthmatic controls did not react.

A beautician with a history of mild seasonal rhinitis developed work-related asthma (Schwartz, 1989). Lung function was normal, and she was not hyperresponsive to methacholine. She underwent blinded bronchial challenges with a number of hair care preparations, and reacted only to a persulphate-containing bleach with an immediate reaction (it was unclear for how long measurements were continued). The patient declined challenge with persulphate itself.

All of these well-conducted studies provide evidence that persulphate salts are capable of inducing asthma and can cause specific reactions at bronchial challenge under conditions which do not induce a response in normal or previously non-exposed asthmatic people.

These studies are backed up by several case reports of occupational asthma associated with persulphate use, in which the bronchial challenge tests performed were not blinded and omitted controls. These include two cases, both positive at challenge (Pepys et al., 1976); 5 cases, 4 challenged - 2 positive, 1 negative, 1 equivocal (Therond et al., 1989); one case, positive (Gamboa et al., 1989); one case, positive (Schwaiblmair et al., 1990); three cases, one challenged - positive (Wallenstein et al., 1993).

There are also reports of persulphate effects in occupations other than hairdressing. One concerns an Italian factory that used ammonium and potassium persulphate during the manufacture of hydrogen peroxide, in which 12% of the workers suffered from asthma that usually developed within 6 months of starting work (Barsotti et al., 1951). Bronchial challenges were performed with an aerosol of a 1% ammonium persulphate solution; affected workers, but not controls, responded positively to challenge. In another study, 2 chemical factory workers who bagged persulphates developed work-related nasal and asthmatic symptoms within a few weeks of beginning work (Baur et al., 1979). Neither underwent bronchial challenge, and symptoms resolved on avoiding exposure.

Supporting data
Skin prick tests, and occasionally intradermal or scratch tests, have been performed on many of the people reported as having persulphate-related asthma or rhinitis. Either persulphate or bleach powder solutions have been used; negative controls have sometimes been included. The tests have been positive in most of those studied (Gaultier et al., 1966; Blandin, 1970; Fisher and Dooms-Goossens, 1976; Pepys et al., 1976; Baur et al., 1979; Blainey et al., 1986; Pankow et al., 1989; Agustin et al., 1992; Escudero Pastor et al., 1992; Parra et al., 1992; Wallenstein et al., 1993). There have also been some negative results reported (Baur et al., 1979; Blainey et al., 1986; Gamboa et al., 1989; Agustin et al., 1992; Wallenstein et al., 1993). In one study, the results of intradermal tests in 3 people

correlated with bronchial challenge data (Wallenstein et al., 1993). Amongst employees manufacturing persulphates, work-related breathing difficulties were found more often (6/8) in those who were positive than in those who were negative (9/44) in skin prick tests (Wrbitzky et al., 1995). In an early study, a scratch test that was strongly positive triggered within minutes a "violent" attack of asthma (Blandin, 1970). While most people with persulphate asthma have given positive skin prick tests, this may be because of direct histamine release rather than an immunologically-mediated reaction.

In hairdressers with asthma, total immunoglobulin E (IgE) levels have generally been normal, though increased in two people, and decreased after avoidance of exposure in another (Gamboa et al., 1989; Pankow et al., 1989; Schwaiblmair et al., 1990; Agustin et al., 1992; Parra et al., 1992). No specific IgE to persulphates has been found in three separate cases tested (Gamboa et al., 1989; Schwaiblmair et al., 1990; Parra et al., 1992). However, the serum from an asthmatic patient was positive for both hair bleach and sodium persulphate in a Prausnitz-Kustner test for passive transfer of specific IgE (Escudero Pastor et al., 1992). Overall, these immunological data are scarce and inconclusive.

In peripheral blood studies, one person had eosinophilia, and another developed neutrophilia and eosinophilia following positive bronchial challenge (Schwaiblmair et al., 1990; Parra et al., 1992).

Source : HSE, UK authority.
31.05.2005 (95) (96) (70) (71) (72) (53) (97) (58) (79) (80) (61) (82) (98) (99) (100) (101) (54) (102) (103) (62) (104) (69)

5.11 ADDITIONAL REMARKS

Type : Biochemical or cellular interactions

Method : Human polymorphonuclear neutrophils (PMN) are treated with ammonium persulfate to establish its influence on the release of the inflammatory mediator leukotriene B4 (LTB4).

Test 1: treatment with 0.1-10 mM ammonium persulfate in presence of LTB4 stimulating Ca ionophore A23187 or sodium fluoride (NaF) and with 0.01-10 mM in presence of LTB4 stimulating tripeptide formyl-methionyl-leucyl-phenylalanine (fMLP).

Test 2: treatment with 0.1-1 mM ammonium persulfate, washing of the cells with buffer solution and subsequent stimulation of LTB4 with Ca ionophore A23187, tripeptide formyl-methionyl- leucyl-phenylalanine (fMLP) or sodium fluoride (NaF)

Result : Test 1: with all treatments a dose-related decrease of LTB4 formation was seen.

Test 2: cells which were pre-activated with ammonium persulfate and subsequently washed showed an increase in leukotriene formation after stimulation with fMLP or NaF, but not with the Ca ionophore.

In addition it was demonstrated that ammonium persulfate decreased the stability of leukotrienes in cell free systems.

Conclusion : The concentration of ammonium persulfate at local tissue sites as well as the occurrence and nature of a secondary cell-activating stimulus finally determine to what extent persulfates will interfere with cellular functions, e.g. mediator suppression or induction.

From the results it can be concluded that ammonium persulfate may induce

and amplify inflammatory reactions by leukocyte priming and by alteration of mediator profiles. This altered mediator profile may induce the pseudoallergic reactions and prime exposed individuals to allergic manifestations.

11.11.2004 (105)

Type : Biochemical or cellular interactions

Method : Test 1: rat peritoneal mast cells were exposed to ammonium persulfate (0.33-2.7 mg/mL cell suspension) under different conditions (temperature, pH and time). Histamine release was measured (corrected for spontaneous release) and cells were investigated for degranulation and/or membrane disruption.

Test 2: guinea pig skin slices (from the abdomen) were exposed to 0.2-16 mg/mL ammonium persufate or 0.2 mg/mL 48/80 for 30 minutes at 37 and 4 degC. Histamine release was measured (corrected for spontaneous release).

Test 3: guinea pigs were exposed intradermally to ammonium persulfate at 4, 8 and 16 mg/mL saline. Animals were killed after 40 minutes and the skin was removed and assessed for lesions. The size of the lesion was recorded.

Result : Test 1: Histamine release increased dose dependently. Temperature, pH and incubation time influenced the reaction. At cellular level an alteration of the granules was observed.

Test 2: At 37 degC a dose related increase of histamine was seen. The effect at 4 degC was less clearly.

Test 3: lesions were dose dependently increased in size and intensity.

Conclusion : Ammonium persulfate causes a release of histamine, which appears to be caused by an alteration of mast cell granules without disruption of the membrane. Part of the reaction may be caused by the ammonium ion, which can release histamine itself. The reaction is slow.

31.05.2005 (100)

Type : other: in vitro skin reaction

Method : METHOD
500 µm thick abdominal skin slices (3/exp) of guinea pigs (Dunkin-Hartley), rats (CFY) and monkeys (Rhesus) were incubated with ammonium persulfate (1, 10, 100 and 1000 µg/ml) for 15-30 min at 37 C in histamine release experiments. Positive control was compound 48/80 at 1, 10 and 100 µg/ml.
Histamine release was expressed as percentage of the total histamine (released and residual) per sample. Histamine content was determined by a histamine bioassay using atropinized terminal guinea pig ileum.

Result : RESULTS
Guinea pig (5 experiments at 1-100; 1 at 1000 µg/ml): 0 for all concentrations of ammonium persulfate; 10% (10 µg/ml) and 37 (100 µg/ml) for 48/80
Rat (5 replicates at 1-100; 3 at 1000 µg/ml): 0 (1-100 µg/ml) and 21 (1000 µg/ml)* for ammonium persulfate; 7% (10 µg/ml) and 22 (100 µg/ml) for 48/80
Monkey (1 replicate for all concentrations): 0 for all concentrations of ammonium persulfate; 8% (10 µg/ml) and 41% (100 µg/ml) for 48/80

*Probably a non-specific toxic reaction, since release was not reduced by lowering the incubation temperature.

Conclusion : Ammonium persulfate is not a potent histamine liberator.
Reliability : (4) not assignable
Non-guideline study.
11.11.2004 (98)

Type : other: rabbit model for effects on the respiratory tract

Method : Rabbits (8/treatment, all narcotised, intubated, catheterised) are provoked for 1 minute to air containing 0.2 or 2% acetylcholine. Subsequently the animals were exposed to 5, 50 and 500 mg/m3 ammonium persulfate (aerosol) for 2X2 hours. After 2 and 4 hours the provocation with acetylcholine was repeated.
Dynamic resistance (as a measure of air-way constriction) and arterial O2 and CO2 pressure were determined over a period of 15 minutes after the provocation with acetylcholine.

Result : Initial provocation with 0.2% acetylcholine did not change dynamic elasticity, O2 and CO2 pressure. At 2% acetylcholine dynamic elasticity (max. after 1 minute) was doubled, O2 pressure decreased and CO2 pressure was unchanged.

The provocation after ammonium persulfate resulted in no effects on elasticity after 0.2% acetylcholine and a dose-related increase of the elasticity to maximum 600% at 500 mg/m3 after 2% acetylcholine. O2 pressure decreased 15% and 61% (after 0.2 and 2% acetylcholine challenge), while CO2 pressure did not change.

Conclusion : Ammonium persulfate may cause effects on the respiratory tract.
11.11.2004 (106)

Type : other: physiological effects

Remark : in-vitro test: influx of calcium into cardiomyocytes (rat) was decreased by ammoniumpersulfate.
Test substance: no data
GLP : no data
Literature could not be retrieved.

Source : Degussa AG Frankfurt am Main
EUROPEAN COMMISSION - European Chemicals Bureau Ispra (VA)
19.11.2004 (107) (108)

(1) SPIN database 08-12-04

(2) SAX's dangerous properties of industrial materials, Van Nostrand Reinhold, 1996.

(3) Degussa AG, Safety Data Sheet: Ammonium persulphate (13-09-2000), 2000.

(4) Merck; The Merck Index; 10 ed.; Merck and Co., Inc., Rahway, New Jersey (1983).

(5) Sax, N.I.; Dangerous properties of industrial materials; 4 ed.; Van Nostrand Reinhold Co., New York (1975).

(6) CRC Handbook of chemistry and physics, CRC Press, 1999/2000.

(7) Merck Index, CD-ROM 1999.

(8) FMC Corporation Material Safety Data Sheet: Ammonium persulfate (19-07-01: date approved), 2001.

(9) Degussa AG, safety data sheet, 23.11.93

(10) FMC, Toxicology department, Princeton, letter of March 8, 1994 (1994).

(11) FMC Corporation Material Safety Data Sheet: Ammonium persulfate (19-07-01: date approved), 2001.

(12) Peroxid-Chemie GmbH; unpublished report; 24.9.91 (1991).

(13) FMC, internal communication.

(14) Koltoff I. and Miller I K (1951). The chemistry of persulfate. I. The kinetics and mechanism of the decomposition of the persulfate ion in aqueous medium. J. Am. Chem. Soc., 73, 3055-3059.

(15) Degussa AG, unpublished, report no.: Degussa AG, US-IT-Nr. 88-0013-DGO (1988).

(16) Solvay and Cie, unpublished, File no. 372 (1991).

(17) FMC Corporation, Acute toxicity of ammonium persulfate to rainbow trout (Oncorhynchus mykiss), Study no. I92-1247, 1993.

(18) FMC Corporation, Acute toxicity of ammonium persulfate to bluegill (Lepomis macrochirus), Study no. I92-1246, 1993.

(19) Degussa AG, Acute toxicity study with Poecilia reticulata exposed to ammoniumperoxydisulfat, Study no. 88-0016-DGO, 1988.

(20) FMC Corporation, Acute toxicity of ammonium persulfate to the water flea (Daphnia Magna), Study no. I92-1248, 1993.

(21) Degussa AG, Acute immobility test with Daphnia Magna exposed to ammoniumperoxydisulfat, Study no. 88-0015-DGO, 1988.

(22) FMC Corporation, Acute toxicity of ammonium persulfate to grass shrimp (Palaemonetes pugio), Study no. I92-1249, 1993 .

(23) Bringmann, G.; Kuehn, R.; Gesundheits - Ingenieur, vol. 4, 115 - 120 (1959).

(24) FMC Corporation, Ammonium persulfate: acute toxicity to the freshwater green alga, Selenastrum capricornutum, under static test conditions, Study no. I97-2227, 1998.

(25) OHMTADS Data Bank (1989) in: Solvay and Cie, unpublished, file no.: 372 (1991).

(26) Degussa AG, Assessment of the acute toxicity of ammonium persulfate on the cell multiplication of a pure culture of Pseudomonas putida bacteria. (acute bacteria cell multiplication inhibition test), Study no. 88-0014-DGO, 1988.

(27) Takeda Chemical Industries Ltd., Japan (1966), 1302392, Fukuda et al. (1971).

(28) Akademie der Landwirtschaftswissenschaften der DDR, Institut fuer Pflanzenschutzforschung, Kleinmachnow; Bergmann, H. et al.; Patentschrift, DD, 221 058 A1 (1985).

(29) Boczek, J. et al.; J. Georgia Entomol. Soc., vol. 19, 235 - 248 (1984).

(30) Ignatowicz, S.; Zeszyty Problemowe Postepow Nauk Rolniczych, vol. 252, 205 - 229 (1983).

(31) FMC corporation, Acute oral toxicity, Study no. I2001-2331 (unaudited report), 2001.

(32) FMC Corporation, Acute and 28-day subacute toxicity of ammonium persulfate, Study no. ICG/T-79-025, 1979.

(33) Smyth H. F. et al.; Am. Ind. Hyg. Ass. J., vol. 30, 470 - 476 (1969).

(34) FMC Corporation, unpublished, FMC study no.: I91-1201 (1991).

(35) FMC Corporation, Acute inhalation toxicity study with ammonium persulfate in the rat, Study no. I87-0969, 1989.

(36) FMC Corporation, Ammonium persulfate: acute dermal toxicity study in rats, Study no. I91-1200, 1991.

(37) FMC Corporation, Ammonium persulfate: primary skin irritation study in rabbits, Study no. I87-0970, 1988.

(38) Degussa AG, unpublished, Report No.: Degussa AG, US-IT-Nr. 83-0023-DKT (1983).

(39) FMC Corporation, Ammonium persulfate: primary eye irritation study in rabbits, Study no. I87-0968, 1988.

(40) Degussa AG, unpublished, Report No.: Degussa AG, US-IT-Nr. 83-0024-DKT (1983).

(41) Degussa AG, Ammonium-Persulfat (APS); Prüfung auf sensibilisierende Eigenschaften an der Haut des Meerschweinchens (Optimierungs-Test), Study no. 85-0014-DKT, 1985.

(42) FMC Corporation, A 13-week inhalation toxicity study (with recovery) of ammonium persulfate in albino rats, Study no. I97-2205, 1998.

(43) Last, J. A. et al.; Inhalation Toxicology of Ammonium Persulfate, an Oxidant Aerosol, in Rats. Toxicology and Appl. Pharmacology, vol. 63; 257 - 263 (1982).

(44) Arnold, A.; Goble, F. C.; Cereal Chem., vol. 27, 375 (1950) in: BIBRA report, Toxicity profile, 1st. ed (1988).

(45) Arnold, A.; Goble, F. C.; Fed. Proc., vol. 8, 377 (1949) in: BIBRA report; Toxicity profile, 1st ed. (1988).

(46) Shimizu, H., The results of microbial mutation test for forty-three industrial chemicals, Jpn, J. Ind. Health 27, 400-419, 1985.

(47) Ishidate, M., Primary mutagenicity screening of food additives currently used in Japan, Fd. Chem. Toxic. 22(8), 623-636, 1984.

(48) Pagano, D. A. et al.; Mutation Research, vol. 228, 89-96 (1990).

(49) JETOC (Japan Chemical Industry, Ecology-Toxicology and Information Center) Newsletter, vol. 3, 11 - 13 (1984).

(50) Kurokawa, Y. et al., Studies on the promoting and complete carcinogenic activities of some oxidizing chemicals in skin carcinogenesis. Cancer Letters, vol. 24, 299 - 304 (1984).

(51) Kurokawa, Y. et al.; Cancer Letters, vol. 24, 299 - 304 (1984).

(52) Weaver, E.V. Oral Reproductive/Developmental Toxicity Screening Test in Rats with Ammonium Persulfate in Feed. Covance Laboratories, Inc. Vienna, VA, USA. Covance Study Number 7463-101, FMC Study Number I2003-2337. Final Report, 2004.

(53) Calnan, C., Shuster, S., Reactions to ammonium persulfate, Arch. Dermatol. 88, 812-815, 1963 (43).

(54) Schwaiblmair, M., Asthma bronchiale durch Blondiermittel im Friseurberuf, Deutsche Med. Wochenzeitschrift 115(18), 695-697, 1990.

(55) Final Report on the Safety Assessment of Ammonium, Potassium, and Sodium Persulfate, International Journal of Toxicology 20 (Suppl. 3): 7-21, 2001 (Cosmetic Ingredient Review (CIR), Washington, DC, 20036, USA).

(56) Leino, T. et al., Working conditions and health in hairdressing salons, Applied Occupational and Environmental Hygiene 14 (1), 26-33, 1999a.

(57) Leino, T. et al., Occupational skin and respiratory diseases among hairdressers, Scandinavian journal of work, environment & health 24 (5): 398-406, 1999b.

(58) Fisher, A. A.; Dooms-Goossens, A.; Persulfate Hair Bleach Reactions, Cutaneous and Respiratory Manifestations. Archs. Derm., vol. 112,1407 (1976).

(59) J. Reiffers, N. Hunziker, R. Brun, B. Vidmar, Unusual Allergic Skin Sensitizations, Dermatologica 148, 285-291, 1974.

(60) K. Meindl and R. Meyer, Asthma and urtricaria in the hairdresser's trade due to bleaching agents containing persulfates, Zbl. Arbeitsmed. 19(3): 75-79, 1969.

(61) J.K. Kellett and M.H. Beck, Ammonium persulphate sensitivity in hairdressers, Contact Dermatitis 13, 26-28, 1985.

(62) W. Pankow, H. Hein, K. Bittner, P.v.Wichert, Persulfate-asthma in the hairdressing trade, Pneumologie 43, 173-175, 1989.

(63) Priority Existing Chemical Assessment Report No. 18, Ammonium, Potassium and Sodium Persulfate. June 2001
National Industrial Chemicals Notification and Assessment Scheme, Commonwealth of Australia.

(64) X. Baur and G. Fruhmann, Bronchial Asthma of Allergic and Irritative Origin as an Occupational Disease, Prax. Pneumol. 33, 317-322, 1979.

(65) I.R. White, H.E. Catchpole, R.J.G. Rycroft, Rashes amongst persulphate workers, Contact Dermatitis 8: 168-172, 1982.

(66) Report of Persulfate Worker Study of the FMC Plant in Buffalo, New York 1990-1991. Unpublished report for FMC Corporation. FMC Study I1992-1713, Jan. 15, 1992.

(67) Preliminary Report: Lung Function Assessment of Persulfate Workers: 1990-1996. FMC, Buffalo, NY. Unpublished report for FMC Corporation. By William W. Greaves, May 23, 1997.

(68) Merget, R. et al., Cross sectional study of chemical workers exposed to sodium and ammonium persulfate, Dermatosen in Beruf und Umwelt, (1997) 45/3 (130-131).

(69) Wrbitzky, R., Drexler, H. and Letzel, S., Early reaction type allergies and diseases of the respiratory passages in employees from persulphate production, Int. Arch. Occup. Environ. Health 67, 413-417, 1995.

(70) Baur, X. et al.; Respiration, vol. 38, 144 - 150 (1979).

(71) Blainey, A. D. et al.; Thorax, vol. 41, 42 - 50 (1986).

(72) Blandin, G.; Desensitization in Hairdressers (Sprays and Bleaching Agents) Rev. franc. Allergol., vol. 10, 327 - 331
(1970).

(73) Brubaker, M. M.; Urticarial Reaction to Ammonium Persulfate. Arch. Dermatol., vol. 106, 413 - 414 (1972)

(74) Brun, R. et al.; Epicutaneous test with immediate reaction (ammonium persulfate). Dermatologica, vol. 133, 89 (1966).

(75) Fisher, A. A.; Cutis, vol. 36, 25 - 27 (1985).

(76) Fisher, A. A.; Cutis, vol. 6, 523 - 525 (1985).

(77) Fisher, A. A.; Dermatitis Due to Sulfites in Home Permanent Preparations. Part II. Cutis, vol. 44, 108 - 109 (1989).

(78) Fisher, A. A.; The Persulfates: A Triple Threat Part II: Occupational Exposures. Cutis, vol. 36, 25 - 27 (1985).

(79) Gamboa, P. M. et al.; Allergol. Et. Immunopathol., vol. 17,
109 - 111 (1989).

(80) Gaultier, M. et al.; Two Causes of Professional Asthma among Hairdressers: Persulfates and Silk. Arch. Mal. Prof., vol. 27, 809 - 813 (1966).

(81) Hardel et al.; Amthma in Hairdressers: Danger of Capillary Bleaching Agents Containing Alkaline Persulfates. La Nouvelle Preese Medicale, vol. 7, 4151 (1978).

(82) Kleinhans, D.; Ranneberg, K. M.; Allergologie, vol. 12, 353 - 354 (1989).

(83) Marks, R.; Cronin, E.; Aust. J. Derm., vol. 18, 123 - 126 (1977).

(84) Plunckett, E. R.; Handbook of Industrial Toxicology, 2nd. ed. New York, 26 - 27 (1976).

(85) v. Krogh, G.; Maibach, H. J The contact urticaria syndrome-an updated review.; J. Am. Acad. Dermatol., vol. 5, 328 - 342 (1981).

(86) Young, E.; Dermatilogica (Basel), vol. 148, 39 - 42 (1974).

(87) Van Joost, Th. et al.; Contact Dermatitis, vol. 11, 159 - 162 (1984).

(88) Van Joost, Th. Roesyanto, I. D.; Contact Dermatitis, vol. 24, 376 - 378 (1991).

(89) Gehse et al.; Zbl. Arbeitsmed., vol. 40, 243 (1990).

(90) Cronin, E.; Contact Dermatitis. Curchill Livingstone, Edinburgh (1980)in: BIBRA report, toxicity profile, 1st. ed. (1988).

(91) Bonnevie, P.; Aetologie und Pathogenese der Eczemkrankheit. Kopenhagen, Nyt Nordisk Forlag, 1939 in: Fisher, A. A.; Dooms- Goossens, A.; Arch. Dermatol., vol. 112, 1407 - 1409 (1976).

(92) Forck, G.; Berufsdermatosen, vol. 16, 84 - 92 (1968).

(93) Schulz, K. H.; Z. Haut Geschlechtskr., vol. 42, 499 - 509 (1967).

(94) Veine, N., Hattel, T. and Laurberg, G., Contact dermatitis due to potassium persulfate. Contact Dermatitis 45, 176, 2001.

(95) Agustin P, Martinez-Cocera C, Cimarra M et al (1992) Persulphate-induced occupational respiratory allergy Rev Esp Alergol Inmunol Clin. 7; 91-97.

(96) Barsotti M, Parmeggiani L and Sassi C (1951) Symptoms of bronchial asthma and eczema in workers assigned to hydrogen peroxide production units Med Lav. 42; 49-68.

(97) Escudero Pastor AI, Hernandez Garcia J, Lopez Sanchez JD et al (1992) Occupational asthma caused by persulphate inhalation Rev Esp Alergol Inmunol Clin. 7; 87-90.

(98) Mahzoon, S., Response of skin to ammonium persulphate, Acta Dermatovener (Stockhollm) 57, 125-126, 1977 (42).

(99) Parra FM, Igea JM, Quirce S et al (1992) Occupational asthma in a hairdresser caused by persulphate salts Allergy (Eur J Allergy Clin Immunol). 47; 656-660.

(100) Parsons, JF et al., Studies on the action of histamine release by persulphates, Fd. Cosmet. Toxicol. 17, 129-135, 1979 (45).

(101) Pepys J, Hutchcroft BJ and Breslin ABX (1976) Asthma due to inhaled chemical agents-persulphate salts and henna in hairdressers Clin Allergy. 6; 399-404.

(102) Schwartz HJ (1989) Effect of chronic chromolyn sodium therapy in a beautician with occupational asthma J Occup Med. 31; 112-114.

(103) Therond M, Geraut C, Dupas D and Gayoux C (1989) Pathology of alkaline persulphates: concerning 19 recent cases Arch Mal Prof Med Trav Secur Soc. 50; 837-838.

(104) Wallenstein G, Wagner E and Schoneich R (1993) Airway symptoms in hairdressers with occupational contact eczema Arbeitsmed Sozialmed Praventivmed. 28; 441-444.

(105) Köller, M., Dual effect of ammonium persulfate on the generation of leukotrienes from human neutrophil granulocytes, Int. Arch. Allergy Immunol. 110, 318-324, 1996 (44).

(106) Marek, W., Bronchiale Überempfindlichkeit nach Arbeitsstoffexposition: Korrelation respiratorischer Parameter mit den arteriellen Blutgasen am Kaninchen, Atemswegs- und Lungenkrankheiten 22, 317-319, 1996 (47).

(107) Kaminishi, T. et al.; Can. J. Cardiol., vol. 5, 168 - 174 (1989).

(108) Kaminishi, T.; Kako, K. J.: 72nd Ann. Meet. Fed. Amer. Societies Experimental Biology, Las Vegas, vol. 2, Abstr. 1378 (1988).