Methane, chlorodifluoro-: Environment tier II assessment

22 November 2013

CAS Registry Number: 75-45-6.

Preface

This assessment was carried out by staff of the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) using the Inventory Multi-tiered Assessment and Prioritisation (IMAP) framework.

The IMAP framework addresses the human health and environmental impacts of previously unassessed industrial chemicals listed on the Australian Inventory of Chemical Substances (the Inventory).

The framework was developed with significant input from stakeholders and provides a more rapid, flexible and transparent approach for the assessment of chemicals listed on the Inventory.

Stage One of the implementation of this framework, which lasted four years from 1 July 2012, examined 3000 chemicals meeting characteristics identified by stakeholders as needing priority assessment. This included chemicals for which NICNAS already held exposure information, chemicals identified as a concern or for which regulatory action had been taken overseas, and chemicals detected in international studies analysing chemicals present in babies' umbilical cord blood.

Stage Two of IMAP began in July 2016. We are continuing to assess chemicals on the Inventory, including chemicals identified as a concern for which action has been taken overseas and chemicals that can be rapidly identified and assessed by using Stage One information. We are also continuing to publish information for chemicals on the Inventory that pose a low risk to human health or the environment or both. This work provides efficiencies and enables us to identify higher risk chemicals requiring assessment.

The IMAP framework is a science and risk-based model designed to align the assessment effort with the human health and environmental impacts of chemicals. It has three tiers of assessment, with the assessment effort increasing with each tier. The Tier I assessment is a high throughput approach using tabulated electronic data. The Tier II assessment is an evaluation of risk on a substance-by-substance or chemical category-by-category basis. Tier III assessments are conducted to address specific concerns that could not be resolved during the Tier II assessment.

These assessments are carried out by staff employed by the Australian Government Department of Health and the Australian Government Department of the Environment and Energy. The human health and environment risk assessments are conducted and published separately, using information available at the time, and may be undertaken at different tiers.

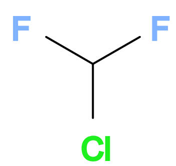
This chemical or group of chemicals are being assessed at Tier II because the Tier I assessment indicated that it needed further investigation.

For more detail on this program please visit: www.nicnas.gov.au.

Disclaimer

Acronyms & Abbreviations

Chemical Identity

Synonyms	Hydrochlorofluorocarbon 22 (HCFC-22) Chlorodifluoromethane Monochlorodifluoromethane Refrigerant 22 (R 22) Fluorocarbon 22 Freon 22
Structural Formula	

Molecular Formula	$CHClF_2$
Molecular Weight (g/mol)	86.47
SMILES	C(F)(F)Cl

Physical and Chemical Properties

The physical and chemical property data for this chemical were retrieved from the databases included in the OECD QSAR Toolbox (LMC, 2013).

Physical Form	Gas
Melting Point	-157°C (exp.)
Boiling Point	-40.7°C (exp.)
Vapour Pressure	967 000 Pa (exp.)
Water Solubility	2770 mg/L (exp.)
Ionisable in the Environment?	No
log K_{ow}	1.08 (exp.)

Import, Manufacture and Use

Australia

Methane, chlorodifluoro- (or HCFC-22) is an ozone depleting substance. Ozone depleting substances are controlled under the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* (the Ozone Act) (Cwlth) in Australia (Commonwealth of Australia, 1989).

HCFC-22 was once the most widely used refrigerant in air-conditioning and refrigeration systems in Australia. The chemical also had minor uses as a foam blowing agent and as an aerosol propellant (Energy Strategies, 2008). However, under the Ozone Act, imports of HCFC-22 are currently being phased out.

In 2012 and 2013, the annual import limit of all HCFCs is 40 ozone depleting potential (ODP) tonnes, equating to a theoretical maximum of 720 metric tonnes of HCFC-22 per year (assuming no other HCFCs are imported). In 2014 and 2015, this will be reduced to a theoretical maximum of 180 metric tonnes and further reduced to a theoretical maximum of 45 metric tonnes per year between 2016 and 2029. In practice, small amounts of other HCFCs are imported every year, so actual amounts of HCFC-22 imported will be less. These volumes exclude feedstock uses, or HCFCs contained in products or equipment (Australian Government Department of the Environment, 2013a; Commonwealth of Australia, 1989).

A controlled substances licence from the Australian Government is required to manufacture HCFCs, and for the import and export of any amount of HCFCs (Australian Government Department of the Environment, 2013a; Commonwealth of Australia, 1989). There is no domestic manufacture of the chemical.

Importers of equipment containing HCFC-22 are also required to be licensed. However, imports of most equipment containing the chemical have been banned since 2010.

The quantity of the chemical that is imported or manufactured for use as a feedstock must be reported to the Australian Government Department of the Environment on a quarterly basis (Commonwealth of Australia, 1989). There have been no reported imports of the chemical as a feedstock in the last 10 years.

International

Historically, the major use of HCFC-22 was as a refrigerant gas in air-conditioning and refrigeration applications (US NLM, 2013). However, the production and consumption of the chemical for this use is currently being phased out globally under the *Montreal Protocol on Substances that Deplete the Ozone Layer* (the Montreal Protocol) (UNEP, 2012).

According to reporting data held by the United Nations Environment Programme (UNEP), approximately 450 000 tonnes of the chemical were produced globally for feedstock uses in 2011. The major feedstock use of the chemical is for the production of tetrafluoroethylene, which is used to make fluorinated polymers. There appears to be no current alternative to the use of HCFC-22 for this feedstock application (UNEP, 2013a).

The Registration Dossier for the chemical under the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) legislation states that 10 000 to 100 000 tonnes of HCFC-22 are used per annum in the European Union. Registered uses include applications as a chemical feedstock, laboratory use, and use as an intermediate (ECHA, 2013).

Environmental Regulatory Status

Australia

HCFC-22 is a scheduled substance under the Ozone Act. The Act gives effect to Australia's obligations under the Montreal Protocol by controlling the manufacture, import and export of ozone depleting substances and listing banned applications. The chemical can only be imported if a licence is obtained from the Australian Government Department of the Environment, unless it is to be used exclusively as a feedstock (Commonwealth of Australia, 1989).

United Nations

The chemical is one of the controlled substances listed under Annex C of the Montreal Protocol (UNEP, 2012). The Protocol calls for a 99.5% reduction in consumption of the chemical in developed countries by 1 January 2020. Thereafter, consumption will be restricted to the servicing of refrigeration and air-conditioning equipment existing at that date (UNEP, 2012). All 197 countries of the United Nations have ratified the Montreal Protocol, including Australia, and only a few countries are yet to ratify the last amendment (UNEP, 2013b).

OECD

The chemical has been sponsored by Italy for assessment under the Cooperative Chemicals Assessment Programme (CoCAP), but no assessment is available (OECD, 2013).

Canada

The chemical is listed on Schedule 1 of the *Canadian Environmental Protection Act 1999* (the Toxic Substances List) along with all HCFCs. The chemical is required to be phased out from use and production by 2020, except for servicing applications (Environment Canada, 2013a).

The chemical has been categorised as Persistent (P), not Bioaccumulative (not B) and not Inherently Toxic to the Environment (not iT_E) by Environment Canada during the Categorization of the Domestic Substances List (DSL) (Environment Canada, 2013b).

European Union

The chemical is identified as an ozone depleting substance and is controlled under *Regulation No 1005/2009 of the European Parliament and of the Council of 16 September 2009 on Substances that Deplete the Ozone Layer*. The chemical is to be phased out of production, trade and use by 2020 (European Union, 2009).

United States of America

The chemical is listed as a Class II Substance under Title VI of the *Clean Air Act 1970*. Use of the chemical is restricted to chemical that has already been used, recovered or recycled; is entirely consumed during use; is used as a refrigerant in appliances manufactured prior to 1 January 2010; is used before 2020 to service existing appliances manufactured before 2010; or has a listed acceptable use. Production of the chemical is also scheduled for phase-out (US EPA, 2013).

Environmental Exposure

HCFC-22 is used mainly as a refrigerant, and has minor uses as a foam blowing agent and an aerosol propellant. There is the potential for release of HCFC-22 into the atmosphere during its use as a propellant or from foam products. There is also potential for the chemical to be released as the result of leaks from existing refrigeration or air-conditioning equipment (Energy Strategies, 2008).

Intentional and preventable emissions of ozone depleting substances are an offence under the Ozone Act unless provided for by regulation. These provisions include emissions from use as a propellant and from foam products. End use regulations for the refrigeration and air conditioning industry have been established. Under the regulations, supply of fluorocarbon refrigerants is restricted to authorised businesses and handling of these refrigerants restricted to appropriately trained and licensed technicians. Authorised businesses and licensed technicians are required to adhere to relevant Australian Standards and codes of practice, and to recover and return waste refrigerant for appropriate disposal (Australian Government Department of the Environment, 2013b).

Environmental Fate

Partitioning

The measured Henry's Law constant for partitioning of HCFC-22 from water to air is 4110 Pa-m^3/mol at 22°C (LMC, 2013). This large partitioning ratio indicates that the chemical is highly volatile from water and moist soil.

Calculations with a standard multimedia partitioning (fugacity) model, assuming sole release to the atmosphere, predicts that 100% of the chemical will remain in the air compartment (US EPA, 2008). The latter scenario is expected to be the most likely route of release of the chemical into the environment based on its predominant use as a refrigerant gas.

The chemical is a gas under ambient conditions and, if released, it will partition primarily to the atmosphere.

Degradation

The chemical is not rapidly degradable in water under aerobic conditions. The aerobic microbial degradation of the chemical was determined to be 0% after 28 days in a study conducted in accordance with OECD Test Guideline (TG) 301 D (LMC, 2013). The chemical is also resistant to degradation in sewage sludge and sediment slurries under anaerobic conditions (US NLM, 2013).

The major environmental degradation processes for HCFC-22 involve oxidation and photolysis in the atmosphere. The chemical undergoes relatively slow indirect photo-oxidation by hydroxyl radicals. The lifetime of the chemical with respect to degradation by hydroxyl radicals in the lower atmosphere (troposphere) is 12.8 years (WMO, 2011).

A fraction of the quantity of HCFC-22 that is released to the atmosphere will be transported through the troposphere to the upper atmosphere (stratosphere) (NOAA, 2013). The chemical is ultimately degraded in the stratosphere by the action of high-energy ultraviolet (UV) radiation which initiates the photodecomposition of the chemical. The lifetime of the chemical in the stratosphere is calculated to be 186 years (WMO, 2011).

The overall lifetime for the chemical in the atmosphere is 11.9 years. This lifetime takes into account all major loss mechanisms such as reactions with hydroxyl radicals, destruction in the stratosphere and uptake by oceans (WMO, 2011). The lifetime of the chemical in the atmosphere significantly exceeds the domestic criterion for persistence in air (half life = 2 days).

HCFC-22 is persistent in the atmosphere, which is the main receiving compartment for emissions of the chemical. The chemical is therefore categorised as persistent.

Bioaccumulation

No measured bioaccumulation data are available for the chemical. The measured octanol-water partition coefficient (K_{ow}) for HCFC-22 is low (log K_{ow} = 1.08), which indicates that the chemical is unlikely to bioconcentrate in aquatic organisms.

Transport

HCFC-22 is the most abundant HCFC in the atmosphere (WMO, 2011). The major route for global distribution of the chemical is through transport in the atmosphere. The chemical is also transported to the stratosphere where it is eventually degraded by UV photolysis (Moore and Remedios, 2008; NOAA, 2013).

Predicted Environmental Concentration (PEC)

A PEC for HCFC-22 in the atmosphere has not been calculated as there is a large body of high quality atmospheric monitoring data available from multiple sites around the world (WMO, 2011). Based on these data, the global mean abundance of the chemical in the atmosphere in 2008 was 188–192 parts per trillion (ppt), and was increasing at a rate of 8.0 ± 0.5 ppt per year. The levels of HCFC-22 in the atmosphere are projected to increase further due to the persistence of the chemical and its continued use during the phase out period under the Montreal Protocol (WMO, 2011). However, ultimately, atmospheric concentrations of HCFC-22 are projected to decline as emissions are reduced following the phase out of production and consumption of the chemical (WMO, 2011).

Environmental Effects

Effects on the Atmosphere

The stratospheric ozone layer protects life on Earth by absorbing UV radiation from the sun. This form of radiation can be damaging to most forms of life on Earth (Australian Government Department of the Environment, 2013c). Therefore, the destruction of ozone in the atmosphere is of environmental concern.

Photolysis of the chemical in the stratosphere by high-energy UV radiation liberates highly reactive chlorine atoms. These atoms undergo reactions that destroy ozone and hence deplete the capacity of the ozone layer to absorb harmful UV radiation. 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) (US EPA, 2010; WMO, 2011). HCFC-22 is assigned an ODP of 0.055 under the Ozone Act (Commonwealth of Australia, 1989).

Halocarbons such as HCFC-22 also contribute to global warming by absorbing radiation emitted from Earth and thus trapping the energy in the atmosphere (radiative forcing) (WMO, 2011). The amount of global warming that can be caused by a substance is typically reported in terms of the global warming potential (GWP) metric. The GWP is the ratio of the warming caused by the substance to the warming caused by the same mass of carbon dioxide, and is calculated for various time horizons (US EPA, 2010; WMO, 2011). HCFC-22 has a one hundred year GWP of 1790, relative to carbon dioxide (WMO, 2011).

Effects on Aquatic Life

HCFC-22 is a gas and is not expected to be released to the aquatic environment in significant quantities. The chemical is also highly volatile from water and can be expected to have a short residence time in the aquatic compartment. Limited ecotoxicological data are available for the chemical. Hence, calculated endpoints (median lethal concentrations (LC50s) and median effective concentrations (EC50s) derived from quantitative structure-activity relationships (QSARs)) have been used to characterise the acute aquatic ecotoxicity of the chemical (US EPA, 2012).

Acute toxicity

The following acute ecotoxicity endpoints for a taxonomic group from all three major aquatic trophic levels were calculated using the respective neutral organic QSAR models that are available in ECOSAR version 1.11 (US EPA, 2012):

Taxon	Endpoint	Method
Fish	96 h LC50 = 698.9 mg/L	Calculated (Neutral Organics SAR)
Invertebrates	48 h LC50 = 358.3 mg/L	Calculated (Neutral Organics SAR)

Taxon	Endpoint	Method
Algae	96 h EC50 = 175.0 mg/L	Calculated (Neutral Organics SAR)

Acute toxicity endpoints for fish and daphnia have been reported in safety data sheets (SDS) for the chemical. These values are a 96 h LC50 for fish of 777 mg/L and a 48 h EC50 for daphnia of 433 mg/L. Both tests were reported to be conducted under static conditions where the test solution was not replenished during the test period. Although the reported endpoints are consistent with the calculated acute endpoints, the reliability of these studies cannot be verified with the available information.

HCFC-22 is not harmful to aquatic organisms in short term exposures based on the above calculated acute ecotoxicity endpoints.

Chronic toxicity

There are no suitable data available to evaluate the long-term effects of the chemical on aquatic organisms.

Predicted No-Effect Concentration (PNEC)

The PNEC for the chemical in the air compartment was not calculated. The current global consensus is that anthropogenic emissions of this chemical should be minimised in order to maintain the health of the ozone layer and to reduce global warming resulting from pollutants entering the atmosphere.

The PNEC for the aquatic compartment was not calculated as the chemical is not expected to partition significantly to this compartment.

Categorisation of Environmental Hazard

Persistence

Persistent (P). The chemical is not rapidly degraded by natural processes in the environment and has a half life of greater than 2 days in the atmosphere. The chemical is therefore categorised as Persistent.

Bioaccumulation

Not Bioaccumulative (Not B). The log K_{ow} for the chemical is 1.08, which is below the domestic threshold for a bioaccumulation hazard in aquatic organisms (log K_{ow} ≥ 4.2). The chemical is therefore categorised as Not Bioaccumulative.

Toxicity

Not Toxic (Not T). The chemical is not expected to be toxic to aquatic organisms based on the calculated acute toxicity endpoints, which are all greater than 1 mg/L. The chemical is therefore categorised as Not Toxic.

Summary

HCFC-22 is categorised according to domestic environmental hazard thresholds (EPHC, 2009; NICNAS, 2013) as:

- P
- Not B
- Not T

Risk Characterisation

Risk quotients (RQs) have not been calculated for this chemical.

The international consensus is that release of this chemical to the atmosphere poses a risk to the environment. However, measures have been introduced under the Ozone Act to limit emissions of the chemical in Australia. These measures are intended to minimise the environmental releases of this chemical as production and consumption of HCFC-22 is phased out.

A PEC was not calculated for the aquatic compartment as there is limited potential for release of the chemical to the aquatic environment. As the chemical is a gas and environmental exposure is controlled under the Ozone Act, the risk to the aquatic environment resulting from current industrial uses of the chemical is low.

The risks to the soil and sediment compartments are expected to be low as the chemical is not expected to partition to these compartments.

Key Findings

The release of HCFC-22 to the environment is of concern due to the ozone depleting and global warming properties of the chemical. However, the manufacture, import and export of HCFC-22 are controlled in Australia under the Ozone Act and control measures are in place to limit environmental emissions of the chemical due to existing industrial uses. There is also a long term strategy in place to phase out the consumption of the chemical in Australia which will further reduce emissions of the chemical into the environment over time.

The chemical is not a PBT substance according to domestic environmental hazard criteria.

Recommendations

The manufacture, import and export of methane, chlorodifluoro- (HCFC-22) are controlled in Australia under the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989*. The control measures implemented under the Act also provide a long term strategy to limit emissions of this chemical to the environment resulting from industrial use. Current risk management measures are therefore considered adequate to protect the environment. No further assessment is required.

Environmental Hazard Classification

In addition to the categorisation of environmental hazards according to domestic environmental thresholds presented above, the classification of the environmental hazards of HCFC-22 according to the third edition of the United Nations' Globally Harmonised System of Classification and Labelling of Chemicals (GHS) is presented below (UNECE, 2009):

Hazard	GHS Classification (Code)	Hazard Statement

Hazard	GHS Classification (Code)	Hazard Statement
Ozone Layer	Category 1 (H420)	Harms public health and the environment by destroying ozone in the upper atmosphere

There are insufficient reliable data to classify the short and long-term aquatic hazards of the chemical.

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Last update 22 November 2013

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