SIDS INITIAL ASSESSMENT PROFILE

CAS No. and Chemical Name	106-98-9	1-Butene
	107-01-7	2-Butene
	590-18-1	*cis*-2-Butene
	624-64-6	*trans*-2-Butene
	115-11-7	Isobutylene (2-Methylpropene)
	25167-67-3	Butene, mixed isomers
CAS Numbers with Structural Formula	106-98-9	$CH_2{=}CH{-}CH_2{-}CH_3$
	107-01-7	$CH_3{-}CH{=}CH{-}CH_3$ (contains *cis*- and *trans*- forms)
	590-18-1	$CH_3{-}CH{=}CH{-}CH_3$ (*cis*- form)
	624-64-6	$CH_3{-}CH{=}CH{-}CH_3$ (*trans*- form)
	115-11-7	$CH_2{=}C({-}CH_3)_2$
	25167-67-3	Contains all butene structures above

SUMMARY CONCLUSIONS OF THE SIAR

Category/Analogue Rationale (if appropriate)

The Butenes Category includes six CAS numbers that are similar from a process and toxicology perspective. Each substance within this category is a C4 olefin or contains a mixture of selected C4 olefins that are produced from a reaction and/or separation activity in an olefins chemical plant. Four CAS numbers describe different C4 isomers, each is a hydrocarbon with the same chemical formula and one double bond between two carbon atoms. Two CAS numbers describe mixtures of C4 olefins that contain either two or all four different isomers. The six substances share relatively similar physico-chemical properties, which suggests that their environmental fate will be similar. The chemicals are expected to have similar kinetic properties because of similar physical-chemical properties. No specific target organ was identified and no or minimal changes in body weight were found at the highest dose only for all the butenes. Therefore the butenes can be treated as a category.

Physical-chemical properties

The physical properties of Butenes Category members are given in ranges as the substance differ minimally in these properties. Melting Point (°C) ranges from -105.5 to –185.3, boiling point (°C) ranges from –6.9 to 3.7, relative Density (g/cm^3 at 25°C) ranges from 0.588 to 0.6213, vapor pressure (hPa at 25°C) ranges from 2,106 to 3,080 (determined experimentally), water solubility (mg/L at 25°C) ranges from 222 – 700 and the log Kow (at 25°C) ranges from 2.31 - 2.4.

Human Health

The acute toxicity data on members of the Butenes Category is limited. Only acute inhalation studies are available. Overall, these limited data suggest that the members of this category have a low order of acute toxicity. The 4-hr LC_{50} value of 2-butene was found to be higher than 10,000 ppm (23,100 mg/m^3). The 2-hour LC_{50} of isobutylene in mice was 180,000 ppm (415,000 mg/m^3) and the 4-hour LC_{50} in rats was 270,000 ppm (620,000 mg/m^3). At concentrations exceeding the lower explosion limit (LEL > 8000 ppm (18,400 mg/m^3)), the butenes have the potential to produce narcosis or cause asphyxia by reducing the available concentration of oxygen.

There are no data to evaluate the dermal or ocular irritation potential of butenes. However, should skin or eye contact occur to this chemical in its liquid state, tissue freezing, severe cold burn, and/or frostbite may result. This is likely to be a function of the temperature as the boiling point is around 0°C. There are no data to evaluate the skin or respiratory tract sensitization potential of butenes in either animals or humans.

Based on the results of the repeated-dose studies conducted in animals, the members of the Butenes Category appear to have a low order of sub-chronic toxicity. The NOAEL for 1-butene in an inhalation OECD 422 guideline study (combined repeated dose toxicity and reproductive/developmental toxicity test) was > 8000 ppm (18,400 mg/m^3). In a repeated- dose study conducted with 2-butene, exposure of animals to 2500 ppm (5700 mg/m^3) and 5000 ppm (11,500 mg/m^3) did not induce significant systemic toxicity in male rats exposed for up to 46 days, or in pregnant female rats exposed for 2 weeks pre-mating, through mating and gestation to day 19. The only statistically significant effects were effects on body weight and body weight gain. However, as these effects were not dose-related and not consistently present during the study, it was concluded that the NOAEC for butene-2 in this study was ≥5000 ppm (11,500 mg/m^3). Isobutylene was not toxic to rats or mice exposed to concentrations up to 8,000 ppm (18,400 mg/m^3) for 14 weeks or 2,000 ppm (4,600 mg/m^3) for 105 weeks. The NOAEC of 2,000 ppm (4,600mg/m^3) is based on minimal effects in the nasal cavity at the highest dose.

None of the members of the butenes category that have been tested produced mutagenic responses either *in vitro* or *in vivo*. 1-butene, 2-butene and isobutylene did not induce gene mutations in reverse mutation assays conducted in *S. typhimurium* and/or *E. coli* either in the presence or absence of metabolic activation. 2-butene was not clastogenic to rat lymphocytes *in vitro*. Isobutylene tested negative in an *in vitro* cell transformation assay using a mouse embryo fibroblast derived cell line and in a mouse lymphoma assay both in the presence or absence of metabolic activation. In addition, neither 1-butene nor isobutylene induced micronuclei formation in mouse bone marrow cells from animals exposed up to 22,000 ppm (50,600 mg/m^3) or 10,000 ppm (23,000 mg/m^3), respectively.

A carcinogenicity study on isobutylene (the only available study on this endpoint, in both rats and mice) is used to assess the potential of all Butenes Category members to cause cancer. Although isobutylene produced an increase in follicular cell carcinomas of the thyroid in male rats exposed for 105 weeks, this was observed only at the highest exposure concentration (i.e., 8000 ppm) and did not occur in female rats nor male or female mice. In addition, the follicular cell carcinomas in the thyroid were reported to be morphologically similar to spontaneously developing follicular cell carcinomas and there was no concurrent increase in the incidence of follicular cell hyperplasia or adenoma in male rats. It should also be noted that there was no evidence of any carcinogenic activity in female rats or mice up to 8000 ppm. As isobutylene is not genotoxic and as the thyroid tumors only occurred in male rats at the highest dose, i.e., 8000 ppm (18,400 mg/m^3), the mechanism for the formation of the thyroid tumors most likely has a threshold. Overall, these data suggests that isobutylene as well as the other members of the Butenes Category have a potential for carcinogenicity, although the relevance for humans is unclear. The NOAEC in a chronic carcinogenicity study of isobutylene was 2,000 ppm (4,600 mg/m^3).

Based on the reproductive/developmental toxicity studies conducted with 1-butene, 2-butene and isobutylene, it appears that the members of the Butenes Category are neither reproductive nor developmental toxicants.

The NOAEL for parental and F1 offspring was 8000 ppm (18400 mg/m^3) in a combined repeated dose toxicity and reproduction/development toxicity study of 1-butene in rats conducted according to OECD guideline 422.

In a 422 guideline study of 2-butene, the parental NOAEL and the NOAEC for the F1 offspring were both ≥ 5000 ppm (11,500 mg/m^3). The only statistically significant effects were effects on parental body weight and body weight gain. However, these effects were not dose-related and not consistently present during the study, therefore considered not toxicologically relevant.

In a prenatal developmental toxicity study of isobutylene conducted to OECD 414 guidelines, the NOAEL was 8,000 ppm (18,400 mg/m^3) for maternal and foetal effects. There was no effect of isobutylene on the number, growth or survival of the foetuses in utero and no adverse effects on foetal development. These findings, along with the findings of no biologically significant effects on male or female reproductive organs attributed to isobutylene exposure in 14-week repeat dose inhalation studies in two rodent species, leads to a conclusion of low concern for reproductive toxicity for members of this category.

Environment

Results of distribution modelling show that butenes will partition primarily to the air compartment, with a negligible amount partitioning to water. In spite of their water solubility, wet deposition of butenes is not likely to play a significant role in their atmospheric fate because of rapid photodegradation. Volatilisation to the air will contribute to the rapid loss of butenes from aqueous and terrestrial habitats. In the air, butenes have the potential to rapidly degrade through indirect photolytic processes mediated primarily by hydroxyl radicals and ozone with calculated degradation half-lives ranging from approximately 1.38 to 24.32 hours, respectively, depending on hydroxyl radical and ozone concentrations. Because of the relatively short half-life of selected butenes in the atmosphere and the low environmental concentrations typically found, their contribution to potential global warming can be considered minor. Aqueous photolysis and hydrolysis will not contribute to the transformation of butenes in aquatic environments because they are either poorly or not susceptible to these reactions.

A butene isomer has been detected in air samples. Isobutylene concentrations have been reported to range in urban air samples ranging from 1 to 10 ppb. Butene-2 has been detected directly over diesel exhausts to a lesser extent than butene-1. The more highly reactive trans-2-butene occurs at a much lower frequency in the atmosphere than other comparable hydrocarbons.

Although the biodegradability of the butene isomers have not been evaluated with standard 28-day test guidelines, research studies designed largely to evaluate the metabolic pathways involved in the degradation of butenes have demonstrated that selected isomers can be degraded by bacteria isolated from soil and surface water samples. The results from these studies suggest that the butenes are subject to microbial degradation. However, biodegradation is unlikely to contribute to the overall degradation of butene isomers in the environment because they are gaseous and the primary environmental compartment to which they will partition is the air. Additionally, data from the BIOWIN model, a biodegradation structure-activity relationship model, suggest that category members are biodegradable.

The butene isomers are not expected to sorb significantly to organic matter in soil, sediment, and wastewater solids based on a log Koc range of 1.5 to 1.6.

Due to the fact that substances in the Butenes Category are gaseous at ambient temperature and pressure, and are expected to partition predominantly to the atmosphere, no aquatic toxicity testing has been conducted. The ECOSAR model was used to predict the aquatic toxicity of butene isomers using the equation for neutral organics, a reliable estimation method for this class of substances. Calculated acute toxicity values for fish and invertebrates range from 18 to 23 mg/L. For algae, the calculated 96-hr EC50 ranges from 12 to 15 mg/L. Chronic toxicity values range from 1.2 to 2.8 mg/L for the three trophic levels; 30-day fish chronic values of 2.4 to 2.8 mg/L, 16-day invertebrate EC50 values of 1.2 to 1.4 mg/L, and 96-hour alga chronic values of 1.6 to 1.8 mg/L. The butene isomers have a low potential to bioaccumulate in aquatic species based on a calculated log bioconcentration factor range of 1.08 to 1.15 for category member constituents.

Exposure

Fuel markets account for about 90% of butenes produced world-wide. The major fuel application is in the manufacture of gasoline blending components, such as gasoline alkylate, polymer gasoline, and dimersol. Isobutylene serves as a raw material for the oxygenates methyl tert-butyl ether (MTBE) and ethyl tert-butyl ether (ETBE). Butenes may also be blended directly into gasoline for volatility control. They are also marketed with propane and butane as liquefied petroleum gas (LPG). In chemicals applications, n-Butenes are used as a precursor for sec-butyl alcohol, butadiene, butene-1, and other smaller applications. Isobutylene is used to produce butyl rubber and polybutenes.

Estimated US production of various butene isomers totalled 49,000 Mlbs (22.2 x 10^3 ktonne) in 2001, of which 11,770 Mlbs (5.3 x 10_3 ktonne) was 1-butene, 18,990 Mlbs (8.6 x 10^3 ktonne) was 2-butene, and 18,250 Mlbs (8.3 x 10^3 ktonne) was isobutylene. Use in fuel applications, predominantly alkylation (34,000 Mlbs) and production of MTBE (12,245 Mlbs) consumed most of the butenes produced in the US. Western European production in 2001 was 2,125 kilotonnes (995 kilotonnes of isobutylene and 1,130 kilotonnes n-butenes), and Japanese production for 2000 (latest data available) was 3,190 kilotonnes (1,300 kilotonnes isobutylene and 1,890 kilotonnes n-butenes). Butenes are also produced in South America and Saudi Arabia.

Exposure to substances in the Butenes Category may occur at workplaces where they are manufactured. Based on physical properties, the primary workplace exposure would be by inhalation. Extensive consumer exposure is not foreseen because there are no direct sales to consumers; however, butenes have been reported in the vapor from gasoline refueling of passenger vehicles. Exposure to butenes in the environment can also occur from motor vehicle exhaust.

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

Human Health: The chemicals in this category are currently of low priority for further work. One chemical in this category may possess properties indicating a hazard for human health (carcinogenicity, although it is unknown if the findings related to isobutylene carcinogenicity are of relevance to humans). Based on data presented by the sponsor country, exposure to humans is anticipated to be low, and therefore, this chemical is currently of low priority for further work. Countries may desire to investigate any exposure scenarios that were not presented by Sponsor Countries.

Environment: The chemicals in this category are currently of low priority for further work. The chemicals in this category possess properties indicating a hazard for the environment. This does not warrant further work as it is related to acute aquatic toxicity which may become evident only at high exposure levels. It should nevertheless be noted by chemical safety professionals and other users.