

Direct precursors to perfluorocyclohexane sulfonate and related perfluoroalkylcyclohexane sulfonates: Environment tier II assessment

01 September 2015

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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

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Acronyms & Abbreviations

Grouping Rationale

This Tier II assessment considers the environmental risks associated with the industrial uses of potassium salts of four perfluorinated cycloalkyl sulfonic acids:

Cyclohexanesulfonic acid, undecafluoro-, potassium salt (potassium perfluorocyclohexane sulfonate)
Cyclohexanesulfonic acid, decafluoro(trifluoromethyl)-, potassium salt (potassium perfluoromethylcyclohexane sulfonate)
Cyclohexanesulfonic acid, nonafluorobis(trifluoromethyl)-, potassium salt (potassium perfluorodimethylcyclohexane sulfonate)
Cyclohexanesulfonic acid, decafluoro(pentafluoroethyl)-, potassium salt (potassium perfluoroethylcyclohexane sulfonate)

The organic anions of all four salts contain a perfluorocyclohexane ring with an attached sulfonate group. The four salts differ principally in the number and type of perfluoroalkyl substituents attached to the perfluorocyclohexane ring. All four substances are expected to dissociate in water to release potassium cations and the perfluorocyclohexane sulfonate anion or one of three similar perfluoroalkylcyclohexane sulfonate anions.

The parent acids of the salts considered in this assessment are all members of a larger group of industrially important perfluorinated alkane sulfonic acids. This group includes perfluoroalkylsulfonic acids with six or more perfluorinated carbons in a chain which are known to be of high environmental concern. An important member of this group of high concern chain compounds is the C₈ acid, perfluorooctanesulfonic acid, which dissociates into the perfluorooctanesulfonate anion (PFOS) in the environment.

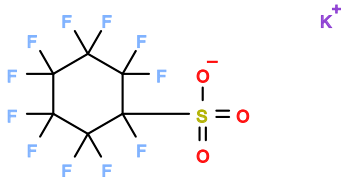
Perfluorooctanesulfonic acid and certain PFOS-related substances are identified as Persistent Organic Pollutants (POPs) under Annex B of the *Stockholm Convention on Persistent Organic Pollutants* (the Stockholm Convention). These substances are also listed under Annex III of the *Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade* (the Rotterdam Convention). These listings on two global conventions on chemicals have led to significant and evolving international restrictions on industrial uses of PFOS-related substances. Further information on PFOS-related substances can be found in the IMAP Environment Tier II Assessment of the Direct Precursors to Perfluorooctanesulfonate (PFOS) group (NICNAS, 2015a).

The perfluorinated cyclohexylsulfonate anions released by the salts in this group have six, seven or eight perfluorinated carbon atoms in their structure. It is currently unclear what influence the cyclic arrangement of the perfluorinated carbon atoms in these species has on their environmental hazard characteristics relative to the comparable linear or branched perfluoroalkyl chain compounds, such as perfluorooctanesulfonic acid. This assessment will therefore evaluate the available environmental exposure and hazard data for perfluorinated cyclohexylsulfonates and consider whether it is currently possible to characterise the environmental risks for these substances.

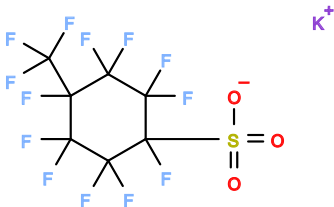
Chemical Identity

There are multiple potential isomers of the perfluoroalkylcyclohexane sulfonate anions in this group based on the relative positions of the sulfonate substituent and the perfluoroalkyl substituents on the cyclohexane ring. Representative two-dimensional chemical structures have been provided for the three different perfluoroalkylcyclohexane sulfonate anions in this group based on available information which indicates that the parent sulfonic acids are synthesised industrially by electrochemical fluorination of alkyl-substituted benzenesulfonyl chloride precursors. For example, according to the patent literature, the parent sulfonic acid of the potassium perfluoroethylcyclohexane sulfonate salt is derived from the electrochemical fluorination of para-ethylbenzenesulfonyl chloride (CAS RN 16712-69-9) (Danielson and Sargent, 1962).

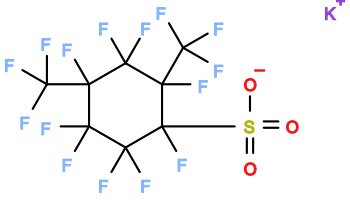
Although representative chemical structure information is provided for the isomers of perfluoroalkylcyclohexane sulfonate anions in this group it is noted that the isomer composition of each substance is not specified in its Chemical Abstracts Service chemical substance name. The relative quantities and structures of the perfluoroalkylcyclohexane sulfonate isomers that may be present in substances identified by these chemical names will depend on the details of the manufacturing process employed, including the chemical structure of the starting alkyl-substituted benzenesulfonyl chloride and any isomers of the main starting material that may be present.

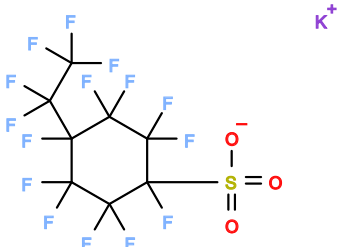
CAS RN	3107-18-4
Chemical Name	Cyclohexanesulfonic acid, undecafluoro-, potassium salt
Synonyms	potassium perfluorocyclohexane sulfonate PFCHS
Structural Formula	
Molecular Formula	C ₆ F ₁₁ KO ₃ S

Molecular Weight (g/mol)	400.21
SMILES	<chem>C1(F)(S(=O)(=O)[O-])C(F)(F)C(F)(F)C(F)(F)C(F)(F)C1(F)F.[K+]</chem>

CAS RN	68156-07-0
Chemical Name	Cyclohexanesulfonic acid, decafluoro(trifluoromethyl)-, potassium salt
Synonyms	potassium perfluoromethylcyclohexane sulfonate PFMeCHS
Representative Structural Formula	
Molecular Formula	$C_7F_{13}KO_3S$
Molecular Weight (g/mol)	450.22
SMILES	<chem>C1(F)(F)C(F)(S(=O)(=O)[O-])C(F)(F)C(F)(F)C(C(F)(F)(F))(F)C1(F)F.[K+]</chem>

CAS RN	68156-01-4
Chemical Name	Cyclohexanesulfonic acid, nonafluorobis(trifluoromethyl)-, potassium salt
Synonyms	potassium perfluorodimethylcyclohexane sulfonate

Representative Structural Formula	
Molecular Formula	C ₈ F ₁₅ KO ₃ S
Molecular Weight (g/mol)	500.22
SMILES	C1(F)(C(F)(F)F)C(F)(S(=O)(=O)[O-])C(F)(F)C(F)(F)C(F)(C(F)(F)(F))C1(F)(F).[K+]

CAS RN	67584-42-3
Chemical Name	Cyclohexanesulfonic acid, decafluoro(pentafluoroethyl)-, potassium salt
Synonyms	potassium perfluoroethylcyclohexane sulfonate PFECHS
Representative Structural Formula	
Molecular Formula	C ₈ F ₁₅ KO ₃ S
Molecular Weight (g/mol)	500.22

SMILES	<chem>C1(F)(F)C(F)(S(=O)(=O)[O-])C(F)(F)C(F)(F)C(C(F)(F)C(F)(F)(F))(F)C1(F)F.[K+]</chem>
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Physical and Chemical Properties

No physical or chemical property data were identified for any of the chemicals in this group. However, a safety data sheet available for a commercial mixture of all four salts indicates that these substances are free flowing solids under ambient conditions (3M Canada Company, 1997).

The parent acids for all substances in this group are perfluorinated alkane sulfonic acids that as a group are known to be very strong acids in water (NICNAS, 2015a). All four potassium salts in this group are therefore expected to undergo dissociation in water to release potassium cations and the respective perfluorocyclohexyl sulfonate mono-anions.

The comparable perfluoroalkylsulfonic acid compounds, such as potassium perfluorooctanesulfonate, are known to be moderately soluble in water at low ionic strength (NICNAS, 2015a). However, it is well established that the apparent water solubilities of perfluoroalkyl acids are influenced by their surface activity in water. It is not currently known to what extent perfluorocyclohexyl sulfonic acids and their salts have similar surface activity to perfluoroalkyl acids. Hence, the reported water solubility values for comparable linear or branched chain compounds are not considered suitable as a guide to the water solubilities of the salts in this group.

General trends in the known partitioning behaviour of comparable perfluoroalkylsulfonic acid compounds are not considered to be suitable as a guide to the partitioning behaviour of perfluorocyclohexyl sulfonic acids (and their salts) in the absence of specific information about the surface activity of the latter group of acids.

Import, Manufacture and Use

Australia

No specific Australian use, import, or manufacturing information has been identified. However, general information on the use of perfluoroalkyl sulfonates has been reported. The most recent data collected by NICNAS indicate that perfluoroalkyl sulfonates are predominantly used in Australia in mist suppressants for the metal plating industry and in fire fighting foams. Approximately 60 tonnes of fire fighting foams containing perfluoroalkyl sulfonates at concentrations up to 5% were held in Australia in 2007. Other uses included carpet treatments, curatives, industrial coatings and printing inks (NICNAS, 2013a).

The chemicals in this group are not manufactured in Australia (NICNAS, 2013a). In 2004, it was reported that 1.6 tonnes of perfluoroalkyl sulfonates and related chemicals were imported into Australia. By 2007, the imported quantity of these chemicals had increased to 13.6 tonnes. It was reported that the majority of these imports were of chemicals based on the C₄ perfluoroalkylsulfonic acid, perfluorobutanesulfonic acid (CAS RN 375-73-5).

International

The chemicals in this group have been used as erosion inhibitors in specialised phosphate ester hydraulic fluids used in the aviation industry. They were commercially available from the 3M Company as a mixture under the tradename FC-98 (3M Canada Company, 1997; De Silva, et al., 2011; UNEP, 2011). According to more recent information, the main chemical component of FC-98 (potassium perfluoroethylcyclohexane sulfonate) has been phased out of production by 3M (UNEP, 2011).

According to the patent literature, the perfluorocyclohexyl sulfonate salts in this group have other potential industrial uses including as components in printer inks (Wei-Ping, 2002).

Environmental Regulatory Status

Australia

The use of the chemicals in this group is not subject to any specific national environmental regulations.

United Nations

The chemicals in this group are not currently identified as Persistent Organic Pollutants (UNEP, 2001), ozone depleting substances (UNEP, 1987), or hazardous substances for the purpose of international trade (UNEP & FAO, 1998).

OECD

The chemicals in this group have not been sponsored for assessment under the Cooperative Chemicals Assessment Programme (CoCAP) (OECD, 2013).

The OECD has been leading an international collaboration on the scientific assessment of, and surveys of, perfluorinated chemicals. Since July 2000, Australia has been actively involved in this work through NICNAS.

Canada

During the Categorization of the Canadian Domestic Substances List (DSL), all four chemicals in this group were found to be Persistent (P), not Bioaccumulative (Not B) and Not Toxic (Not T) (Environment Canada, 2013). These chemicals were not prioritised for further assessment.

European Union

The chemicals in this group have been pre-registered, but have not yet undergone the full registration process, under the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) legislation (ECHA, 2014a, 2015). Under the phase-in arrangements of the REACH legislation, full registration was required for chemicals used at volumes greater than 100 tonnes per annum in 2013 (ECHA, 2014b).

United States of America

Use of the chemicals in this group is subject to a Significant New Use Rule. Under the Rule, approval must be sought from the United States Environmental Protection Agency (US EPA) for specified new uses of these chemicals (US EPA, 2007, 2013).

Environmental Exposure

Based on the available information, the main industrial use for the chemicals in this group has been in aircraft hydraulic fluids. It has been assumed that this use pattern would not involve significant emissions of perfluorocyclohexyl sulfonates to the environment. However, recent monitoring studies conducted internationally have identified perfluoromethyl- and perfluoroethylcyclohexane sulfonates in the environment (De Silva, et al., 2011; Houde, et al., 2013; Lescord, et al., 2015; Letcher, et al., 2015). It is uncertain if these measured environmental concentrations are indicative of ongoing release of perfluorinated cyclohexylsulfonates used in aircraft hydraulic fluids, or whether they may also represent emissions from other industrial uses (current or historical) and/or the degradation of unidentified precursors to perfluorinated cyclohexylsulfonates.

No domestic environmental monitoring data were identified for the chemicals in this group. Based on the globally integrated nature of the aviation industry, it is assumed that the substances in this group will be present in the hydraulic fluids of aircraft operating in Australia. Hence, it is considered possible that perfluorocyclohexyl sulfonates are potentially being emitted into the domestic environment.

The potassium cation present as a counterion in these four salts is a ubiquitous, naturally occurring inorganic species that is essential for many biological functions. The environmental fate and effects of this cation are not further considered in this assessment.

Environmental Fate

Dissolution, Speciation and Partitioning

The partitioning behaviour of the perfluorocyclohexyl sulfonate anions released by the chemicals in this group is not well defined.

All four potassium salts in this group will dissociate in water to release potassium cations and the respective perfluorocyclohexyl sulfonate mono-anions. The comparable perfluoroalkylsulfonate species, such as PFOS, are expected to remain in water if released to this compartment, unless adsorbed to particulate matter or assimilated by organisms (NICNAS, 2015a). It is unclear if the same trends in partitioning behaviour will apply to perfluorocyclohexyl sulfonate anions because of uncertainties regarding the surface activity of perfluoroalkylsulfonic acids. However, some of the anions from substances in this group, notably the perfluoroethylcyclohexane sulfonate anion, have been detected in environmental waters from multiple sites (De Silva, et al., 2011; Lescord, et al., 2015; Letcher, et al., 2015). Some partitioning of these anions into the aquatic compartment is therefore possible.

Degradation

The perfluorocyclohexyl sulfonate anions released by the chemicals in this group are assumed to be persistent in the environment.

No studies on the degradation of these substances in the environment have been identified. However, the perfluorocyclohexyl sulfonate anions are fully fluorinated organic species that are expected to be recalcitrant towards typical abiotic and biological degradation processes in the environment, based on the exceptional environmental persistence of perfluoroalkyl sulfonates, such as perfluorobutanesulfonate and perfluorooctanesulfonate (NICNAS, 2015a, b). The perfluoroalkyl sulfonates are considered suitable analogues in this case because the general recalcitrance of perfluorinated substances in the environment is due to the high thermal stability and chemical inertness of the carbon-fluorine bond, which inhibits the typical environmental degradation pathways for organic substances.

Bioaccumulation

The bioaccumulation potential of perfluorocyclohexyl sulfonate anions is uncertain.

Perfluorinated organic species have been observed to bioaccumulate by binding to proteins in plasma and liver, rather than the more conventional partitioning to fatty tissue (Ng and Hungerbühler, 2014). For example, PFOS has been found to be highly bioaccumulative when taking into account accumulation in protein-rich tissues, but also based on high biomagnification factors measured in wildlife (NICNAS, 2015a). The C₆ homologue, perfluorohexanesulfonate (PFHxS), is also bioaccumulative and has been found to biomagnify in various prey-predator relationships in the Barents Sea, for example (NICNAS, 2015c).

A bioaccumulation factor (BAF) for perfluoroethylcyclohexane sulfonate in fish was determined as part of a recent study of the occurrence and distribution of perfluorocyclohexyl sulfonates in the Great Lakes of North America (De Silva, et al., 2011). According to this study, the mean BAF for perfluoroethylcyclohexane sulfonate is 630 L/kg, based on the ratio of mean measured concentrations of the anion in fish tissue (whole body homogenate, wet weight) to concentrations measured in lake water. The mean measured BAF for PFOS in the same study was 31 622 L/kg.

The BAF value for perfluoroethylcyclohexane sulfonate is below the domestic categorisation criterion for bioaccumulation (BAF ≥ 2000 L/kg), which nominally indicates that this species is not highly bioaccumulative. However, as the authors of this study noted, biomagnification and trophic magnification are typically more conclusive indicators of bioaccumulation. For example, in the case of the C₆ perfluoroalkyl sulfonate, PFHxS, measured whole-body BAFs in fish are in the range 157 to 1784 L/kg for various species of fish, whereas biomagnification factors (BMF) for prey-predator relationships are in the range 6 to 8.5, which indicates that the perfluorohexanesulfonate anion biomagnifies (NICNAS, 2015c).

No studies of the biomagnification or trophic magnification of perfluorocyclohexyl sulfonates were identified during this assessment. Based on the measured BAF value available for perfluoroethylcyclohexane sulfonate and taking into account the highly bioaccumulative nature of comparable perfluoroalkyl sulfonates, it is concluded that the perfluorocyclohexyl sulfonate anions in this group have some potential to bioaccumulate, although the magnitude of the bioaccumulation hazard is currently uncertain.

Transport

The long-range transport potential of perfluorocyclohexyl sulfonate anions is uncertain.

Numerous studies have identified various perfluoroalkyl sulfonates in locations worldwide. For example, the PFOS anion has been measured in marine mammals in remote regions far from anthropogenic emission sources, including Alaska, the Northern Baltic Sea, Arctic and Sable Islands. The global distribution of perfluoroalkyl sulfonates as environmental contaminants has been difficult to rationalise in terms of conventional long range transport pathways. It has been hypothesised that such distribution may occur through transport in surface water or oceanic currents, transport of volatile precursors, adsorption to particles and/or through living organisms (UNEP, 2006).

The first measurement of a perfluorocyclohexyl sulfonate anion in the high Arctic was recently reported by Lescord et al. (2015). This study identified the perfluoroethylcyclohexane sulfonate anion in water, sediment and benthic invertebrates from two lakes in the vicinity of a small community in the Canadian Arctic. According to the study authors, use of aircraft hydraulic fluids at a nearby small airport provides a feasible point source for emissions of perfluoroethylcyclohexane sulfonate into these two lakes. Nevertheless, this anion was also detected in whole fish taken from lakes that are not subject to potential direct contamination from the local airport.

Based on the recent monitoring results from the Arctic, it is unclear if long range transport of perfluorocyclohexyl sulfonates has been demonstrated. However, the likely exceptional environmental persistence of these anions, their chemical similarity to better studied perfluorinated sulfonates, and their detection in surface waters at lower latitudes does suggest a potential for long range transport by similar mechanisms to those that have resulted in the global distribution of perfluoroalkyl sulfonates in the environment.

Predicted Environmental Concentration (PEC)

There is currently insufficient information on use volumes and emission pathways in Australia to reliably estimate the environmental concentrations of the chemicals in this group. Recent international monitoring data for perfluorocyclohexyl sulfonates present in surface waters near large urban centres in North America have therefore been used to indicate possible environmental concentrations in Australia.

A recent environmental monitoring study in the Great Lakes of North America identified both perfluoroethylcyclohexane sulfonate and perfluoromethylcyclohexane sulfonate in surface waters at multiple sites (De Silva, et al., 2011). The measured concentration of perfluoroethylcyclohexane sulfonate was consistently 13.6 times the concentration of perfluoromethylcyclohexane sulfonate, except in Lake Superior where the concentration of the latter species was less than the method detection limit. The strong correlation between the measured concentrations of these two perfluorocyclohexyl sulfonates was attributed to the presence of perfluoromethylcyclohexane sulfonate as an impurity in the perfluoroethylcyclohexane sulfonate salt used in industrial formulations.

The highest concentrations of the perfluoroethylcyclohexane sulfonate anion were measured in Lake Michigan, where the average concentration was 5.65 nanograms per litre (ng/L). The concentrations of this species were higher than the sum of PFOS isomers (2 ng/L) in this lake. Overall, the concentrations of perfluoroethylcyclohexane sulfonate were not correlated with

the concentration of PFOS or perfluorooctanoic acid (PFOA) measured in the Great Lakes. The authors were not able to definitively identify the sources of perfluorocyclohexyl sulfonate emissions into the Great Lakes as part of this study.

Environmental Effects

The potential acute and long-term toxicity of the chemicals in this group is uncertain.

No measured aquatic toxicity data were identified for the chemicals in this group. In addition, only limited mammalian toxicity data are available. One exploratory 28 day oral toxicity study with rats using a mixture of all four substances in this group as the test substance revealed primary morphological changes in the liver of the test animals that were not completely reversed in all animals at the end of the recovery period (US EPA, 2003).

The aquatic toxicity data available for comparable perfluoroalkylsulfonic acids indicate that the primary toxicity concern for these substances is chronic, intergenerational toxicity. Fish toxicity data available for PFOS indicate potential for increased mortality in offspring when the parent generation is exposed to concentrations as low as 0.01 milligrams per litre (mg/L) (NICNAS, 2015a). The toxicity of perfluoroalkyl sulfonates decreases with chain length (Hagenaars, et al., 2011; Ulhaq, et al., 2013). Consistent with this trend, data currently available for the C₄ homologue, perfluorobutanesulfonate, do not indicate a potential for high chronic toxicity (NICNAS, 2015b).

There are insufficient toxicity data available to evaluate whether the toxicity of perfluorinated cycloalkyl sulfonic acids can be considered similar to comparable long-chain perfluoroalkylsulfonic acids. However, the expected high environmental persistence and possible bioaccumulation of perfluoroethylcyclohexane sulfonate in fish does increase the potential for chronic toxic effects. The potential of the chemicals in this group to have high chronic toxicity is therefore currently assessed as uncertain.

Categorisation of Environmental Hazard

The categorisation of the environmental hazards of cyclohexanesulfonic acid, decafluoro-, potassium salt; cyclohexanesulfonic acid, decafluoro(trifluoromethyl)-, potassium salt; cyclohexanesulfonic acid, nonafluorobis(trifluoromethyl)-, potassium salt; and cyclohexanesulfonic acid, decafluoro(pentafluoroethyl)-, potassium salt according to domestic environmental hazard thresholds is presented below (EPHC, 2009; NICNAS, 2013b).

Persistence

Persistent (P). Based on the non-degradability of comparable perfluoroalkyl sulfonates such as PFOS, all chemicals in this group are categorised as Persistent.

Bioaccumulation

Uncertain (Uncertain B). There is currently insufficient information to conclude whether the perfluorocyclohexyl sulfonate anions in this group biomagnify in food webs. The bioaccumulation potential of the chemicals in this group is therefore categorised as Uncertain.

Toxicity

Uncertain (Uncertain T). There is currently insufficient information to conclude whether the chemicals in this group have intergenerational toxic effects similar to long-chain perfluoroalkyl sulfonates. The toxicity of these chemicals is therefore categorised as Uncertain.

Summary

Cyclohexanesulfonic acid, undecafluoro-, potassium salt; cyclohexanesulfonic acid, decafluoro(trifluoromethyl)-, potassium salt; cyclohexanesulfonic acid, nonafluorobis(trifluoromethyl)-, potassium salt; and cyclohexanesulfonic acid, decafluoro(pentafluoroethyl)-, potassium salt are categorised as:

- P
- Uncertain B
- Uncertain T

Risk Characterisation

The chemicals in this group have been identified as persistent and potentially bioaccumulative. Chemicals which are persistent and bioaccumulative remain in the environment and accumulate in biota over an extended period of time, even if new emissions of the chemicals cease. These characteristics can result in very high internal concentrations in exposed organisms, which may cause long-term toxic effects that are not readily identified through standard testing protocols. Chemicals with these hazard characteristics are therefore considered to be of concern for the environment.

Key Findings

The chemicals in this group have been categorised as persistent (P) according to domestic environmental hazard criteria. The bioaccumulation potential and toxicity of the chemicals in this group are categorised as Uncertain. These findings do not indicate a lack of potential hazard for some chemicals in this group, but rather a lack of suitable data available at the time of this assessment to characterise these potential hazards for each individual chemical.

Recent international environmental monitoring studies have identified at least two of the perfluorocyclohexyl sulfonate anions from this group in surface waters near major urban centres in North America. At some monitoring sites, the concentration of perfluorocyclohexyl sulfonate anions exceeded the concentration of the long-chain perfluoroalkyl sulfonate anion, PFOS, which is known to be of high environmental concern. The major sources of emission of these species into the environment have not been identified. However, these recent results may indicate that emission of perfluorocyclohexyl sulfonates from their principal known industrial use as components in aircraft hydraulic fluids is greater than previously assumed.

The absence of domestic use and exposure data or environmental monitoring data for the substances in this group precludes a more complete assessment of the environmental risks posed by their industrial uses in Australia. The potential consequences of ongoing emissions of these chemicals also cannot be fully evaluated as there are critical gaps in the available environmental hazard data such as the biomagnification potential of these substances in food webs and their potential to cause intergenerational toxic effects.

This group of chemicals may need to be prioritised for a Tier III risk assessment under the IMAP framework if evidence emerges to indicate that these substances are present at significant levels in the domestic environment, or there is evidence that perfluorocyclohexyl sulfonates biomagnify in food webs and/or have intergenerational toxic effects.

Recommendations

It is recommended that direct precursors to perfluorocyclohexane sulfonate and related perfluoroalkylcyclohexane sulfonates be considered for assessment of environmental concerns at Tier III level under the IMAP framework if significant new domestic exposure information or hazard data become available.

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 cyclohexanesulfonic acid, undecafluoro-, potassium salt; cyclohexanesulfonic acid, decafluoro(trifluoromethyl)-, potassium salt; cyclohexanesulfonic acid, nonafluorobis(trifluoromethyl)-, potassium salt; and cyclohexanesulfonic acid, decafluoro(pentafluoroethyl)-, potassium salt 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
Chronic Aquatic	Category 4 (H413)	May cause long lasting harmful effects to aquatic life

There are insufficient reliable data to classify the acute aquatic hazards of the chemicals in this group. The chemicals in this group were classified as Chronic Category 4 ("safety net" classification), as the available evidence indicates they are highly persistent and there are significant concerns that they may be bioaccumulative in aquatic ecosystems (UNECE, 2007).

Should additional data become available to suggest an alternate hazard classification is warranted for any of the chemicals in this group, these classifications may be revised as appropriate.

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