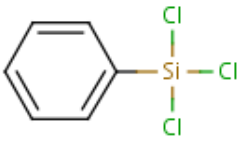
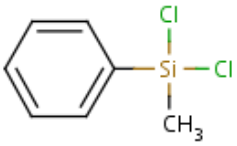
SIDS INITIAL ASSESSMENT PROFILE

Category name	Phenylchlorosilane Category
CAS No(s).	98-13-5 149-74-6
Chemical Name(s)	Trichlorophenylsilane (**TClPS**) Dichloromethylphenylsilane (**DClMPS**)
Structural Formula(s)	**TClPS**:  **DClMPS**: 

SUMMARY CONCLUSIONS OF THE SIAR

Analogue/Category Rationale

These chemicals can be represented by a similar general molecular formula:

$(Cl)_xSiPh(Me)_{(3-x)}$

Where Cl = chlorine, x = 2 or 3;

Si = silicon [=1];

Ph = phenyl, [=1];

Me = CH_3

Chlorosilanes, including the phenyl chlorosilanes, react rapidly when exposed to moisture or polar reagents (those that are protic and as such contain a dissociable H_+), producing hydrogen chloride (HCl; CAS No. 7647-01-0) and the corresponding silanols (in general, siloxane oligomers and polymers at concentrations greater than 500 mg/L). Specifically, **TClPS** hydrolyses to form three moles of HCl and one mole of phenylsilanetriol, and **DClMPS** hydrolyses to form two moles of HCl and one mole of methylphenylsilanediol. The half-lives of the phenylchlorosilanes are expected to be < 1 minute based on data with supporting substance diphenyldichlorosilane (DClDPS, CAS No. 80-10-4); data are not available for **TClPS** or **DClMPS**. The assessment for **TClPS** focuses exclusively on the sponsored substance which contains up to 1% benzene as an impurity.

As noted, the silanols resulting from initial hydrolysis can condense spontaneously to form highly cross-linked polymeric gels in uncontrolled environments. Exposure to parent chlorosilane is likely to be transient and observed toxicity in standard test systems will therefore, depending on the conditions of the system (e.g. pH and concentration of test material), likely be to hydrolysis products and condensed silanol material (at concentrations greater than 500 mg/L).

Hydrolysis analogues. DClDPS hydrolyses rapidly in contact with water (half-life 0.2 minutes at pH 7 and 1.5 ^{o}C). Based on the rapid hydrolysis of DClDPS, similar rates of hydrolysis are expected for **TClPS** and **DClMPS**.

Human Health and Aquatic Toxicity Analogues.

(1) Due to their reactivity, the category members are expected to hydrolyse prior to exposure, or locally at the port of entry, to form HCl and a corresponding silanol hydrolysis product. The levels of chlorosilane required to generate concentrations near those tested for corresponding or analogous silanols would result in severely corrosive HCl concentrations. Therefore, data for HCl can be used to partially address the toxicity of the phenylchlorosilanes. The primary hazard for the sponsored phenylchlorosilanes is considered to be exposure to the hydrogen chloride hydrolysis product.

(2) A previously assessed alkoxysilane, trimethoxy(phenyl)silane (TMPS; CAS No 2996-92-1) hydrolyses to form three moles of methanol and one mole of phenylsilanetriol (CAS No 3047-74-3, the same expected hydrolysis product as **TClPS**). TMPS hydrolyses more slowly at pH 7 (half-life ca. 0.4 hours), but under acidic conditions such as in the stomach following ingestion, much more rapid hydrolysis can be expected. While phenylsilanetriol is not the expected hydrolysis product of **DClMPS**, both phenylsilanetriol and methylphenylsilanediol are expected to be water soluble due to the hydroxy groups on the silicon, have low log Kow values, and are expected to be readily absorbed and excreted. Hydrolysis of the sponsored substances produces HCl, while TMPS produces methanol as a hydrolysis product. The contribution of methanol from TMPS to the toxicity assessment of the sponsored substances is expected to be negligible as compared to the effects of HCl. TMPS is considered to be a suitable analogue for human toxicity endpoints for **DClMPS**.

HCl and TMPS were presented and agreed under the OECD Cooperative Chemicals Assessment Programme (http://www.oecd.org/env/hazard/data). The assessment for **TClPS** focuses exclusively on the sponsored substance which contains up to 1% benzene (CAS No. 71-43-2) as an impurity. Benzene has also previously been presented and agreed under the OECD HPV Chemicals Programme (http://www.oecd.org/env/hazard/data).

The read across strategy for the phenylchlorosilanes follows:

Endpoint	**TClPS**	**DClMPS**
Hydrolysis	DClDPS	DClDPS
Biodegradation	Data available	**TClPS**
Acute inhalation toxicity	HCl	HCl
Acute oral toxicity	**DClMPS**, TMPS, HCl	Data available
Skin, eye and respiratory tract irritation	HCl	HCl
Repeated dose toxicity: inhalation	TMPS, HCl	TMPS, HCl
Repeated dose toxicity: oral	TMPS	TMPS
Genetic toxicity *in vitro*: gene mutation	Data available	Data available

Genetic toxicity *in vitro*: chromosome aberration	TMPS, HCl	TMPS, HCl
Toxicity to fertility	TMPS, HCl	TMPS, HCl
Developmental toxicity	TMPS, HCl	TMPS, HCl

Physical-chemical Properties

The category members are liquids with measured melting points of -49.4 (**DClMPS**) and -40 °C (**TClPS**), measured boiling points of 201.8 (**TClPS**) and 206 – 207 °C (**DClMPS**) and vapour pressures of 0.44 (**TClPS**; estimated) and 0.47 (**DClMPS**; extrapolated) hPa at 20 ºC. The calculated octanol-water partition coefficients (log K_{ow}) are 3.60 (**TClPS**) and 3.8 (**DClMPS**; reliability = 4), and the estimated water solubilities are 48.7 (**DClMPS**) and 78.5 mg/L (**TClPS**) at 20 °C. The calculated water solubility and log K_{ow} values may not be accurate because the substances are hydrolytically unstable.

Human Health

No data are available on the toxicokinetics, metabolism and distribution of the phenylchlorosilanes. However, these substances rapidly hydrolyse to HCl and the corresponding silanol hydrolysis products on contact with moisture. Damage to membranes caused by the corrosive nature of HCl might enhance the uptake of the sponsored substances or the silanol hydrolysis products. Hydrogen and chloride ions will enter the body's natural homeostatic processes. HCl will rapidly dissociate and its effects are thought to be a result of pH change (local deposition of H^+). The hydrophilic nature of phenylsilanediol or –triol may limit diffusion across certain membranes. The low molecular weight and high water solubility of the silanols suggest elimination via the kidneys in urine.

Acute inhalation studies were not located for the phenylchlorosilanes. The acute inhalation toxicity of the phenylchlorosilanes is expected to be well-characterized by the effects of HCl exposure, rather than systemic effects of silanol hydrolysis products. The principal clinical signs are expected to be indicative of respiratory and ocular effects resulting from HCl exposure. Inhalation LC_{50} values for HCl were determined to be 4.2 - 4.7 mg/L for 1 hour for rats. The oral LD_{50} for one of the phenylchlorosilane category members, **DClMPS**, was >200 to <2000 mg/kg bw in rats [OECD TG 423]. For the supporting substance TMPS, in an acute toxicity study conducted according to OECD TG 425, a total of 7 female rats were administered TMPS by oral gavage including 4 animals at 2000 and 3 animals at 550 mg/kg bw in polyethylene glycol 300. When the single animal dosed at 2000 mg/kg bw in a limit test died spontaneously on study day 2, a main test with 6 animals was conducted. In the main test, all three animals dosed at 2000 mg/kg bw had to be killed in extremis on study days 4, 5 or 6 and all animals dosed at 550 mg/kg bw survived. Animals at 2000 mg/kg bw appeared unhealthy; effects on respiration, coordination and body weight loss were noted. Slight ruffled fur and slight sedation were observed in two of three animals dosed at 550 mg/kg bw; no clinical signs were observed in the third animal dosed at 550 mg/kg bw. There was no effect on body weight at 550 mg/kg bw. Three animals dosed at 2000 mg/kg bw showed a greater than 20% loss of body weight prior to being killed in extremis; no body weight was recorded at the spontaneous death of the first animal dosed at 2000 mg/kg bw that was found dead on test day 2. Macroscopic findings at 2000 mg/kg bw included light red congested lungs, black brown stomach distended with gas, tan discoloration of kidneys, and spleen reduced in size; there were no macroscopic findings at 550 mg/kg bw. The estimated LD_{50} was 1049 mg/kg bw. The acute oral LD_{50} values of HCl were determined to be 238 - 277 mg/kg bw for female rats.

Irritation data are not available for the sponsored substances. The phenylchlorosilanes rapidly hydrolyse to HCl and the associated silanol. HCl is corrosive and highly irritating to the skin, eyes and respiratory tract. As such, the sponsored substances are expected to be corrosive to the skin, cause serious damage to the eyes and be highly irritating to the respiratory tract. Sensitization data are not available for the phenylchlorosilanes or the expected hydrolysis products.

Repeated dose toxicity data are not available for the sponsored substances. Data from supporting substance TMPS and hydrolysis product HCl are used to fill the repeated-dose toxicity endpoint for the phenylchlorosilanes. TMPS was administered to four groups of 10 rats/sex/dose level by gavage daily at 0 (dried and deacidified corn oil), 100, 250 and 500 mg/kg bw/day. Males were exposed for 28 days (including 14 days

prior to pairing) and females were exposed for 14 days prior to pairing, through the pairing and gestation periods until the F1 generation reached day 4 postpartum. Administration of TMPS at 500 mg/kg bw/day caused a reduction of food consumption in males during the first week of treatment and in females during the pre-pairing period up to day 14 of the gestation period. Reduced body weight was noted in males throughout the study and in females throughout the gestation period. Kidney weight was increased in males and thickened urinary bladder in males and females was seen at this dose. An increase of concentration of urea, bile acids and cholesterol was also noted in males at 500 mg/kg bw/day. Multifocal tubular degeneration/regeneration and transitional cell hyperplasia of kidney were noted in males and females. At 250 mg/kg bw/day, an increase in the urea and bile acid concentrations was observed. Multifocal tubular degeneration/regeneration and transitional cell hyperplasia of kidney were noted in males and females at this dose. The urinary bladder was observed to be thickened in males and females at all dose levels. This finding correlated with the histopathology examination showing perivascular lymphoid cell infiltration and transitional cell hyperplasia of the urinary bladder. Based on the findings in urinary bladder, a NOAEL (No Observed Adverse Effect Level) for systemic toxicity of TMPS could not be established. The LOAEL was 100 mg/kg bw/day. For the analogue substance TMPS, in a 4-week whole-body vapour inhalation (7 hr/day, 5 days/week) study conducted similar to OECD TG 412, there were no adverse treatment-related effects noted at any of the vapour concentrations administered. The NOAEC was determined to be 649 mg/m^3 (highest concentration tested). In repeated dose toxicity studies of HCl by the inhalation route, local irritant effects were observed in the groups of rats and mice exposed to 0.015 mg/L and above for 90 days. The inhalation NOAEC for systemic toxicity for HCl, excluding the local effects of irritation, has been determined to be 0.030 mg/L, with a LOAEC of 0.075 mg/L. The toxicity of the phenylchlorosilanes is expected to be well characterized by the effects of HCl inhalation exposure, the prevalent route of the phenylchlorosilanes exposure.

The sponsored substances did not induce gene mutations in bacterial cells *in vitro* [similar or equivalent to OECD TG 471], and the sponsored substance **TClPS** was negative for induction of gene mutations in mouse lymphoma cells [OECD TG 476]. Chromosomal aberration studies were not located for the sponsored substances. The supporting substance TMPS did not induce gene mutations in bacterial cells [similar to OECD TG 471], but did induce chromosomal aberrations in Chinese hamster V79 cells *in vitro* in the presence of metabolic activation [OECD TG 473]. Based on these results, TMPS is considered to be genotoxic *in vitro*. The hydrolysis product HCl did not induce gene mutations in bacterial cells. Positive results in the *in vitro* chromosome aberration test with HCl were considered to be the effect of low pH. Based on the available data, the phenylchlorosilanes are not expected to cause gene mutations *in vitro*; it may be clastogenic *in vitro*.

No data are available for the carcinogenicity of the phenylchlorosilanes.

Toxicity for reproduction data are not available for the sponsored substances. Data for supporting substance TMPS and hydrolysis product HCl are used to fill the reproductive toxicity endpoint for the phenylchlorosilanes. In the combined repeated-dose/reproductive/developmental toxicity screening test [OECD TG 422] with TMPS, the NOAEL for reproductive/developmental toxicity was 500 mg/kg bw/day (highest dose tested). The LOAEL for maternal toxicity was 100 mg/kg bw/day. Overall, TMPS did not show evidence of reproductive/developmental toxicity. No reliable studies have been reported regarding toxicity to reproduction and development in animals after oral, dermal or inhalation exposure to hydrogen chloride/hydrochloric acid. Because proton and chloride ion are the normal constituents in the body fluid of animal species, low concentrations of hydrogen chloride gas/mist or solution do not seem to cause adverse effects to animals. In fact, the cells of gastric glands secrete hydrochloric acid into the cavity of stomach and orally administered sulfuric acid, which results in pH change as well, did not cause developmental toxicity to laboratory animals. These facts indicate that hydrogen chloride/hydrochloric acid is not expected to have developmental toxicity. In addition, no effects on the gonads were observed in a 90-day inhalation repeated-dose study up to concentrations of 0.075 mg/L HCl. The toxicity of the phenylchlorosilanes is expected to be well-characterized by the effects of HCl inhalation exposure, the prevalent route of the phenylchlorosilanes exposure, and the phenylchlorosilanes are not expected to be reproductive toxicants.

The sponsored phenylchlorosilanes possess properties indicating a hazard for human health [lethality from acute studies (oral and inhalation), corrosive and highly irritating to the skin, eyes and respiratory tract (based on hydrolysis product, HCl), repeated dose toxicity (based on analogue substance, TMPS), and genotoxic (clastogenic *in vitro* based on analogue substance, TMPS)]. Adequate screening-level data are available to characterize the human health hazard for the purposes of the OECD Cooperative

Chemicals Assessment Programme.

Environment

Not all programs within EPI Suite have been validated for chemicals that contain the element Si, but recent upgrades to the Kow module, found in the current version of EPI Suite (v4.10), may improve estimates for silanes and siloxanes for this endpoint. However, there is still uncertainty associated with the calculated values and they should be used with caution whenever they are reported.

The chlorine group is the most active functional group on these molecules and determines many aspects of the behaviour of the category members. The phenylchlorosilanes undergo rapid hydrolysis in the presence of moisture to form two or three moles of HCl and one mole of di- or tri- silanol, depending on the parent substance. An OECD TG 111 (Hydrolysis as a Function of pH) test was conducted at 1.5 ºC for supporting substance DClDPS; half-lives of less than one minute were reported at pH 4, 7, and 9. Likewise, **TClPS** and **DClMPS** are expected to hydrolyse rapidly under environmentally relevant conditions.

In the atmosphere, indirect photo-oxidation by reaction with hydroxyl radicals is predicted to occur with half-lives of 2.7 to 5.5 days. Any potential for photodegradation might be superseded by hydrolysis of the parent compound depending on the concentration of water vapour in the air. The biodegradation of **TClPS** was determined in OECD TG 310; there was essentially no (1%) biodegradation of the test substance in 28 days. HCl is an inorganic compound and biodegradation tests are not applicable. Based on this information, the sponsored substances are not expected to be readily biodegradable. Due to rapid hydrolysis of the sponsored substances, any potential for biodegradation is likely to be of the hydrolysis products. Consequently, the only biodegradable materials in the test system will be silanols, and condensed silanol materials (high molecular weight polymers). At high concentrations (>500mg/L), the silanols will condense to form highly cross linked, high molecular weight polymers that are water insoluble and effectively nonbiodegradable.

A level III fugacity model calculation with equal and continuous distributions to air, water and soil compartments suggests that the sponsored substances will distribute mainly to the air (47.6%) and soil (47.7%) compartments with minor distribution to the water and sediment compartments. Level III fugacity modeling using equal loading rates of 1000 kg/h each for air, soil and water predicts that the silanol hydrolysis products will distribute mainly to soil (ca. 83%), with a smaller fraction to water (ca. 16%) and negligible amounts to sediment and air. Based on the more realistic scenario of 100% release to air, the model predicts that the silanol hydrolysis products will be distributed mainly in air (96%) and water (ca. 4%).

The sponsored substances are not expected to bioaccumulate in the aquatic environment based on rapid hydrolysis to silanols, with estimated BCFs of 3.2 L/kg wet-wt. The calculated bioconcentration factors for the sponsored substances were 110 (**TClPS**) - 1009 (**DClMPS**) L/kg wet-wt

The following acute toxicity test results have been determined for aquatic species:

Test substance	Species	Result (mg/L)	Guideline; Test type
Fish, acute toxicity			
Sponsored substances			
TClPS	*Oncorhynchus mykiss*	96-hr LC_{50} >100 (nominal; pH adjusted to 7.0)	OECD TG 203; static
DClMPS			
Supporting hydrolysis products DClDPS			
HCl	*Cyprinus carpio*	96-hr LC_{50} = 4.92 (pH = 4.3)	OECD TG 203; semi-static
Aquatic invertebrate, acute toxicity			
Sponsored substances			
TClPS	*Daphnia magna*	48-hr EC_{50} > 100 (nominal; pH adjusted to 7.0)	OECD TG 202; static
DClMPS	*Daphnia magna*	48-hr EC_{50} = 38	OECD TG 202; static

		(without pH adjustment; nominal); >100 (with pH adjustment to 7.9; nominal)	
Supporting hydrolysis products DClDPS			
HCl	*Daphnia magna*	48-hr EC_{50} = 0.492 (pH= 5.3)	OECD TG 202; not specified
Aquatic plants, acute toxicity			
Sponsored substances			
TClPS	*Pseudokirchneriella subcapitata*	72-hr E_rC_{50} and E_bC_{50} > 100 (nominal; pH adjusted to 7.0)	OECD TG 201; static
Supporting hydrolysis products DClDPS			
HCl	*Pseudokirchneriella subcapitata*	72-hr E_rC_{50} = 0.492 (pH= 5.3)	OECD TG 201; static

The sponsored phenylchlorosilanes possess properties indicating a hazard for the environment (acute aquatic toxicity values between < 1 and 100 mg/L). The hydrolysis product, HCl, has properties that can result in toxicity of < 1 mg/L to aquatic organisms in poorly buffered systems, mainly due to acidification of the test medium. The sponsored phenylchlorosilanes and their hydrolysis products have low potential for bioaccumulation and are not readily biodegradable. Adequate screening-level data are available to characterize the hazard for the environment for the purposes of the OECD Cooperative Chemicals Assessment Programme.

Exposure

Production and import volumes (metric tonnes) for 2010 are summarized below.

Substance	**United States**		**Europe**		**Japan**	
	Production	**Import**	**Production**	**Import**	**Production**	**Import**
TClPS	2268 - 9072	<454	0	0	227 – 2268	0
DClMPS	454 - 3629	0	0	0	0	0

Ranges are provided to protect confidential business information. **TClPS** is used in formulations up to 100% as intermediates for silicone oligomers and polymers. **DClMPS** is used in formulations at 100% as an intermediate (details not provided). No parent substance is expected to remain after end use.

The phenylchlorosilanes are produced and processed in closed systems; commercial customers use the phenylchlorosilanes in closed systems. Due to the dynamic and exothermic nature of the processes incorporating chlorosilanes, many engineering controls are always in place to prevent occupational exposure such as water scrubber devices and related equipment; closed sampling loop; and local and general ventilation. Employees involved in chlorosilane production and application use personal protective equipment (PPE) such as safety glasses or goggles, steel-tipped shoes, flame-resistant clothing, hard hats, chemical resistant gloves, and respirator masks. Potential routes of exposure include inhalation and dermal exposure.

There are no consumer uses of the phenylchlorosilanes.

Environmental exposure is not expected.