Australian Government

Department of Health

Australian Industrial Chemicals Introduction Scheme

Dichloromethane (Methane, dichloro-)

Evaluation statement

14 September 2021

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AICIS evaluation statement

Subject of the evaluation

Dichloromethane (Methane, dichloro-)

Chemical in this evaluation

Name	CAS Registry Number
Methane, dichloro-	75-09-2

Reason for the evaluation

The Evaluation Selection Analysis indicated a potential risk to the environment.

Parameters of evaluation

The chemical in this evaluation has been evaluated for its risks to the environment according to the following parameters:

- combined annual introduction volume of approximately 1300 tonnes
- annual emissions to the atmosphere in Australia of 689 tonnes
- industrial uses listed below in the 'Summary of Use' section.

Summary of evaluation

Summary of introduction, use and end use

The chemical is used as a solvent in the following industrial applications:

- paint strippers and surface coating products
- cleaning and degreasing products
- chemical manufacturing.

The chemical is also used as a blowing agent in polymer foam production.

Environment

Summary of environmental hazard characteristics

Dichloromethane (DCM) belongs to a category of ozone depleting chemicals known as 'very short-lived substances' (VSLSs). The chemical, DCM contributes to depletion of ozone in the stratosphere.

According to domestic environmental hazard thresholds and based on the available data the chemical is:

- Persistent (P)
- Not Bioaccumulative (not B)
- Not Toxic (not T)

Environmental hazard classification

The chemical satisfies the criteria for classification according to the Globally Harmonised System of Classification and Labelling of Chemicals (GHS) for environmental hazards as follows. This does not consider classification of physical hazards and health hazards.

Environmental Hazard	Hazard Category	Hazard Statement
Acute Aquatic	Category 3	H402: Harmful to aquatic life

Summary of environmental risk

The chemical has a range of industrial uses which result in emission into the atmosphere. This is of potential concern because DCM contributes to depletion of ozone in the stratosphere, and this may delay the recovery of the ozone layer. However, global agreements that restrict the emissions of other ozone depleting chemicals do not currently include DCM or other VSLSs.

The results of atmospheric monitoring studies show that emissions of DCM into the atmosphere from Australia have been declining. This evaluation did not identify any specific reasons for this declining trend in emissions of the chemical. If this trend continues and no global restrictions on the use and emissions of VSLSs are introduced, specific risk reduction measures for industrial uses of DCM are unlikely to be required.

Conclusions

The conclusions of this evaluation are based on the information described in the statement. Obligations to report additional information about hazards under section 100 of the *Industrial Chemicals Act 2019* apply.

The Executive Director is satisfied that the identified environment risks can be managed within existing risk management frameworks. This is provided that all requirements are met under environmental, workplace health and safety and poisons legislation as adopted by the relevant state or territory.

Supporting information

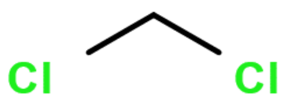
Rationale

This evaluation considers the environmental risks associated with the industrial uses of dichloromethane (DCM). This chemical is used in high volumes as a blowing agent in the manufacture of polyurethane foams and as a solvent in paint strippers, degreasers, and in chemical manufacturing.

The Evaluation Selection Analysis for DCM indicated that it is potentially of concern to the environment based on the high introduction volume and emissive use patterns of the chemical, and its potential to deplete ozone in the stratosphere. The ozone depleting properties of DCM are a relevant consideration for this evaluation because recent atmospheric modelling has indicated that the current scale of cumulative global emissions of this chemical may be sufficient to delay the recovery of the ozone layer (Hossaini, et al., 2017). This evaluation will consider the scale of current emissions of DCM to the atmosphere and the risk to the environment from industrial uses of this chemical in Australia.

Chemical identity

The chemical is one member of a group of chlorinated methanes all of which have industrial uses (Rossberg, et al., 2011). It is manufactured on an industrial scale by the chlorination of methane at high temperatures (350–450°C), which produces a mixture of all the chlorinated methanes including DCM, chloromethane (CAS RN 74-87-3), chloroform (CAS RN 67-66-3) and carbon tetrachloride (CAS RN 56-23-5). This mixture of chemicals is separated by distillation.

Synonyms	dichloromethane (DCM) methylene chloride Freon 30 R 30
Structural Formula	
Molecular Formula	CH_2Cl_2
Molecular Weight (g/mol)	84.93
SMILES	ClCCl
Chemical Description	colourless liquid

Relevant physical and chemical properties

The following measured physical and chemical property data for DCM were retrieved from the recent risk evaluation of the chemical conducted by the United States Environmental Protection Agency (US EPA, 2020b):

Physical Form	liquid
Melting Point	-95°C
Boiling Point	40°C
Vapour Pressure	58 kPa (25°C)
Water Solubility	13 grams per litre (g/L)
Henry's Law Constant	295 Pa·m^3/mol (25°C)
Ionisable in the Environment?	no
pK_a	N/A
log K_{OW}	1.25 (20°C)

The chemical DCM is a highly volatile neutral organic chemical which is readily soluble in water. The low measured octanol-water partition coefficient (K_{OW}) indicates that DCM has low lipophilicity. The chemical is highly volatile from water and moist soil based on the measured Henry's Law constant.

Introduction and use

Australia

The following industrial uses of DCM in Australia have been identified (BOC, 2019; DAWE, 2019; Dynaweld, 2015; NICNAS, 2006):

- solvent in paint strippers
- solvent used in chemical manufacturing
- blowing agent used in the production of polymer foams
- in aerosol products (welding anti-spatter spray).

The chemical is listed on the 2006 Australian High Volume Industrial Chemical List (AHVICL) with a reported use volume of 1 000–9 999 tonnes/year (NICNAS, 2006). According to World Trade Organisation (WTO) import data, 1260 tonnes of DCM were imported into Australia in 2019 under tariff code '290312' (WTO, 2021).

International

The chemical DCM is a high production volume chemical with widespread global use, primarily as an organic solvent.

The following industrial uses were identified in the OECD SIDS Initial Assessment Report (OECD, 2011):

- feedstock to produce difluoromethane (HFC-32; CAS RN 75-10-5)
- metal cleaning (cold and vapour degreasing)
- in aerosol formulations
- in sealants and adhesives
- heat transfer fluid
- solvent for the removal of protective coatings during the production of printed circuit boards.

Current global emissions of DCM to the atmosphere are estimated to be 1.2 million tonnes per year (Claxton, et al., 2020). A portion of these emissions are from biomass burning and biogenic sources, which contribute an estimated 90 000 tonnes per year (Trudinger, et al., 2004).

Approximately 120,000 tonnes of DCM were introduced in the United States of America (USA) in 2015 (US EPA, 2020b). The chemical is registered in Europe (EU) in the volume range of 100,000–1,000,000 tonnes/year (REACH, 2020). Japan introduced or manufactured
40,000–50,000 tonnes of DCM in the 2018 financial year (NITE, 2020).

As of 2016, the major uses for DCM in the USA were as a solvent in the production of pharmaceuticals and polymers as well as use in paint removers. Production of pharmaceuticals was estimated to comprise 30% of total consumption, and chemical processing consumed 5%. Consumption of the chemical for paint stripping was expected to decrease due to new regulatory action to control the use of DCM for this end-use (US EPA, 2020b).

Existing Australian regulatory controls

Environment

The chemical is subject to reporting under the Australian National Pollutant Inventory (NPI). Under the NPI, emissions of DCM are required to be reported annually by facilities that use or emit more than 10 tonnes of the chemical during a reporting year (DAWE, 2019). Emissions arising from consumer uses of the chemical are not reported under the NPI.

Disposal of DCM is controlled through state and territory legislation and by local water authorities (Government of Queensland, 2020). Permissible limits for DCM in trade waste released to sewers range from prohibition of release to concentrations of 2 milligrams per litre (mg/L) (Barwon Water, 2015; SA Water, 2018).

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Water Quality Guidelines) include low reliability trigger values for DCM. Values for 99%, 95%, 90% and 80% species protection are 3, 4, 5 and 7 mg/L respectively, based on calculated aquatic toxicity end-points and limited experimental toxicity data (ANZECC and ARMCANZ, 2000).

International regulatory status

United Nations

The chemical is not currently identified as a Persistent Organic Pollutant (UNEP, 2001) or hazardous substance for the purpose of international trade (UNEP & FAO, 1998).

The chemical is not listed in the annexes of the Montreal Protocol (UNEP, 1987). The significance of the contribution to stratospheric chlorine from substances such as DCM was discussed during the 29th Meeting of the Parties of the Montreal Protocol in November 2017. The Scientific Assessment Panel reviewed very short-lived substances such as DCM and concluded that 'understanding the role of VSLS emissions in long-term future stratospheric ozone changes remained an open science question' (UNEP, 2020).

The atmospheric concentration of DCM and other chlorinated hydrocarbons are being monitored globally and they have been included in the quadrennial Scientific Assessments of Ozone Depletion released by the World Meteorological Organisation (WMO, 2018).

OECD

The chemical was sponsored by Switzerland under the Cooperative Chemicals Assessment Programme (CoCAP) (OECD, 2011). The 1st Cooperative Chemicals Assessment Meeting (CoCAM 1) in 2011 agreed that the chemical was a low priority for further work. The screening assessment concluded that DCM possessed acute aquatic toxicity properties indicating a hazard for the environment.

Canada

The chemical is listed under Schedule 1 (the Toxic Substances List) of the *Canadian Environmental Protection Act 1999* (CEPA 1999) (Government of Canada, 2020).

Use of DCM is subject to the Environmental Emergency Regulations (2019), where facilities with on-site volumes ≥9.1 tonnes are required to report their use quantities and have an environmental emergency plan (Government of Canada, 2019).

The chemical is also listed on the Canadian National Pollutant Release Inventory (NPRI) (ECCC, 2020). Emissions are required to be reported if the chemical is manufactured, processed, or otherwise used at quantities greater than 10 tonnes.

European Union

The chemical is registered under the Registration, Evaluation, Authorisation and Restriction of Chemicals legislation (REACH, 2020). The chemical is subject to restrictions under Annex XVII of REACH. Use of paint strippers containing more than 0.1% weight/weight (w/w) of DCM is restricted to use within industrial facilities and to certified professionals in certain EU Member States (ECHA, 2020b).

The chemical is listed on the Public Activities Coordination Tool (PACT) as 'appropriate for informal hazard assessment and/or risk management option analysis' under the SVHC Roadmap due to its potential as an endocrine disruptor, a carcinogenic, mutagenic and reprotoxic (CMR) substance, and as a substance with high aggregate tonnage (ECHA, 2020a).

The chemical is prohibited from use in cosmetic products under Annex II of the Cosmetics Regulations (EC 1223/2009) (European Commission, 2009; 2020).

The chemical is subject to the Industrial Emissions Directive (2010/75/EU) where it meets the criteria of a volatile organic compound. Emissions of DCM are required to be reported according to its different use patterns (European Commission, 2010).

United States of America

The chemical, DCM is listed on the United States Environmental Protection Agency (US EPA) Chemical Substance Inventory, established under the *Toxic Substances Control Act 1976*. The chemical is registered as 'active' on the Chemical Substance Inventory, which indicates that it has recently been manufactured, imported or processed by industry in the USA (US EPA, 2020a).

The chemical is prohibited from use in paint and coating removers for consumer use due to human health concerns (US EPA, 2019).

Environmental exposure

The chemical is primarily emitted into the atmosphere and emissions are dominated by anthropogenic sources.

The chemical is produced naturally by macroalgae (Gribble, 2009) and mangrove forests (Kolusu, et al., 2018), and is also generated from the combustion of biomass (Lobert, et al., 1999). However, most of the emissions of this chemical to the environment are from industrial sources (Leedham Elvidge, et al., 2015; Trudinger, et al., 2004; WMO, 2018).

Direct emission of DCM to the atmosphere will occur during its use as a solvent in paint stripper, in aerosols, as a cleaning agent, as a vapour degreaser, in adhesives, and as a urethane foam blowing agent (OECD, 2011; US EPA, 2020b). A proportion of the chemical used in these ways may be captured before emission to the atmosphere by engineering controls.

Release of DCM to surface water may occur from the use of the chemical as a solvent in industrial facilities. Wastewater effluent from these facilities may be contaminated with residual DCM and be released to sewage treatment as trade waste. These releases are likely to be small due to the high volatility of the chemical from water and existing state and territory regulations on the release of dichloromethane in trade waste (Barwon Water, 2015; Government of Queensland, 2020; SA Water, 2018).

Environmental fate

Partitioning

The chemical partitions to air when released into the environment, with a minor fraction partitioning to water.

The chemical has a high Henry's Law constant and is expected to volatilise from water and moist soil. For example, volatility modelling shows that DCM has a volatilisation half-life of 1 hour from a model river and 90 hours (3.7 days) from a model lake (US EPA, 2017).

Calculations with a standard multimedia partitioning (fugacity) model assuming equal and continuous emissions to air, water and soil compartments (Level III approach) predict that the chemical will mainly partition to air (43%) and water (44.7%) compartments, with minor partitioning to soil (12.2%). However, with sole release to the atmosphere, the model predicts that 98.9% of the chemical will partition to the air compartment with 1.0% partitioning to water (US EPA, 2017).

Degradation

DCM is persistent in the atmosphere.

The main degradation pathway for DCM in the atmosphere involves indirect photo-oxidation by hydroxyl radicals. DCM has an atmospheric lifetime of 180 days, corresponding to a half-life of 125 days (WMO, 2018).

The chemical is expected to undergo rapid biodegradation in water and sediment systems. The chemical was readily biodegradable in a closed bottle screening test (OECD Test Guideline (TG) 301D), with 68% degradation occurring in 28 days and the 10-day window criterion was satisfied (REACH, 2020).

The chemical, DCM has a hydrolysis half-life of 1.5 years and abiotic degradation in water is; therefore, not expected to be a significant dissipation pathway for this chemical in the environment compared to volatilisation and biodegradation (OECD, 2011; US EPA, 2020b).

Bioaccumulation

The chemical has a low potential to bioaccumulate in aquatic life.

The chemical is readily water soluble and has low lipophilicity. Therefore, it is expected to have a low potential to bioconcentrate in aquatic life. This expectation is supported by measured bioconcentration factors (BCFs) for the chemical in fish that are in the range of 2.0–40 L/kg (NITE, 2020).

Environmental transport

The chemical is present throughout the atmosphere and is transported to the stratosphere.

The chemical is highly volatile and persistent in air. Studies have demonstrated that DCM emitted at the surface of the planet can reach the stratosphere (Hossaini, et al., 2015; Oram, et al., 2017; WMO, 2018).

Due to its comparatively short atmospheric lifetime of 180 days, DCM is not homogenously mixed in the atmosphere. Higher concentrations are observed in the Northern Hemisphere than in the Southern Hemisphere (Claxton, et al., 2020). Additionally, emissions of DCM from the East Asian region are subject to transport mechanisms that result in higher concentrations of DCM reaching the stratosphere from this region than emissions from other global regions (Adcock, et al., 2021; Oram, et al., 2017).

The water compartment is not expected to be an important transport medium for DCM because this chemical is expected to dissipate rapidly from water through a combination of volatilisation to the atmosphere or biodegradation.

Predicted environmental concentration (PEC)

The Southern Hemisphere atmospheric concentration of DCM has been measured as 60 nanograms per cubic metre (ng/m^3). The concentration of DCM in Australian surface waters is estimated to be 0.78 micrograms per litre (µg/L) based on available international monitoring data.

Atmospheric monitoring conducted by the CSIRO indicates that emissions of DCM from Australia have been variable year on year, but with a strong downward trend. The most recent monitoring data show domestic emissions were 1180 tonnes in 2017 and 689 tonnes in 2018 (CSIRO, 2020). Emissions of DCM reported to the NPI have also been trending down from a recent peak of 1529 tonnes in 2005-2006 (DAWE, 2019). In the last 5 years, emissions of 730–830 tonnes/year have been reported.

The concentration of DCM in the atmosphere of the Southern Hemisphere peaked at 60 ng/m^3 or 17 parts-per-trillion (ppt) in 2018 (CSIRO, 2020). The concentrations of DCM in the Northern Hemisphere were at a recent minimum in 2005, but had increased to 177–212 ng/m^3 (50–60 ppt) by 2015 (Claxton, et al., 2020; WMO, 2018). The rate of growth in the concentration of DCM in the atmosphere has been decreasing in both hemispheres since 2016. Between the years 2018 and 2019, concentrations in air at the Cape Grim monitoring station in Tasmania were constant (CSIRO, 2020). It is uncertain whether the recent decrease in the DCM emission rate reflects a stabilisation of DCM emissions or if it is a reflection of large-scale atmospheric variability (WMO, 2018).

No surface water monitoring data for DCM in Australia were available for this evaluation. In a survey of surface waters in the USA for the period 2013–2017, DCM was detected in 2.7% of samples with an average concentration of 0.78 µg/L (62 detections in 2286 samples) (US EPA, 2020b). Concentrations of DCM in surface waters among various European rivers have been measured in the range of 0.0003–4.98 µg/L (Christof, et al., 2002). Assuming use patterns and per capita emission rates are similar in Australia, Europe, and the USA, a concentration of 0.78 µg/L is assumed for DCM in surface waters in Australia.

Environmental effects

Effects on the atmosphere

The chemical, DCM contributes to depletion of ozone in the stratosphere despite having a short atmospheric lifetime compared to other ozone depleting substances.

Volatile chlorinated organic chemicals, such as DCM, contribute to the depletion of the ozone layer by providing a source of chlorine in the stratosphere. When these chemicals are degraded in the stratosphere, they release reactive inorganic chlorine that destroys stratospheric ozone. The emission location and atmospheric stability of these chemicals governs their ability to be transported to the stratosphere (Hossaini, et al., 2015).

The chemical belongs to a category of ozone depleting chemicals known as ‘very short-lived substances’ (VSLSs). These substances have very short atmospheric lifetimes compared to ozone depleting chemicals controlled under the Montreal Protocol (WMO, 2018). The impact of ozone depleting chemicals on stratospheric ozone is typically reported in terms of the ozone depletion potential (ODP) metric. The ODP is the ratio of the impact of the substance on ozone compared to the impact of the same mass of the reference chemical, trichlorofluoromethane (CFC-11, ODP = 1) (WMO, 2018). DCM has an estimated ozone depleting potential (ODP) of 0.01–0.02 depending on its release location (Claxton, et al., 2019). The release of DCM close to the Asian tropics increases the ozone depletion potential of the chemical as there is better troposphere to stratosphere transport of volatile chemicals at these latitudes.

Effects on aquatic life

The chemical, DCM has low acute toxicity to aquatic organisms, with an expected narcosis or baseline toxic mode of action (LMC, 2020).

Acute toxicity

The following measured median effective concentration (EC50) and median lethal concentration (LC50) values for freshwater model organisms across two trophic levels were taken from the REACH registration dossier and the US EPA risk evaluation of DCM (REACH, 2020; US EPA, 2020b):

Taxon	Endpoint	Method
Fish	96 h LC50 = 193 mg/L	*Pimephales promelas* (fathead minnow) Flow-through conditions Measured concentration
Algae	96 h EC50 = 33 mg/L	*Pseudokirchneriella subcapitata* (green algae) Biomass Static closed-system Measured concentration

Chronic toxicity

The following measured no-observed effect concentration (NOEC) value was retrieved from the REACH registration dossier for DCM (REACH, 2020):

Taxon	Endpoint	Method
Fish	28 d NOEC = 83 mg/L	*Pimephales promelas* (fathead minnow) Growth rate ASTM E729-80 Flow-through Measured concentration

Effects on terrestrial life

No environmentally relevant data were identified.

The effects of DCM on terrestrial model organisms has been addressed in the Inventory Multi-Tiered Assessment and Prioritisation (IMAP) Human Health Tier II assessment of DCM (NICNAS, 2014). Critical health effects identified include systemic long-term effects (carcinogenicity) and neurotoxicity in mice and rats exposed to high concentrations of the chemical through inhalation.

Effects on sediment dwelling life

No relevant data were identified.

Predicted no-effect concentration (PNEC)

A PNEC was not calculated for the chemical.

The chemical, DCM is not expected to significantly partition to the water, soil and sediment compartments as a result of current industrial uses. If released to surface waters, the chemical will rapidly partition to the air compartment. The chemical is listed in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, but no high reliability default guideline values are available for protection of aquatic ecosystems (ANZECC and ARMCANZ, 2000).

Categorisation of environmental hazard

The categorisation of the environmental hazards of the evaluated chemical according to domestic environmental hazard thresholds is presented below:

Persistence

Persistent (P). Based on the very slow degradation of the chemical in the atmosphere and its long half-life in this compartment, DCM is categorised as Persistent.

Bioaccumulation

Not Bioaccumulative (Not B). Based on low measured bioconcentration factors in fish, DCM is categorised as Not Bioaccumulative.

Toxicity

Not Toxic (Not T). Based on the available ecotoxicity studies which demonstrate low acute and chronic toxicity to aquatic life, DCM is categorised as Not Toxic.

GHS classification of environmental hazard

The aquatic hazard of the chemical is classified as Acute Category 3 (H402) under the Globally Harmonised System of Classification and Labelling of Chemicals (GHS, Rev. 7) (UNECE, 2017). The classification of the acute aquatic hazard posed by this chemical was performed based on the measured ecotoxicity data presented in this assessment. The classification outcome for chronic (long-term) aquatic toxicity is ‘Not classified’ due to the measured chronic endpoint being above 10 mg/L and noting that DCM is both readily biodegradable and has a BCF <500 L/kg.

Environmental risk characterisation

Global emissions of DCM may delay the recovery of the ozone layer, but emissions of this chemical from Australia are in long term decline.

Current global emissions of DCM are estimated to contribute 2.3% of the inorganic chlorine present in the stratosphere (WMO, 2018). Inorganic chlorine is hazardous to the ozone layer because it plays a key role in the photocatalytic destruction of ozone. The contribution of DCM to total inorganic chlorine levels in the stratosphere is of potential concern because it may slow the recovery of the ozone layer from the impact of ozone depleting chemicals that are now prohibited under the Montreal Protocol. The emissions of DCM may be of relatively higher concern than other VSLSs because of the large volumes of this chemical that are in use globally and the range of industrial uses (including consumer uses) that result in direct release of the chemical into the atmosphere. Emissions of DCM close to the Asian tropics are of particular concern because the chemical is more efficiently transported to the stratosphere from that region.

Although there are emerging concerns about the impacts of VSLSs on the recovery of the ozone layer, there is not yet a global consensus that restrictions on production and use of these chemicals are required. However, this is an active area of research and atmospheric concentrations of VSLSs, including DCM, are routinely monitored as part of global air monitoring programs. Based on long term atmospheric monitoring conducted in Australia by the CSIRO, domestic emissions of DCM have been in long term decline from more than 6000 tonnes per year in the late 1990s to less than 700 tonnes in 2018.

The reason for the decline in emissions of DCM from Australia since the 1990s was not determined in this evaluation. However, it is noted that the volume of emissions from Australia determined by the CSIRO is comparable with the volume of DCM imported based on the most recent WTO data (1260 tonnes in 2019). If it is assumed that at least 50% of the imported quantity of chemical is eventually emitted into the atmosphere, then the current scale of emissions of DCM from Australia is in line with emissions anticipated from industrial uses of the chemical. A more complete analysis of emission sources for DCM is beyond the scope of this evaluation, but based on the available evidence it is concluded that the risks to the atmosphere from industrial uses of this chemical in Australia are decreasing over time and no specific measures to reduce uses and/or emissions of this chemical are currently required.

The risks of DCM to aquatic life are low, based on its low concentrations in surface waters and high volatility from water. The risks to the soil and sediment compartments from current industrial uses are expected to be low as the chemical is not expected to be released to, or significantly partition to, these compartments.

Uncertainty

This evaluation was conducted based on a set of information that may be incomplete or limited in scope. Some relatively common data limitations can be addressed through use of conservative assumptions (OECD, 2019) or quantitative adjustments such as assessment factors (OECD, 1995). Others must be addressed qualitatively, or on a case-by-case basis (OECD, 2019).

The most consequential area of uncertainty for this evaluation is:

- The impact of VSLSs such as DCM on the ozone layer is an area of active research and continued monitoring. As more data are collected and refinements are made to atmospheric models, the relationship between surface emissions of VSLSs and their contribution to destruction of ozone in the stratosphere will improve. This may lead to future changes in the understanding of the risk DCM poses to the ozone layer. The World Meteorological Organisation is expected to release a scientific assessment of ozone depletion in 2022, while the CSIRO is expected to continue to release their annual atmospheric monitoring reports. The findings in these reports may provide relevant additional information that will decrease uncertainty about the impacts industrial uses of DCM have on the ozone layer.

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