1,1-Dichloroethene

CAS No.: 75-35-4

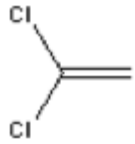

Figure 1: Structure of 1,1-dichloroethene

Introduction

Under the *Canadian Environmental Protection Act, 1999* (CEPA 1999) the Minister of Health may gather information, conduct investigations and evaluations, including screening assessments, relevant for the purpose of assessing whether a substance is entering or may enter the environment in a quantity or concentration or under conditions that constitute or may constitute a danger in Canada to human life or health.

Screening health assessments focus initially on conservative assessment of hazard or effect levels for critical endpoints and upper-bounding estimates of exposure, after consideration of all relevant identified information. Decisions based on the nature of the critical effects and margins between conservative effect levels and estimates of exposure take into account confidence in the completeness of the identified databases on both exposure and effects, within a screening context. Additional background information on screening health assessments conducted under this program is available at http://www.hc-sc.gc.ca/ewh-semt/contaminants/existsub/index_e.html.

A State of the Science Report for a screening assessment has been prepared on 1,1-dichloroethene (see Figure 1) on the basis that this compound was included in the Domestic Substances List pilot phase for screening as a substance likely to be prioritized on the basis for greatest potential for human exposure.

This draft State of the Science Report for a screening assessment and associated unpublished supporting working documentation were prepared by evaluators within the Existing Substances Division of Health Canada; the content of these documents was reviewed at several meetings of senior Divisional staff. The draft Report was subsequently externally reviewed for adequacy of data coverage and defensibility of the conclusions. The supporting working documentation is available upon request by e-mail from ExSD@hc-sc.gc.ca

Information identified as of June 2004 was considered for inclusion in this Report. The critical information and considerations upon which this Report is based are summarized below. Additional data identified between this date and the end of the external peer review period (November, 2004) were also scoped and determined not to impact upon the conclusions presented here.

Identity, Uses and Sources of Exposure

Submissions made under Section 71 of CEPA 1999 indicate that 58.4 tonnes of 1,1-dichloroethene (DCE) were manufactured in, and imported into, Canada in 2000 (Environment Canada, 2001). DCE is used primarily as a chemical intermediate, being an ingredient in the manufacture of polyvinylidene chloride (PVDC) polymers and copolymers. Consumer products in which PVDC is used include plastic films in the food industry, carpets, awnings and photographic film. PVDC polymers and copolymers are also used as flame retardants in paper and paperboard coatings (IPCS, 1990). It is expected that exposure to DCE in PVDC products is minimal, as DCE is present in these products only at low residual levels; for example, monomer residual levels have been reported to be <5 mg/kg in both carpet latex and food packaging (U.S. EPA, 2002b).

Because of its volatility (boiling point 31.6°C), DCE can readily enter the atmosphere as emissions during its production and use (ATSDR, 1994). Other sources of DCE emissions are the environmental degradation of tetrachloroethene, trichloroethene, 1,1,1-trichloroethane (ATSDR, 1994; U.S. EPA, 1995) and polyvinyl chloride (OME, 2001). However, 1,1,1-trichloroethane production will be phased out by 2005 under the Montreal Protocol (Environment Canada, 2003b).

Information reported under Section 71 of CEPA 1999 indicated that DCE is formed as a by-product in the manufacture of hydrogen chloride (Environment Canada, 2003a). There were also releases at companies where DCE was used as a solvent (12.7 tonnes released on site) or was being processed for disposal. Based on the use pattern for this substance in Canada, fugitive emissions from industrial processes would pose the greatest source of potential exposure to DCE in the environment.

Exposure Assessment, Hazard Characterization and Risk Evaluation

The upper-bounding estimates of total daily intake range from 0.74 µg/kg-bw per day in adults (60+ years) to 2.26 µg/kg-bw per day in children (0.5–4 years) (Table 1). Based on these estimates, inhalation is the major route of exposure for the general population, with indoor air being the major source of exposure.

Because of their quantity of production and widespread use, two products containing DCE, carpet and food wrap, were selected to provide a representative assessment of exposure to

DCE in consumer products. Estimates were made of 1) contributions to indoor air concentrations and daily intake via inhalation as a result of the use of DCE in carpet latex backing and 2) daily intake from the ingestion of food that has been in contact with DCE-containing polymer food wrap. The estimates are based on scenarios contained in a Voluntary Children's Chemical Evaluation Program (VCCEP) submission on DCE (U.S. EPA, 2002b). Details of the calculations are presented in Appendix A. The conservative estimates for contributions to indoor air from emissions of DCE from carpet latex backing ranged from 0.032 to 0.0634 µg/m^3. For children (0.5–4 years), the group with the highest inhalation volume and food consumption relative to body weight, conservative screening estimates of intakes from the two products were 0.02–0.04 µg/kg-bw per day (inhalation of indoor air with emissions from carpet latex backing) and 0.03 µg/kg-bw per day (ingestion of food in contact with film packaging). In a recent survey of 75 homes in Ottawa (Health Canada, 2003), there was no correlation between the carpeted floor area and the measured values of DCE in indoor air. In that study, the mean indoor air concentration was 0.27 µg/m^3 (values ranged from non-detected to 4.05 µg/m^3, with a detection limit of 0.011 µg/m^3).

The level of confidence in the upper-bounding estimate of exposure set is high, as it was based on recent adequate monitoring data in Canada for DCE in ambient air and indoor air Health Canada, 2003). In the absence of measured concentrations for drinking water, the detection limit from measurements at Canadian water treatment plants was used (OME, 1988, 1989). Although food can be in contact with residual DCE in packaging film, the low octanol/water partition coefficient (K_{ow}) and high volatility of DCE reduce the potential for exposure through this pathway. To provide a conservative estimate, food intake estimates were based on a study in the United Kingdom (MAFF, 1980), as DCE was not detected in food in three separate studies in Ontario, Quebec and Alberta (ETL, 1991, 1992, 1993). There is uncertainty in these values, as only a limited number of food groups was monitored. However, the low K_{ow} for DCE is indicative of the improbability of finding significant levels of DCE in foods and adds support to the estimates that are based on sparse and non-Canadian data for this medium. No quantitative data were available on the presence of DCE in breast milk, although it has been qualitatively detected in 1 of 12 samples in four cities across the United States (Pellizzari et al., 1982).

Table 2 contains an overview of the toxicological database, in which confidence is considered to be moderate to high, as a wide range of toxicity studies was identified. Carcinogenicity bioassays reviewed in several identified assessments (IARC, 1986, 1999; IPCS, 1990, 2003; U.S. EPA, 2002a) include those conducted by oral, inhalation and subcutaneous routes of exposure as well as a dermal tumour initiation study. Many of these studies are limited by study design or conduct, including exposure durations of 1 year or less or administration of less than the maximum tolerable dose. An exposure-related, increased incidence of tumours (renal adenocarcinomas) was observed in male (but not female) Swiss mice exposed by inhalation for 1 year to 0, 10 or 25 ppm DCE (equivalent to 0, 40 and 100 mg/m^3, respectively) (significant increase at the highest concentration only) (Maltoni et al., 1984, 1985; IPCS, 1990).

Incidences of other tumours, namely mammary carcinomas in female Swiss mice and pulmonary adenomas in male and female Swiss mice, were significantly increased, but without a clear exposure–response relationship. DCE was also active as an initiator of lung papillomas in female Swiss mice (Van Duuren et al., 1979). There was no evidence of carcinogenicity in studies in rats or hamsters and no observed increases in the incidences of other tumours observed in mice that were significant and exposure-related.

DCE is genotoxic in microorganisms in both the presence and absence of an exogenous metabolic activating system; mixed results have been produced in mammalian cells *in vitro.* It is generally non-genotoxic in *in vivo* assays (chromosomal aberration, rat; dominant lethal, mouse and rat; micronucleus, mouse), although chromosomal aberrations in the bone marrow of Chinese hamsters and minimal DNA binding in the liver and kidneys of mice and rats have been reported (IPCS, 1990; U.S. EPA, 2002a). Plausible carcinogenicity was also predicted by a rule-based structure–activity relationship model (DEREK; LHASA Ltd., 2002), which contributes to the weight of evidence for carcinogenicity.

DCE has been classified by IARC (1999) as *not classifiable as to its carcinogenicity to humans* based on *inadequate evidence* in humans and *limited evidence* in experimental animals, whereas the U.S. EPA (2002a) concluded that there is *suggestive evidence* for the carcinogenicity of DCE.

The target organs for non-neoplastic effects are the liver, kidney and lung. The lowest lowest-observed-adverse-effect concentration (LOAEC) identified was 10 ppm (40 mg/m^3), based upon significant increases in kidney damage (regressive changes and/or abscesses and nephritis in male Swiss mice in a 52-week study) (Maltoni et al., 1984, 1985). The lowest oral lowest-observed-effect level (LOEL) was 5 mg/kg-bw per day, based upon chronic renal inflammation in male and female F344 rats in a 2-year gavage study (NTP, 1982).

In the critical carcinogenicity bioassay (Maltoni et al., 1984, 1985), renal adenocarcinomas were observed at the highest concentration (100 mg/m^3) only. This concentration is 25 000 times higher than the highest identified concentration of DCE in indoor air (approximately 4 µg/m^3; Health Canada, 2003). A comparison of the lowest critical inhalation effect level for non-neoplastic effects (40 mg/m^3; Maltoni et al., 1984, 1985) with the highest identified concentration of DCE in indoor air results in a margin of exposure of 10 000. Since the protocol in this study involved exposure for only 4 hours per day, 4 or 5 days per week, if the critical inhalation effect level was adjusted to account for continuous exposure, the margin of exposure would decrease by approximately ten-fold.

The margin of exposure between the highest upper-bounding estimate of intake from all sources (2.26 µg/kg-bw per day; Table 1) and the critical oral effect level for non-neoplastic effects (5 mg/kg-bw per day; NTP, 1992) is 2200.

Available data on the mode of induction by DCE of non-neoplastic critical effects (associated with cytotoxicity) in target organs in rats and mice (i.e., the liver, kidney and Clara cells of the lung) indicate that damage is associated with covalent binding of CYP2E1 activated metabolic products to cellular macromolecules (U.S. EPA, 2002a). The margins of exposure mentioned above are likely sufficient to address uncertainties related to intraspecies and interspecies variations and biological adversity or severity of the observed non-neoplastic effects, taking into account (crudely) the approximate impact of quantitative variations between experimental species and humans in CYP2E1-mediated metabolism to the active metabolite, which binds with cellular macromolecules. However, there is also limited evidence for the carcinogenicity of DCE in mice and comprehensive evidence of genotoxicity *in vitro* with and without metabolic activation, but much lesser evidence of genotoxicity in *in vivo* assays. While it is possible that the active metabolites (principally DCE epoxide) associated with non-neoplastic effects could interact directly with DNA, the potential is low, based on results of *in vivo* studies.

Although the weight of evidence for carcinogenicity and genotoxicity is limited, a mode of action for induction of effects involving direct interaction with genetic material cannot be precluded. Therefore, the outcome of this evaluation on 1,1-dichloroethene is that it is suspected that the margin between levels causing non-neoplastic effects in experimental animals and exposure may not be sufficient to account for the uncertainties in the database.

Data addressing uncertainties in intraspecies and interspecies variations in sensitivity and mode of induction of effects would permit a more definitive conclusion.

Table 1: Upper-bounding deterministic estimates of daily intake of 1,1-dichloroethene by the general population in Canada

Route of exposure	**Estimated intake (µg/kg-bw per day) of 1,1-dichloroethene by various age groups**						
	0–6 months[1–3]		**0.5–4 years[4]**	**5–11 years[5]**	**12–19 years[6]**	**20–59 years[7]**	**60+ years[8]**
	formula fed	**not formula fed**					
Ambient air[9]	0.029		0.062	0.049	0.028	0.024	0.021
Indoor air[10]	0.99		2.13	1.66	0.94	0.81	0.70
Drinking water[11]	0.011	0.0040	0.0045	0.0035	0.0020	0.0021	0.0022
Food and beverages[12]		0.1	0.065	0.039	0.024	0.017	0.012
Soil[13]	4.80×10^{-7}		7.74×10^{-7}	2.52×10^{-7}	6.06×10^{-8}	5.08×10^{-8}	5.00×10^{-8}
Total intake	1.03	1.13	2.26	1.75	1.00	0.85	0.74

[1] No quantitative data were available for the presence of DCE in breast milk, although it has been qualitatively detected in 1 of 12 samples in four cities across the United States (Pellizzari et al., 1982).

[2] Assumed to weigh 7.5 kg, to breathe 2.1 m^3 of air per day, to drink 0.8 L of water per day (formula fed) or 0.3 L per day (not formula fed) and to ingest 30 mg of soil per day (EHD, 1998).

[3] For exclusively formula-fed infants, intake from water is synonymous with intake from food. The concentration of DCE in water used to reconstitute formula was based on City of Toronto (1990). No data on concentrations of DCE in formula milk were identified for Canada. Approximately 50% of not-formula-fed infants are introduced to solid foods by 4 months of age and 90% by 6 months of age (NHW, 1990).

[4] Assumed to weigh 15.5 kg, to breathe 9.3 m^3 of air per day, to drink 0.7 L of water per day and to ingest 100 mg of soil per day (EHD, 1998).

[5] Assumed to weigh 31.0 kg, to breathe 14.5 m^3 of air per day, to drink 1.1 L of water per day and to ingest 65 mg of soil per day (EHD, 1998).

[6] Assumed to weigh 59.4 kg, to breathe 15.8 m^3 of air per day, to drink 1.2 L of water per day and to ingest 30 mg of soil per day (EHD, 1998).

[7] Assumed to weigh 70.9 kg, to breathe 16.2 m^3 of air per day, to drink 1.5 L of water per day and to ingest 30 mg of soil per day (EHD, 1998).

[8] Assumed to weigh 72.0 kg, to breathe 14.3 m^3 of air per day, to drink 1.6 L of water per day and to ingest 30 mg of soil per day (EHD, 1998).

[9] In a survey of ambient air near 75 homes in Ottawa, DCE was detected in 13 samples; the highest concentration measured was 0.83 µg/m^3 (Health Canada, 2003). Canadians are assumed to spend 3 h per day outdoors (EHD, 1998). The critical data were identified from a data set of studies of ambient air (Chan et al., 1990; OME, 1991; Environment Canada, 1992, 1994, 1995, 2000; Health Canada, 2003).

[10] In a survey of indoor air in 75 houses in Ottawa, DCE was detected in 34 samples; the highest concentration measured was 4.05 µg/m^3 (Health Canada, 2003). Canadians are assumed to spend 21 hours per day indoors (EHD, 1998). The critical data were identified from a data set of indoor air studies from Canada and the United States (Pleil et al., 1985; Shah and Heyerdahl, 1988; Chan et al., 1990; OME, 1991; CARB, 1992; Health Canada, 2003).

[11] In the absence of measured values, the detection limit of DCE in raw, treated and distributed water (0.1 µg/L) from 44 treatment plants in Ontario was used to calculate the maximum intake (OME, 1988, 1989). Consumption estimates are for "total tap water" (EHD, 1998). The critical data were identified from a data set of drinking water and groundwater studies from Canada and the United States (Otson et al., 1982; Westrick et al., 1984; Cotruvo, 1985; U.S. EPA, 1985; Otson, 1987; OME, 1988, 1989; City of Toronto, 1990; Rajagopal and Li, 1991; Health Canada, 1994).

[12] In the absence of detected amounts in foods analyzed in Canada (ETL, 1991, 1992, 1993), estimates of intakes from food were based on a study by the Ministry of Agriculture, Fisheries and Food, United Kingdom (MAFF, 1980). The intake analysis is based on the following selected food groups (EHD, 1998):
- Dairy products: 1.0 µg/kg; detection limit used, as it was not detected in smoked cheese
- Fats: 0 µg/kg; not analyzed in this study
- Fruits: 0 µg/kg; not analyzed in this study
- Vegetables: 0 µg/kg; not analyzed in this study
- Cereal products: 0 µg/kg; not analyzed in this study
- Meat and poultry: 5.0 µg/kg; measured in cooked sausage
- Fish: 0 µg/kg; not analyzed in this study
- Eggs: 0 µg/kg; not analyzed in this study
- Foods, primarily sugar: 1 µg/kg; detection limit used, as it was not detected in marshmallow
- Mixed dishes and soups: 0 µg/kg; not analyzed in this study
- Nuts and seeds: 0 µg/kg; not analyzed in this study
- Soft drinks and alcohol: 0 µg/L; not analyzed in this study

[13] The highest concentration of 0.12 µg DCE/kg detected in a study of 59 soil samples from Ontario parklands was used in these calculations (OMEE, 1993).

Table 2: Summary of health effects information for 1,1-dichloroethene

Endpoint	**Lowest effect levels[1] / Results**
Acute toxicity	Lowest **inhalation LC_{50}** (mouse) = 200 mg/m^3 (Zeller et al., 1979a,b,c,d) [Additional studies: Carpenter et al., 1949; Siegel et al., 1971; Jaeger et al., 1973, 1974; Klimisch and Freisberg, 1979a,b; Zeller et al., 1979a,b,c,d] Lowest **oral LD_{50}** (mouse) = 194 mg/kg-bw (Jones and Hathway, 1978a) [Additional studies: Jenkins et al., 1972; Andersen and Jenkins, 1977; Ponomarkov and Tomatis, 1980]
Short-term repeated-dose toxicity	Lowest **inhalation LOEC** (rat) = 200 mg/m^3: fatty changes and focal liver cell necrosis (4 weeks) (Plummer et al., 1990); changes to the liver and kidneys (7 days, with observation period to 28 days) (Maltoni and Patella, 1983) [Additional studies: Gage, 1970; Short et al., 1977; Oesch et al., 1983; Norris and Reitz, 1984] Lowest **oral LOEL** (gavage) (rat) = 200 mg/kg-bw (2 times per week): increased serum sorbitol dehydrogenase and aminotransferases indicative of hepatotoxicity (4 weeks) (Siegers et al., 1983) [Additional studies: NTP, 1982; Maltoni and Patella, 1983]
Subchronic toxicity	Lowest **inhalation LOEC** (rat) = 100 mg/m^3: minimal, reversible liver cell cytoplasmic vacuolation (90 days) (Norris, 1977; Quast et al., 1977) [Additional studies: Lazarev, 1960; Prendergast et al., 1967] Lowest **oral LOEL** (rat) = 19 mg/kg-bw per day: minimal, recoverable liver cell cytoplasmic vacuolation (90 days) (Norris, 1977; Quast et al., 1977) [Additional studies: NTP, 1982; Quast et al., 1983]

Endpoint	Lowest effect levels[1] / Results
Chronic toxicity/ carcinogenicity	Lowest **inhalation LOAEC** (mice) = 40 mg/m^3: significant increases in kidney damage (regressive changes and/or abscesses and nephritis in males) (52 weeks) (Maltoni et al., 1984, 1985) [Additional studies: Lee et al., 1977; Rampy et al., 1977, 1978; Viola and Caputo, 1977; Hong et al., 1981; Quast et al., 1986; Cotti et al., 1988] Lowest **oral LOEL** (rat) = 5 mg/kg-bw per day: increased incidence of chronic renal inflammation in male and female F344/N rats, 2-year gavage study (NTP, 1982) [Additional studies: Ponomarkov and Tomatis, 1980; Quast et al., 1983; Maltoni et al., 1984, 1985] **Inhalation study in Swiss mice:** 0, 10 or 25 ppm (0, 40 or 100 mg/m^3; conversion by IPCS, 1990) for 52 weeks; significantly increased incidence of renal adenocarcinomas (0/126, 0/25 and 28/119 for the control, low and high concentrations, respectively) in males at 100 mg/m^3; mammary carcinomas (3/185, 6/30 and 16/148 for the control, low and high concentrations, respectively) in females and pulmonary adenomas (12/331, 14/58 and 41/288 for the control, low and high concentrations, respectively) in males and females were not clearly exposure-related (Maltoni et al., 1984, 1985) No significant increases in tumours considered to be related to exposure were observed in rats or hamsters in inhalation bioassays or in any species in studies by oral, dermal or subcutaneous routes of exposure (Lee et al., 1977, 1978; Rampy et al., 1977, 1978; Viola and Caputo, 1977; Van Duuren et al., 1979; Hong et al., 1981; NTP, 1982; Quast et al., 1983, 1986; Maltoni et al., 1984, 1985). **Dermal initiation–promotion study in female mice:** initiation with DCE; promotion by phorbol myristate acetate for 428–576 days, beginning 14 days after exposure to DCE; 8/30 treated mice with lung papillomas versus 9/120 controls (Van Duuren et al., 1979)
Developmental toxicity	Lowest **inhalation LOAEC** (mouse) = 60 mg/m^3: significant increase in the mean number of fetuses with an unossified incus and incompletely ossified sternebrae (gestation days 6–16); maternal LOEC = 119 mg/m^3, based upon decrease in weight gain (Short et al., 1977) [Additional studies: Murray et al., 1979] Lowest **oral LOEL** (maternal, rat) = 14 mg/kg-bw per day; *dams:* minimal hepatocellular fatty change; reversible, accentuated hepatic lobular pattern; *pups:* no effects were observed (three-generation study) (Nitschke et al., 1983) Note: Although 0.02 mg/kg-bw per day (rat) was the lowest identified oral LOAEL (Dawson et al., 1993), based on several factors, the U.S. EPA (2002b) could not conclude that exposure to DCE caused these effects. [Additional studies: Murray et al., 1979]

Endpoint	Lowest effect levels[1] / Results
Genotoxicity and related endpoints: *in vivo*	**Chromosomal aberrations** *Positive:* hamster, bone marrow (Hofmann and Peh, 1976) [inhalation; 120 or 400 mg/m^3, 6 hours/day, 5 days/week, 6 weeks] *Negative:* rat, bone marrow (Rampy et al., 1977) [inhalation; 100 or 300 mg/m^3, 6 hours/day, 5 days/week, 6 months]; mouse, bone marrow (Cerna and Kypenova, 1977) [intraperitoneal injection for 5 days] **DNA adduct formation** *Positive:* CD1-mice [inhalation; 40 or 200 mg/m^3, 6 hours], Sprague-Dawley rats [inhalation, 40 mg/m^3, 6 hours], liver and kidney (Reitz et al., 1980) **Dominant lethal test** *Negative:* mouse (Andersen et al., 1977) [inhalation; 50 ppm (198 mg/m^3), 6 hours/day, 5 days]; rat (Short et al., 1977) [inhalation; 55 ppm (218 mg/m^3), 6 hours/day, 5 days/week, 11 weeks] **Micronuclei test** *Negative:* mouse, bone marrow [oral, 200 mg/kg-bw]; mouse, fetal erythrocytes [oral, 100 mg/kg-bw] (Sawada et al., 1987) **Non-mammalian sex-linked recessive lethal assay** *Negative: Drosophila* (Foureman et al., 1994) [oral, 20 000 or 25 000 ppm, 72 hours; or injection, 5000 ppm, 24 hours] **Unscheduled DNA synthesis** *Positive:* CD-1 mice, liver and kidney (Reitz et al., 1980) [inhalation; 200 mg/m^3, 6 hours]
Genotoxicity and related endpoints: *in vitro*	**Aneuploidy** *Positive: Saccharomyces cerevisiae*, with and without activation (Koch et al., 1988) **Chromosomal aberrations** *Positive:* Chinese hamster lung cells, with activation (Sawada et al., 1987) *Negative:* Chinese hamster lung cells, without activation (Sawada et al., 1987); Chinese hamster fibroblast CHL cells (Ishidate, 1983); Chinese hamster DON-6 cells (Sasaki et al., 1980) **Gene conversion** *Positive: S. cerevisiae*, without activation (Koch et al., 1988); *S. cerevisiae*, with activation (Bronzetti et al., 1981) *Negative: S. cerevisiae*, without activation (Bronzetti et al., 1981); *S. cerevisiae*, with activation (Koch et al., 1988) **Mutagenicity** *Positive:* *Salmonella typhimurium* BA13/BAL13, with activation (Roldan-Arjona et al., 1991) *S. typhimurium* TA100, with activation (Bartsch et al., 1975, 1979; Baden et al., 1976, 1978, 1982; Jones and Hathway, 1978b; Simmon and Tardiff, 1978; Waskell, 1978;

Endpoint	Lowest effect levels[1] / Results
	Oesch et al., 1983; Strobel and Grummt, 1987; Malaveille et al., 1997) *S. typhimurium* TA100, without activation (Baden et al., 1976, 1978, 1982; Cerna and Kypenova, 1977; Waskell, 1978; Strobel and Grummt, 1987) *S. typhimurium* TA1535, with activation (Baden et al., 1977; Jones and Hathway, 1978b; Oesch et al., 1983) *S. typhimurium* TA1535, without activation (Cerna and Kypenova, 1977) *S. typhimurium* TA1537, with activation (Oesch et al., 1983) *S. typhimurium* TA1538, without activation (Cerna and Kypenova, 1977) *S. typhimurium* TA98, with activation (Oesch et al., 1983; Strobel and Grummt, 1987) *S. typhimurium* TA98, without activation (Cerna and Kypenova, 1977) *S. typhimurium* TA92, with activation (Oesch et al., 1983) *S. typhimurium* TA97, with activation (Strobel and Grummt, 1987) *Escherichia coli* K12, with activation (Oesch et al., 1983) *E. coli* K12, without activation (Greim et al., 1975) *E. coli* WP2, with activation (Oesch et al., 1983) *S. cerevisiae*, with activation (Bronzetti et al., 1981; Koch et al., 1988); *S. cerevisiae*, without activation (Koch et al., 1988) Mouse lymphoma L5178Y T/K +/- cells, with activation (McGregor et al., 1991) *Negative:* *S. typhimurium* BA13/BAL13, without activation (Roldan-Arjona et al., 1991) *S. typhimurium* TA100, with activation (Mortelmans et al., 1986) *S. typhimurium* TA100, without activation (Bartsch et al., 1975, 1979; Simmon and Tardiff, 1978; Oesch et al., 1983; Mortelmans et al., 1986) *S. typhimurium* TA104, with and without activation (Strobel and Grummt, 1987) *S. typhimurium* TA1535, with activation (Mortelmans et al., 1986) *S. typhimurium* TA1535, without activation (Baden et al., 1977; Oesch et al., 1983; Mortelmans et al., 1986) *S. typhimurium* TA1537, with activation (Mortelmans et al., 1986) *S. typhimurium* TA1537, without activation (Oesch et al., 1983; Mortelmans et al., 1986) *S. typhimurium* TA98, with activation (Mortelmans et al., 1986) *S. typhimurium* TA98, without activation (Oesch et al., 1983; Mortelmans et al., 1986; Strobel and Grummt, 1987) *S. typhimurium* TA92, without activation (Oesch et al., 1983) *S. typhimurium* TA97, without activation (Strobel and Grummt, 1987) *E. coli* K12, without activation (Oesch et al., 1983) *E. coli* WP2, without activation (Oesch et al., 1983) Chinese hamster lung V79 cells, *hprt* locus, with and without activation (Drevon and Kuroki, 1979) Chinese hamster lung V79 cells, ouabain resistance, with and without activation (Drevon and Kuroki, 1979) **Sister chromatid exchange** *Positive:* Chinese hamster lung cells, with activation (Sawada et al., 1987); Chinese hamster ovary cells (McCarroll et al., 1983)

Endpoint	Lowest effect levels[1] / Results
	Negative: Chinese hamster lung cells, without activation (Sawada et al., 1987) **Unscheduled DNA synthesis** *Positive:* rat, hepatocytes (Costa and Ivanetich, 1982)

[1] LC_{50} = median lethal concentration; LD_{50} = median lethal dose; LOAEC = lowest-observed-adverse-effect concentration; LOEC = lowest-observed-effect concentration; LOEL = lowest-observed-effect level.

APPENDIX A: Upper-Bounding Estimates of Exposure to 1,1-Dichloroethene from Consumer Products[1]

Consumer product type	Scenarios	Estimated daily exposure
Carpet latex backing	**Inhalation** The background for the following scenarios is detailed in the VCCEP submission on DCE (U.S. EPA, 2002b). - maximum concentration of 3 ppm (3 µg/g) residual DCE monomer in carpet latex, with no loss during manufacturing and storage - carpet is made using 20 oz. of wet latex per square yard of carpet - a typical 20-m^3 room has a ceiling 2.44 m high Average amount = $\frac{(3\ \mu g/g)\ (20\ oz./yd.^2)\ (28.35\ g/oz.)}{(0.83612\ m^2/yd.^2)}$ = 2034 µg/m^2	
	Scenario 1 - air exchanges per hour (k_2) = 0.3 - release is first order and the rate constant (k_1) is very large compared with k_2 - complete release of residual DCE over the 5-year lifetime of the carpet (t = 5 years × 365.25 days/year × 24 h/day = 43 830 h) Average air concn. = $\frac{(2034\ \mu g/m^2)\ (1-\exp(-k_2 t)}{k_2 t\ (2.44\ m)}$ For an average Canadian child 0.5–4 years old, with a breathing rate of 0.39 m^3/h (EHD, 1998): Intake = $\frac{(0.0634\ \mu g/m^3)\ (0.39\ m^3/h)\ (24\ h)}{15.5\ kg}$	Scenario 1 Average air concentration = 0.0634 µg/m^3 Daily intake = 0.038 µg/kg-bw per day

Consumer product type	Scenarios	Estimated daily exposure
	Scenario 2 - emission of DCE from carpet decreases as first-order decay, with the highest concentration being released initially. Over time, the amount available for release is reduced. It is assumed that the release rate constant corresponds to release half-lives of 2 weeks, 1 year and 5 years. - first-order rate constant (k_1) = ln 2/half-life - air exchanges per hour (k_2) = 0.3 - t = 5 × 365.25 × 24 = 43 830 h Air concn. = $\frac{(k_1)(2034\ \mu g/m^2)[1/k_1(1-\exp(-k_1 t) - 1/k_2(1-\exp(-k_2 t)]}{(k_2-k_1)t\ (2.44\ m)}$ For an average Canadian child 0.5–4 years old, with a breathing rate of 0.39 m^3/h (EHD, 1998): Intake = $\frac{(\text{air concn. } \mu g/m^3)\ (0.39\ m^3/h)\ (24\ h)}{(15.5\ kg)}$	Scenario 2 Air concentration (half-life) = 0.0633 µg/m^3 (2 weeks) 0.061 µg/m^3 (1 year) 0.032 µg/m^3 (5 years) Daily intake (half-life) = 0.04 µg/kg-bw per day (2 weeks) 0.04 µg/kg-bw per day (1 year) 0.02 µg/kg-bw per day (5 years)
Food in contact with PVDC film wrap	**Ingestion** - mean residual DCE monomer in film wrap migrating to food is 5 ng/g food (U.S. EPA, 2002b) - mean food consumption for a 15.5-kg average Canadian child (0.5–4 years) is 1.8 kg/day (EHD, 1998) - consumption factor (fraction of food in contact with packaging) for PVDC is 0.05 (U.S. FDA, 2002). Intake = $\frac{(0.05)\ (5\ ng/g)\ (1\ \mu g/1000\ ng)\ (1.8\ kg/day)\ (1000\ g/kg)}{(15.5\ kg)}$	Daily intake = 0.03 µg/kg-bw per day

[1] Each scenario assumes the maximum exposure possible for a 15.5-kg child (0.5–4 years), as this group has the highest inhalation volume and food consumption relative to body weight.

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