Ethene, chloro-: Environment tier II assessment

18 September 2014

CAS Registry Number: 75-01-4.

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.

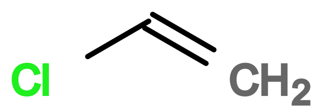
This chemical or group of chemicals are being assessed at Tier II because the Tier I assessment indicated that it needed further investigation.

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

Disclaimer

Acronyms & Abbreviations

Chemical Identity

Synonyms	Vinyl chloride Chloroethene Chloroethylene Vinyl chloride monomer (VCM)
Structural Formula	
Molecular Formula	C_2H_3Cl

Molecular Weight (g/mol)	62.50
SMILES	C(=C)Cl

Physical and Chemical Properties

The physical and chemical property data for ethene, chloro- (or vinyl chloride) were retrieved from the databases included in the OECD QSAR Toolbox (LMC, 2013).

Physical Form	Gas
Melting Point	-154°C (exp.)
Boiling Point	-13.3°C (exp.)
Vapour Pressure	397 301 Pa (exp.)
Water Solubility	8800 mg/L (exp.)
Ionisable in the Environment?	No
log K_{ow}	1.58 (exp.)

Import, Manufacture and Use

Australia

Vinyl chloride is imported in bulk to be used as a monomer feedstock for the manufacture of polyvinyl chloride (PVC) resin. The resin is manufactured at a single plant in Victoria. This plant produces approximately 140 000 tonnes per annum of PVC resin, which represents approximately two thirds of the domestic consumption of this high-volume industrial polymer (Australian Vinyls, 2014; Vinyl Council Australia, 2012).

International

The global production volume of polyvinyl chloride is second only to polyethylene (Summers, 1999). It is used to make a large variety of industrially significant products such as PVC pipe, wire coatings, vinyl external siding for buildings, wall coverings, interior vinyl floor coverings, furniture coverings, and materials for packaging (including food, drug and medical device packaging) (OECD, 2001).

The worldwide production capacity of vinyl chloride in 1999 was approximately 30 million tonnes. In the USA more than 99.5% of vinyl chloride monomer is used to make PVC and various vinyl chloride derived copolymers (for example, vinyl chloride-vinyl acetate and vinyl chloride-vinylidene chloride copolymers). The remainder is used as a feedstock for the manufacture of other chemicals (OECD, 2001).

Vinyl chloride was formerly used as a refrigerant, extraction solvent, and aerosol propellant (US NLM, 2013).

Environmental Regulatory Status

Australia

Under the Australian National Pollutant Inventory (NPI), emissions of vinyl chloride are required to be reported annually by facilities that use or emit more than 10 tonnes of the chemical during a reporting year (Australian Government Department of the Environment, 2013). The emissions may be intentional, accidental or incidental releases arising through industrial processes. Additionally, emissions of vinyl chloride from diffuse sources, such as landfills and domestic solid fuel burning, are also periodically estimated by state environment authorities. Diffuse emissions data are updated much less frequently than facility data (Australian Government Department of the Environment, 2014).

The chemical meets the definition of a Discrete Organic Chemical under the *Chemical Weapons (Prohibition) Act 1994 (Cwlth)*. Production of the chemical in volumes greater than 200 tonnes per annum in Australia must be reported to the Australian Safeguards and Non-Proliferation Office of the Australian Government Department of Foreign Affairs and Trade (DFAT, 2009).

United Nations

The chemical is not currently identified as a Persistent Organic Pollutant (UNEP, 2001), ozone depleting substance (UNEP, 1985), or hazardous substance for the purpose of international trade (UNEP, 1998).

OECD

The chemical is considered a High Production Volume (HPV) chemical by the OECD, which indicates that more than 1000 tonnes of the chemical are used per year in at least one member country (OECD, 2013).

Vinyl chloride was sponsored by the USA for assessment under the 13th Screening Information Dataset (SIDS) Initial Assessment Meeting (SIAM 13). The SIDS Initial Assessment Report (SIAR) made no recommendations for any further work (OECD, 2001).

Canada

Vinyl chloride is listed on the Canadian Domestic Substances List (DSL). During the Categorization of the DSL, the chemical was categorised as not Persistent (not P), not Bioaccumulative (not B) and not Inherently Toxic to the Environment (not iT_E) (Environment Canada, 2013).

European Union

The chemical is not listed on the Candidate List for Eventual Inclusion in Annex XIV or Annex XIV (authorisation) of the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) legislation (ECHA, 2013; 2014a). However, the chemical is listed on Annex XVII (restriction) of the REACH legislation (ECHA, 2014b). The restrictions are that vinyl chloride "Shall not be used as propellant in aerosols for any use" and "Aerosols dispensers containing the substance as propellant shall not be placed on the market".

United States of America

In the USA, vinyl chloride emissions are subject to annual reporting under the Toxics Release Inventory (TRI). Facilities must report emissions of vinyl chloride to the United States Environmental Protection Agency (US EPA) if the facility employs 10 or more full time employees and manufactures or processes more than 25 000 pounds of the chemical (approximately 11 tonnes), or otherwise uses more than 10 000 pounds (approximately 4.5 tonnes) of the chemical in a reporting year (US EPA, 2012a; 2014a; 2014b).

Environmental Exposure

The only known industrial use for vinyl chloride in Australia is as a monomer feedstock for the industrial scale manufacture of PVC resin. Based on extensive international analysis of the manufacturing process for PVC, it is known that the majority of vinyl chloride emitted during manufacturing of PVC involves emissions of the highly volatile gas to the atmosphere (ATSDR, 2006; WHO, 2004). In modern production facilities, manufacture of PVC resin is carried out in closed systems where emissions of vinyl chloride are typically highly controlled to minimise risks to workers from occupational exposure to this chemical (OECD, 2001; Vinyl Council Australia, 2014; WHO, 2004). The current emissions target in Australia is 30 grams of vinyl chloride emitted per tonne of PVC produced (Vinyl Council Australia, 2012).

The majority of Australian vinyl chloride emissions reported in the NPI for 2012–13 are to air and from diffuse sources beyond the scope of this assessment. With respect to emissions from specific industrial facilities, the NPI reports that 3200 kg of vinyl chloride was emitted to the air in 2012–13 by the PVC manufacturing plant in Laverton, Victoria. Three other facilities reported vinyl chloride emissions to air totalling 640 kg due to "polymer product manufacture", but these emissions are understood to result from the manufacture of articles made from PVC resin or other polymers rather than the manufacture of vinyl chloride polymers (Australian Government Department of the Environment, 2014).

The facility emission data collated under the NPI provide an indication of major localised emission sources of vinyl chloride arising from specific industrial uses and processes. Diffuse emissions of the chemical can also occur from landfills, as a result of biodegradation of chlorinated solvents, and through release of residual vinyl chloride monomer from PVC articles (Australian Government Department of the Environment, 2014). The risks arising from these diffuse emissions of vinyl chloride have not been considered as part of this assessment.

Environmental Fate

Partitioning

Vinyl chloride is expected to mainly partition to the atmosphere as a result of industrial use.

Vinyl chloride is a neutral organic chemical which is readily soluble in water and highly volatile. The measured Henry's Law constant for the chemical (2820 Pa-m^3/mole at 24°C) indicates that it is highly volatile from water and moist soil (ATSDR, 2006; LMC, 2013). A measured organic carbon normalised adsorption coefficient (K_{OC} = 56) for the chemical indicates that it is highly mobile in soil and that it has some potential to leach through soils (OECD, 2001). However, evaporative losses are expected to dominate the partitioning behaviour of the chemical in soil.

Calculations with a standard multimedia partitioning (fugacity) model assuming equal and continuous emission of the chemical to the air, water and soil compartments (Level III approach) predict that the majority of the chemical will partition to water (66.6%) and air (29.9%) with minor amounts partitioning to soil (3.29%) and sediment (0.183 %) (US EPA, 2008). Assuming 100% release of vinyl chloride into air, the fugacity model predicts that 99.9% of the chemical will remain in the atmosphere. The latter release scenario is considered more likely for industrial uses of this chemical in Australia.

Degradation

Vinyl chloride is expected to be rapidly degraded in the atmosphere by indirect photo-oxidation.

Vinyl chloride is not expected to degrade by direct photolysis in the atmosphere since it does not absorb wavelengths above 220 nm (WHO, 2004). Rather, indirect photo-oxidation of gaseous vinyl chloride by hydroxyl radicals is predicted to be the primary degradation mechanism for this chemical in the atmosphere (ATSDR, 2006; WHO, 2004). The measured rate constant for this reaction corresponds to an estimated atmospheric half-life of 1.54 days assuming a hydroxyl radical concentration of 1.5×10^6 molecules/cm^3 and 12 hours of sunlight per day (OECD, 2001; US EPA, 2008).

The half-life for hydrolysis of vinyl chloride has been extrapolated to be on the order of years based on measured data (OECD, 2001). Degradation of vinyl chloride by hydrolysis will therefore be insignificant compared with volatilisation of the chemical from water.

According to the 2006 Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profile for vinyl chloride, no change was observed in the biochemical oxygen demand in raw sewage seed (used as a microbial inoculum) and raw sewage seed plus vinyl chloride at 20°C over a 25 day period. However, more recent data have been used to show that vinyl chloride can undergo microbial degradation under aerobic conditions with suitably adapted inocula. For example, using strains isolated from a trichloroethylene-degrading bacterial mixture, >99.9% of vinyl chloride degraded within 7 days. The majority (66–83%) of the labelled carbon was metabolised to carbon dioxide (ATSDR, 2006).

Slow aerobic and anaerobic biodegradation of vinyl chloride has been reported to occur in soils and aquifer materials (ATSDR, 2006).

Bioaccumulation

Vinyl chloride has a low potential to bioaccumulate in fish.

The measured bioconcentration factor (BCF) for vinyl chloride in fish is low (<10). Some higher values were measured for algae (40) and activated sludge (1100). According to the 2006 ATSDR review, the very low measured BCF value for fish, in comparison to the algae and activated sludge results, may suggest a detoxification process in more highly developed organisms such as fish (ATSDR, 2006).

Transport

The chemical is unlikely to undergo long range transport due to its comparatively short half-life in air.

Predicted Environmental Concentration (PEC)

A PEC was not calculated for vinyl chloride.

The majority of vinyl chloride released from industrial processes is expected to partition to the air compartment. Based on air-monitoring studies conducted in the USA and described in the 2006 ATSDR review, the concentration of vinyl chloride in air near vinyl chloride and PVC manufacturing facilities typically ranges from trace levels to 105 µg/m^3, but has exceeded 2600 µg/m^3. More recent monitoring data collected at the fence line of vinyl chloride production facilities show that levels around these sites are generally low and in the range 0.2–90 µg/m^3 (ATSDR, 2006).

Also as described in the 2006 ATSDR review, in the USA, elevated levels of vinyl chloride have been found in the vicinity of hazardous waste sites and municipal landfills. The measured concentrations of vinyl chloride were in a range from below detection limits to 5–8 µg/m^3 in the air above some landfills (ATSDR, 2006).

Vinyl chloride levels in urban air were measured in the EPA 1997 Urban Air Toxics Monitoring Program in the United States (ATSDR, 2006). In general, there were few detections of vinyl chloride in most of the cities sampled and positive detections were below 2.6 μg/m^3. In a Japan Ministry of the Environment study in 1997, very low levels of vinyl chloride were detected in air in the range 0.018–2 μg/m^3 (detection limit 0.015 μg/m^3) (OECD, 2001).

Environmental Effects

Effects on the Atmosphere

Vinyl chloride has a comparatively short half-life in the atmosphere. It is therefore not expected to be transported to the stratosphere where photo-oxidation and photolysis could be expected to release reactive chlorine atoms that destroy ozone.

Effects on Aquatic Life

Vinyl chloride has low acute and chronic toxicity to aquatic life based on the available measured and calculated toxicity values.

Acute toxicity

A median lethal concentration (LC50) value for fish was obtained from a database included in the OECD QSAR Toolbox (LMC, 2013). An LC50 value and a median effective concentration (EC50) value for aquatic invertebrates and algae, respectively, were calculated using ECOSAR (US EPA, 2012b):

Taxon	Endpoint	Method
Fish	96 h LC50 = 210 mg/L	Experimental *Brachydanio rerio* (Zebrafish) OECD TG 203
Invertebrates	48 h LC50 = 61.4 mg/L	Calculated *Daphnid* (Water flea) ECOSAR (Neutral Organics SAR)
Algae	96 h EC50 = 39.6 mg/L	Calculated Green algae ECOSAR (Neutral Organics SAR)

According to the OECD assessment of vinyl chloride, the acute aquatic toxicity of this chemical is more similar to simple alkanes than vinyl halides. Hence, the calculated acute toxicity values for invertebrates and algae were based on the ECOSAR Neutral Organics structure-activity relationship (SAR), rather than the Vinyl/Allyl Halide SAR which would normally be a more appropriate choice as vinyl chloride is categorised as a vinyl/allyl halide by ECOSAR (OECD, 2001). This approach is supported by the calculated acute toxicity to fish for vinyl chloride which is 111.9 mg/L based on the Neutral Organics SAR, but is calculated to be 26.7 mg/L based on the Vinyl/Allyl Halide SAR for fish. The Vinyl/Allyl Halide SAR appears to considerably overestimate acute toxicity to fish in this case.

Chronic toxicity

The following toxicity threshold value for a species of green algae was presented in the OECD SIAR for vinyl chloride (OECD, 2001):

Taxon	Endpoint	Method
Algae	Growth inhibition observed at 710 mg/L after 192 h	Experimental *Scenedesmus quadricauda* (Green algae) Growth inhibition

Effects on Terrestrial Life

Vinyl chloride has low acute toxicity through ingestion (in rats) and low acute toxicity through inhalation (in rats, mice, rabbits and guinea pigs). Long term exposure in experimental animals and humans causes liver cancer (angiosarcoma) (OECD, 2001).

Acute toxicity

The following dietary exposure median lethal dose (LD50) value and inhalation LC50 value for terrestrial model organisms were presented in the OECD SIAR for vinyl chloride (OECD, 2001):

Taxon	Endpoint	Method
Rodents	LD50 >4000 mg/kg bw	Experimental Rat (SPF-Wistar Strain*)* Oral
Rodents	2 h LC50 = 3.9×10^8 µg/m^3 (390 mg/L)	Experimental Rat (species not specified) Inhalation

Chronic toxicity

The following no observed adverse effect levels (NOAELs) values for both long-term inhalation and repeated oral-dose toxicity tests in terrestrial organisms were presented in the OECD SIAR for vinyl chloride (OECD, 2001):

Taxon	Endpoint	Method
Mammals	6 month NOAEL = 128 × 10^3 μg/m^3 (0.128 mg/L)	Experimental Rats, rabbits, guinea pigs and dogs Inhalation
Rodents	Lifetime NOAEL = 0.13 mg/kg/day	Experimental Rat (Wistar Strain) Oral repeated dose

According to the OECD SIAR for vinyl chloride, this chemical is rapidly and well absorbed following inhalation or oral exposure, and is bio-activated by the liver (OECD, 2001).

The International Agency for Research on Cancer has classified the chemical as 'carcinogenic to humans (Group 1)', based on sufficient evidence in both humans and animals that it causes cancer (WHO, 2008).

Predicted No-Effect Concentration (PNEC)

A PNEC was not calculated for vinyl chloride.

Vinyl chloride is expected to be primarily released or partition to the air compartment as a result of current industrial use in Australia. A PNEC for the air compartment has not been calculated because there is currently no recognised method for establishing quantitative toxicity thresholds for inhalation exposure of non-human terrestrial organisms (ECB, 2003).

The PNEC for the chemical in the water, soil and sediment compartments was not calculated as vinyl chloride is not expected to be released to, or significantly partition to, these compartments as a result of current industrial uses.

Categorisation of Environmental Hazard

The categorisation of the environmental hazards of ethene, chloro- according to domestic environmental hazard thresholds is presented below (EPHC, 2009; NICNAS, 2013):

Persistence

Not Persistent (Not P). Based on the estimated atmospheric half-life of 1.54 days, the chemical is categorised as Not Persistent.

Bioaccumulation

Not Bioaccumulative (Not B). Based on the available measured BCF value for fish of <10 and its high volatility from water, the chemical is categorised as Not Bioaccumulative.

Toxicity

Not Toxic (Not T). Based on the available measured and calculated aquatic ecotoxicity values, which are all significantly greater than 1 mg/L, the chemical is categorised as Not Toxic.

Summary

Ethene, chloro- is categorised as:

- Not P
- Not B
- Not T

The chemical has been categorised as Not Toxic based on aquatic hazard data according to the current domestic environmental hazard categorisation procedures. However, vinyl chloride is nevertheless considered to be potentially toxic to terrestrial animals based on clear evidence of specific chronic toxic effects following long term exposure to this chemical.

Risk Characterisation

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

Vinyl chloride is released to the atmosphere from the manufacture of PVC resin in an industrial facility in Australia. However, vinyl chloride is generally not expected to be present in air at concentrations above 100 µg/m^3 beyond the boundaries of closed-system PVC manufacturing facilities based on international air-monitoring studies. This air concentration is more than three orders of magnitude lower than the concentrations of vinyl chloride observed to result in chronic toxicity in experimental animals following prolonged inhalation exposure to the chemical. Furthermore, since vinyl chloride undergoes relatively rapid photo-oxidation in air it does not accumulate in the atmosphere and background environmental concentrations are generally low. Based on this analysis, emissions of vinyl chloride from current industrial uses in Australia are not expected to pose a significant risk to the terrestrial environment.

The risks to the aquatic environment are expected to be low as the chemical is not expected to be exposed to aquatic ecosystems as a result of current industrial uses.

Based on the available data, current industrial uses of vinyl chloride in closed-system industrial manufacturing processes are not expected to pose an unreasonable risk to the environment.

Key Findings

Vinyl chloride is used in Australia for the industrial-scale production of large quantities of PVC resin. A quantity of the chemical is released to the air compartment as a result of its use as a monomer feedstock in this process. However, a closed-system manufacturing process is used and these facilities are equipped with emission control systems to minimise the release of the chemical to the atmosphere. Based on international air-monitoring data, emissions of vinyl chloride from closed-system PVC manufacturing facilities are expected to be below the levels that would pose a concern for the environment.

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

Recommendations

Vinyl chloride is not expected to pose a concern to the environment when used as a monomer feedstock in closed-system polymer manufacturing facilities in Australia. 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 ethene, chloro- 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
Acute Aquatic	Category 3 (H402)	Harmful to aquatic life

The chemical has been classified as Acute Aquatic Category 3 (Harmful to aquatic life) based on the calculated acute toxicity values for vinyl chloride to aquatic invertebrates and algae, which are both in the harmful range of 10–100 mg/L. The use of calculated toxicity values for classification purposes is considered appropriate in this case because the SARs for both of these trophic levels are based on a non-polar narcosis (baseline) mode of action and there is evidence that this is the main mode of action for the acute toxic effects of vinyl chloride in aquatic organisms.

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

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