Direct precursors to perfluorononanesulfonate (PFNS) and perfluorodecanesulfonate (PFDS): Environment tier II assessment

03 July 2015

CAS Registry Numbers: 17202-41-4, 67906-42-7, 68391-09-3.

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

Grouping Rationale

This Tier II assessment considers the environmental risks associated with the industrial uses of salts of two discrete long-chain perfluoroalkyl sulfonic acids and the salts of a mixture of long-chain perfluoroalkyl sulfonic acids:

1-Nonanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,9-nonadecafluoro-, ammonium salt (ammonium PFNS)
1-Decanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heneicosafluoro-, ammonium salt (ammonium PFDS)
Sulfonic acids, C6-12-alkane, perfluoro-, potassium salts

The two discrete chemicals in this group are simple ammonium salts of long-chain perfluoroalkyl sulfonic acids containing a chain of nine or ten perfluorinated carbons. The third member of this group is a mixture of simple potassium salts of perfluoroalkyl sulfonic acids with chains of six to twelve perfluorinated carbons. These chemicals have been assessed in a group because they are all expected to dissociate into long-chain perfluoroalkyl sulfonate anions in the aquatic environment.

The parent acids of the salts in this group are all homologues of perfluorooctanesulfonic acid which contains a chain of eight perfluorinated carbons. This long-chain perfluoroalkyl sulfonic acid is one of a group of closely related chemicals, including simple salts of the acid, which are all direct precursors to the hazardous perfluorooctanesulfonate anion (PFOS). Perfluorooctanesulfonic acid, its salts and perfluorooctane sulfonyl fluoride have recently been 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 on 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 perfluoroalkyl sulfonates containing eight perfluorinated carbons. Further information on PFOS can be found in the Environment Tier II Assessment of the Direct Precursors to Perfluorooctanesulfonate (PFOS) group (see NICNAS, 2015f).

Under the NICNAS action plan for assessing and managing chemicals that could degrade to perfluorinated carboxylic acids, perfluoroalkyl sulfonates and similar chemicals, hazard information for PFOS is used to estimate the hazard of perfluoroalkyl sulfonate degradation products (with four or more perfluorinated carbons), unless sufficient toxicological data are available to demonstrate a lower toxicity profile. More information on the plan can be found in Appendix G of the NICNAS Handbook for Notifiers on the NICNAS website (NICNAS, 2015e).

This assessment will evaluate:

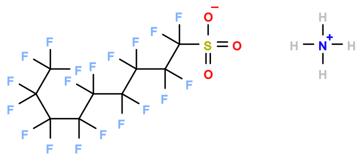
a) the properties of the chemicals in this group and compare them with PFOS; and

b) whether there are sufficient data to use in place of the default assumptions in the action plan.

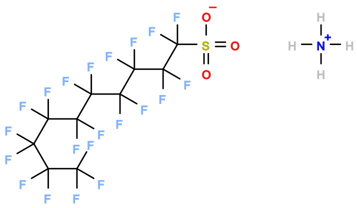
The assessment of these chemicals as a group also provides additional relevant information for the risk assessment of more complex long-chain perfluoroalkyl sulfonates which may degrade to release the corresponding long-chain perfluoroalkyl sulfonate anions in the environment.

Chemical Identity

In this assessment, “PFHxS” is used to denote the conjugate base anion of perfluorohexanesulfonic acid (i.e. the perfluorohexanesulfonate anion), “PFOS” is used to denote the conjugate base anion of perfluorooctanesulfonic acid (i.e. the perfluorooctanesulfonate anion), “PFNS” is used to denote the conjugate base anion of perfluorononanesulfonic acid (i.e. the perfluorononanesulfonate anion), and “PFDS” is used to denote the conjugate base anion of perfluorodecanesulfonic acid (i.e. the perfluorodecanesulfonate anion) (Buck, et al., 2011).

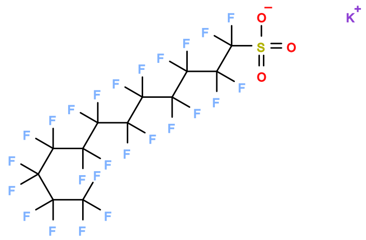
CAS RN	17202-41-4
Chemical Name	1-Nonanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,9-nonadecafluoro-, ammonium salt
Synonyms	ammonium PFNS ammonium perfluorononanesulfonate ammonium nonadecafluorononanesulfonate
Structural Formula	
Molecular Formula	$C_9H_4F_{19}NO_3S$
Molecular Weight	567.17

(g/mol)	
SMILES	C(F)(F)(C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)F)S(=O)(=O)[O-].[NH4+]

CAS RN	67906-42-7
Chemical Name	1-Decanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heneicosafluoro-, ammonium salt
Synonyms	ammonium PFDS ammonium perfluorodecanesulfonate ammonium heneicosafluorodecanesulfonate
Structural Formula	
Molecular Formula	$C_{10}H_4F_{21}NO_3S$
Molecular Weight (g/mol)	617.18
SMILES	C(F)(F)(C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)F)S(=O)(=O)[O-].[NH4+]

The substance represented by CAS RN 68391-09-3 is in the category of unknown or variable composition, complex reaction products or biological materials (UVCBs). Representative chemical identity information is provided below for this substance. However, it should be noted that this UVCB is a mixture of potassium salts of homologous perfluoroalkyl sulfonic acids with chains of six to twelve perfluorinated carbons (including potassium PFOS).

CAS RN	68391-09-3

Chemical Name	Sulfonic acids, C6-12-alkane, perfluoro-, potassium salts
Synonyms	potassium perfluoroalkyl sulfonates (C6-12)
Representative Structural Formula	
Representative Molecular Formula	$C_{12}F_{25}KO_3S$
Representative Molecular Weight (g/mol)	738.25
Representative SMILES	C(F)(F)(C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)F)S(=O)(=O)[O-].[K+]

Physical and Chemical Properties

No measured physical and chemical property data were identified for the chemicals in this group. Therefore, measured data available for the potassium PFOS salt are provided as indicative values (NICNAS, 2015f). Based on these data, the chemicals in this group are expected to have moderate solubility in pure water and low volatility. However, it should be noted that the properties of the UVCB substance in this group (CAS RN 68391-09-3) may differ if it contains a significant proportion of perfluoroalkyl sulfonate salts with less than eight perfluorinated carbons:

Chemical	potassium PFOS
Physical Form	Solid
Melting Point	≥ 400°C (exp.)

Boiling Point	Not measurable
Vapour Pressure	3.31×10^{-4} Pa at 20°C (exp.)
Water Solubility	570 mg/L (exp.)

The parent acids of the chemicals in this group are expected to be strong acids in water. The acids and their salts are also expected to be surface active (NICNAS, 2015f). The octanol-water partition coefficient (K_{OW}) parameter is not considered to provide a reliable indicator of the partitioning behaviour of surface-active perfluorinated anions in the environment and does not form part of the standard set of chemical property data for these substances (OECD, 2002).

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).

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 C_4 homologue, perfluorobutanesulfonic acid. The chemicals in this group are not manufactured in Australia (NICNAS, 2013a).

It is noted that the chemicals in this group may be present in the environment due to historic use, release from pre-treated articles, or the use of other chemicals not in this group (which may degrade to these chemicals or contain these chemicals as contaminants). However, release from these uses is beyond the scope of this assessment.

International

The ammonium salts in this group have previously been reported to have use as surfactants in coating products, especially clear polishes (Flick, 1993). However, concerns regarding the persistence and bioaccumulation hazards of long-chain perfluoroalkyl sulfonates resulted in the largest manufacturer of these chemicals ceasing their production in 2002 (Buck, et al., 2011). This is assumed to have reduced global supply significantly. Nevertheless, use of both chemicals was reported in Sweden up until 2003, and in Denmark up until 2010 (Nordic Council of Ministers, 2015). Limited information suggests more recent uses may have been in photolithography (Wang and Xu, 2007).

Use of the UVCB substance in this group was reported in Denmark in 2013, with use also reported each year from 2000. In Sweden, the substance was reported to be in use between 1999 and 2007 (Nordic Council of Ministers, 2015). No further specific use data were identified.

Environmental Regulatory Status

Australia

In 2008, a factsheet published by NICNAS recommended that PFOS-based and related perfluoroalkyl sulfonate based chemicals be restricted to essential uses only, and that importers ensure that alternative chemicals are less toxic and not persistent in the environment (NICNAS, 2013a).

United Nations

The chemicals in this group are not currently identified as POPs (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, 2013a).

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

The two ammonium salts in this group are listed on the Canadian Domestic Substances List (DSL). During the Categorisation of the DSL, ammonium PFNS was found to be Persistent (P), Bioaccumulative (B) and Inherently Toxic to the Environment (iT_E). Ammonium PFDS was also found to be persistent, but it was not possible to categorise the bioaccumulation and inherent toxicity hazards of this chemical (Environment Canada, 2013a). A subsequent screening assessment found ammonium PFNS was not entering the environment in a manner which posed a danger to the environment (Environment Canada, 2015).

The remaining chemical in this group is not listed on the DSL (Environment Canada, 2013b).

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, 2014; 2015).

United States of America

New uses of the chemicals in this group in the United States of America are prohibited without prior approval from the United States Environmental Protection Agency (US EPA) (United States Government, 2002; 2007).

The US EPA published an action plan on long-chain perfluorinated chemicals, covering the chemicals in this group, in 2009. All chemicals were identified as persistent, bioaccumulative and toxic (US EPA, 2009).

Environmental Exposure

Based on the available domestic and international use information, the chemicals in this group have had some specialty applications as surfactants in industrial coatings and curatives. However, use of the chemicals in this group is expected to have been largely phased out due to international concerns regarding the persistence and bioaccumulation hazards of long-chain perfluoroalkyl sulfonates (Buck, et al., 2011). Therefore, direct release of the chemicals to the environment as a result of current industrial uses is considered unlikely, as these chemicals are not expected to have significant use in Australia.

The chemicals in this group are considered more likely to be released to the environment from the use and disposal of other perfluorinated chemicals. These substances may be present as impurities or degradation products, while components of the

UVCB in this group may have separate uses. (For example, simple salts of PFOS still have small-scale industrial uses in Australia, with the majority used in hexavalent chromium plating (NICNAS, 2015f).) However, these exposure routes are beyond the scope of this assessment. Further information on the environmental exposure resulting from the industrial use of salts of PFOS can be found in the IMAP Environment Tier II Assessment of the Direct Precursors to Perfluorooctanesulfonate (PFOS) (NICNAS, 2015f).

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

Environmental Fate

Dissolution, Speciation and Partitioning

The chemicals in this group will dissolve in water to release homologous long-chain perfluoroalkyl sulfonate anions. The anions may remain in the water compartment, or partition to soil or sediment, depending on the chain-length of each perfluorinated anion.

Perfluoroalkyl sulfonic acids are expected to be very strong acids in water and under environmental conditions these acids will exist predominantly as the conjugate base anion (NICNAS, 2015f). The salts of these strong acids will dissociate into their constituent ions in water. The partitioning behaviour of the acid and its salts in the aquatic compartment will be influenced by the surface activity of the respective perfluorinated anions.

Based on the comparatively high water solubility of PFOS salts, previous studies have concluded that the perfluorooctanesulfonate anion should be expected to remain in water if released to this compartment, unless adsorbed to particulate matter or assimilated by organisms (NICNAS, 2015f). The extent to which this assumed partitioning pattern is relevant to all chemicals in this group is unclear. Some environmental monitoring data for chemicals in this group with more than eight perfluorinated carbons (Myers, et al., 2012; Thompson, et al., 2011) suggest comparatively increased partitioning to soil and sediment compartments.

Degradation

The chemicals in this group are expected to be highly resistant to degradation.

Multiple studies conducted on a range of perfluorinated substances have found no evidence of potential for biodegradation, hydrolysis or aqueous photolysis under environmental conditions (NICNAS, 2015a; 2015f). Although no data are available for PFNS or PFDS, data available for PFOS indicate that the chemicals in this group will be highly persistent. The hydrolysis half life of PFOS has been estimated to be more than 41 years, and there is no indication of direct or indirect photolysis in water. Further, no biodegradation has been observed in ready biodegradability studies conducted according to OECD Test Guideline (TG) 301C (NICNAS, 2015f).

Bioaccumulation

The chemicals in this group are expected to be highly bioaccumulative.

Perfluorinated chemicals 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). Available data for PFHxS and PFOS demonstrate that both of these anions (which are possible components of the UVCB substance in this group) have high bioconcentration and biomagnification potential (NICNAS, 2015c; 2015f).

Bioaccumulation data for perfluoroalkyl sulfonates with more than eight perfluorinated carbons are far more limited. However, multiple studies have identified PFDS in tissues of various organisms (Ahrens, et al., 2009; Hart, et al., 2008; Kumar, et al., 2009; Loi, et al., 2011; Toschik, et al., 2005). Studies which also considered the contamination of the surrounding environment were unable to detect the chemical, which is consistent with efficient uptake and/or slow elimination of the anion (Kumar, et al., 2009; Loi, et al., 2011). Other work has suggested that the bioaccumulation potential of perfluoroalkyl acids increases with chain length up to a maximum bioaccumulation potential for acids with ten to thirteen perfluorinated carbons (Ng and Hungerbühler, 2014; OECD, 2013b).

Based on this analysis, PFOS is considered to be acceptable as an analogue to characterise the bioaccumulation potential of the perfluoroalkyl sulfonate anions released by chemicals in this group. Therefore, based on bioaccumulation data available for both PFHxS and PFOS (NICNAS, 2015c; 2015f), the chemicals in this group are also expected to be highly bioaccumulative.

Transport

The chemicals in this group may undergo long-range transport.

Numerous studies have identified various perfluoroalkyl sulfonates in remote locations worldwide. For example, PFHxS has been detected in Arctic polar bears and Antarctic fur seals, while PFOS has been found in Alaska, the Northern Baltic Sea, the Arctic and Antarctica (NICNAS, 2015c; 2015f). 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).

Data available for PFDS indicate that it may also be globally distributed, with this perfluorinated anion being detected in snow, lake water and seal liver samples collected from Antarctica (Cai, et al., 2012; Schiavone, et al., 2009). However, limited additional data are available. Further, some environmental monitoring data for these chemicals (Myers, et al., 2012; Thompson, et al., 2011) suggest increased partitioning to soil and sediment compartments, compared with PFOS. Therefore, the potential for perfluoroalkyl sulfonates with more than eight perfluorinated carbons to undergo transport in surface water or oceanic currents may be reduced. Nevertheless, based on monitoring data that are available, and their exceptional environmental persistence, the chemicals in this group are assessed as having some potential to undergo long-range transport.

Predicted Environmental Concentration (PEC)

The chemicals in this group are not expected to have significant current industrial use in Australia and PEC values have therefore not been calculated.

Nevertheless, the chemicals in this group may be present in the environment due to past industrial use of other perfluorochemicals contaminated with these substances, use in articles, or from the use of perfluorinated derivatives which degrade to these substances in the environment. In Australia, PFDS has been detected in sediment from the Parramatta River (main tributary of Sydney Harbour) at concentrations up to 0.2 nanograms per gram (ng/g). The chemical was not detected in any water samples (Thompson, et al., 2011). However, PFDS has been detected in drinking water samples obtained in China, India, Japan, the USA, and Canada. Concentrations in samples from the latter three countries were below five nanograms per litre (ng/L) (Mak, et al., 2009).

No Australian monitoring data were identified for PFNS, and only limited international data were identified. Nevertheless, in Spain the chemical has been detected in sewage treatment plant effluent at a mean concentration of 0.04 ng/L, and in sludge at a mean concentration of 2.15 ng/g dry weight (Campo, et al., 2014).

The comparatively shorter-chain perfluoroalkyl sulfonates present as components of the UVCB in this group (including PFHxS and PFOS) are routinely detected in environmental samples collected in Australia (NICNAS, 2015c; 2015f).

Environmental Effects

Effects on Aquatic Life

The chemicals in this group are expected to have long-term toxic effects in aquatic organisms.

Acute toxicity

The following measured median effective concentration (EC50), median lethal concentration (LC50) and median inhibitory concentration (IC50) values for model organisms across three trophic levels for (a) PFOS and (b) PFDS were reported in the IMAP Environment Tier II assessment for Direct Precursors to Perfluorooctanesulfonate (PFOS) (NICNAS, 2015f), or by Hekster et al. (2002):

Taxon	Endpoint	Method
Fish	(a) 96 h LC50 = 4.7 mg/L	Experimental *Pimephales promelas* (Fathead minnow) Static
	(b) 96 h LC50 = 4.8 mg/L	Experimental *Pimephales promelas* (Fathead minnow) OECD TG 203
Invertebrates	(a) 48 h EC50 = 27 mg/L	Experimental *Daphnia magna* (Water flea) OECD TG (1981); static
	(b) 48 h EC50 = 11 mg/L	Experimental *Daphnia magna* (Water flea) OECD TG 202
Algae	(a) 96 h IC50 = 48.2 mg/L	Experimental *Pseudokirchneriella subcapitata* (Green algae)

Chronic toxicity

The findings available for other perfluorinated 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, 2015f). Limited toxicity data are available for PFHxS (NICNAS, 2015c).

However, previous studies have indicated that the developmental toxicity of perfluoroalkyl sulfonates in fish increases with chain length (Hagenaars, et al., 2011; Ulhaq, et al., 2013). This is consistent with the high persistence and bioaccumulation potential of the longer-chain perfluoroalkyl sulfonates, which are hazard characteristics associated with chronic toxicity. The acute data presented in this assessment also indicate that PFDS is bioavailable to aquatic organisms, and is of comparable toxicity to PFOS in short-term exposures.

Based on these data, and the composition of the chemicals in this group, all are expected to be at least as toxic as simple salts of PFOS. Therefore, PFOS is considered to be an acceptable analogue for the chronic toxicity of these chemicals. Based on data available for analogous salts of PFOS (NICNAS, 2015f), the chemicals in this group are expected to cause chronic, intergenerational toxicity in aquatic organisms at low exposure concentrations.

Effects on Sediment-Dwelling Life

The chemicals in this group are expected to have high toxicity to sediment-dwelling life.

Data available for PFOS indicate that the chemical causes toxic effects in exposed midges, with a 10 d NOEC of 0.0491 mg/L available (NICNAS, 2015f). Similar toxic effects are expected for the perfluoroalkyl sulfonates with longer chains.

Effects on Terrestrial Life

The chemicals in this group are expected to have long-term effects in terrestrial organisms.

Multiple studies have considered the toxicity of PFOS to terrestrial organisms. More detail on these studies can be found in the IMAP Tier II Human Health Assessment of Perfluorooctanesulfonic Acid and its Salts (NICNAS, 2015b). The toxicity of longer-chain perfluoroalkyl sulfonates is expected to be no less than that of PFOS (NICNAS, 2015d).

Predicted No-Effect Concentration (PNEC)

Use of the chemicals in this group will result in the environmental release of long-chain perfluoroalkyl sulfonate anions, which are expected to be bioaccumulative and persistent. These two hazard characteristics combined have the potential to result in a range of long-term effects on organisms exposed to these chemicals which cannot be readily identified through standard ecotoxicity tests. For such chemicals, it is not currently possible to estimate a safe exposure concentration using standard extrapolation methods based on laboratory screening level tests. Predicted no-effects concentrations have therefore not been derived for the chemicals in this group.

Categorisation of Environmental Hazard

The categorisation of the environmental hazards of 1-nonanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,9-nonadecafluoro-, ammonium salt (ammonium PFNS); 1-decanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heneicosafluoro-, ammonium salt (ammonium PFDS); and sulfonic acids, C6-12-alkane, perfluoro-, potassium salts according to domestic environmental hazard thresholds is presented below (EPHC, 2009; NICNAS, 2013b):

Persistence

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

Bioaccumulation

Bioaccumulative (B). Based on the established trend of increased bioaccumulation potential of perfluorinated acids with increased chain length, and the bioconcentration and biomagnification factors available for PFHxS and PFOS, all chemicals in this group are categorised as Bioaccumulative.

Toxicity

Toxic (T). Based on the available chronic toxicity values available for salts of PFOS, and the trend of increased toxicity of perfluorinated acids with increased chain length, all chemicals in this group are categorised as Toxic.

Summary

1-Nonanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,9-nonadecafluoro-, ammonium salt (ammonium PFNS); 1-decanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heneicosafluoro-, ammonium salt (ammonium PFDS); and sulfonic acids, C6-12-alkane, perfluoro-, potassium salts are categorised as:

- P
- B
- T

Risk Characterisation

The chemicals in this group have been identified as PBT substances. It is not currently possible to derive a safe environmental exposure level for such chemicals and it is therefore not appropriate to characterise the environmental risks for these chemicals in terms of a risk quotient.

Due to their persistence, PBT chemicals have the potential to become widely dispersed environmental contaminants. Once in the environment, persistent chemicals that are also highly bioaccumulative pose an increased risk of accumulating in exposed organisms and of causing adverse effects. They may also biomagnify through the food chain resulting in very high internal concentrations, especially in top predators. Importantly, it is difficult or impossible to reverse the adverse effects of PBT chemicals once they have been released to the environment. As a result, these chemicals are considered to be of high concern for the environment.

In addition to being PBT chemicals, direct precursors to PFOS have also been identified as POPs. It is noted that potassium PFOS is a component of the UVCB substance in this group, and that simple salts of PFOS have also been identified as appropriate analogues for the chemicals in this group. Therefore, the chemicals in this group may have some of the characteristics of POPs. Persistent organic pollutants are chemicals that are very persistent, very bioaccumulative, toxic, and have potential to undergo long-range transport. The Stockholm Convention identifies POPs and aims to reduce or eliminate the environmental release of such substances.

Key Findings

The chemicals in this group are not expected to have significant current industrial use in Australia. However, if released to the environment, the chemicals in this group are expected to release long-chain perfluoroalkyl sulfonates. Long-chain perfluoroalkyl sulfonates have been detected in remote locations. Available data indicate that these chemicals also have high bioaccumulation potential. Further, these chemicals are expected to cause long-term toxic effects in exposed organisms.

The chemicals in this group have been categorised as PBT substances according to domestic environmental hazard criteria. Therefore, these chemicals are considered to be high concern substances.

Recommendations

The chemicals in this group have been assessed as having the potential to give rise to adverse outcomes for the environment. These chemicals are currently listed on the Australian Inventory of Chemical Substances (the Inventory), and are available to be introduced into Australia without the requirement for assessment by NICNAS. Other chemicals with reduced potential for adverse outcomes are becoming available but, given the properties of these chemicals, their assessment as new chemicals under the *Industrial Chemicals (Notification and Assessment) Act 1989* (the ICNA Act) is still required to fully characterise the human health and the environmental risks associated with their use.

It is recommended that NICNAS consult with industry and other stakeholders to consider strategies, including regulatory mechanisms available under the ICNA Act, to encourage the use of safer chemistry.

The Action Plan

Insufficient data are available to demonstrate a lower toxicity profile for the chemicals in this group compared to PFOS. It is therefore recommended that the action plan currently contained in Appendix G of the Handbook for Notifiers should continue to be applied to the assessment of chemicals which degrade to PFNS and PFDS (NICNAS, 2015e).

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 1-nonanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,9-nonadecafluoro-, ammonium salt (ammonium PFNS); 1-decanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heneicosafluoro-, ammonium salt (ammonium PFDS); and sulfonic acids, C6-12-alkane, perfluoro-, potassium salts 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 2 (H401)	Toxic to aquatic life
Chronic Aquatic	Category 1 (H410)	Very toxic to aquatic life with long lasting effects

The classification of the acute hazards posed by these chemicals has been performed based on the aquatic toxicity data presented in this assessment.

No chronic toxicity data are available for the chemicals in this group. However, based on available information, salts of PFOS have been considered to be appropriate analogues for the toxicity of the chemicals in this group. Therefore, the classification of these chemicals is conducted using chronic toxicity data available for PFOS, which demonstrate toxicity less than 0.1 mg/L. The classification of these chemicals for chronic toxicity also considered the non-rapid ultimate degradation of perfluoroalkyl sulfonates and the very high bioaccumulation potential of long-chain homologues 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.

References

Ahrens L, Siebert U and Ebinghaus R (2009). Temporal trends of polyfluoroalkyl compounds in harbour seals (*Phoca vitulina*) from the German Bight, 1999-2008. *Chemosphere,* **76**(2), pp 151-158.

Buck RC, Franklin J, Berger U, Conder JM, Cousins IT, de Voogt P, Jensen AA, Kannan K, Mabury SA and van Leeuwen SP (2011). Perfluoroalkyl and Polyfluoroalkyl Substances in the Environment: Terminology, Classification and Origins. *Integrated Environmental Assessment and Management,* **7**(4), pp 513-541.

Cai M, Yang H, Xie Z, Zhao Z, Wang F, Lu Z, Sturm R and Ebinghaus R (2012). Per- and polyfluoroalkyl substances in snow, lake, surface runoff water and coastal seawater in Fildes Peninsula, King George Island, Antarctica. *Journal of Hazardous Materials,* **209-210**, pp 335-342.

Campo J, Masia A, Pico Y, Farre M and Barcelo D (2014). Distribution and fate of perfluoroalkyl substances in Mediterranean Spanish sewage treatment plants. *Science of the Total Environment,* **472**, pp 912-922.

ECHA (2014). *Registered Substances*. European Chemicals Agency, Helsinki, Finland. Accessed 9 May at http://echa.europa.eu.

ECHA (2015). *Pre-registered substances*. European Chemicals Agency, Helsinki, Finland. Accessed 1 April at http://echa.europa.eu.

Environment Canada (2013a). *Search Engine for the Results of DSL Categorization*. Environment Canada, Gatineau, Quebec, Canada. Accessed 21 November 2013 at http://www.ec.gc.ca.

Environment Canada (2013b). *Search Engine for Chemicals and Polymers*. Environment Canada, Gatineau, Canada. Accessed 1 May at http://www.ec.gc.ca.

Environment Canada (2015). *Rapid Screening of Substances identified from Phase Two of the Domestic Substances List Inventory Update - Results of the Draft Screening Assessment* Environment Canada, Gatineau, Canada. Accessed 20 April 2015 at http://www.ec.gc.ca.

EPHC (2009). *Environmental Risk Assessment Guidance Manual for Industrial Chemicals*. Environment Protection and Heritage Council, Canberra, Australia. Accessed 9 December 2013 at http://www.scew.gov.au.

Flick EW (1993). *Industrial Surfactants: An Industrial Guide* (2nd ed). Noyes Publications, New Jersey, USA. at https://books.google.com.au/books?id=oOSTN4gZnXYC.

Hagenaars A, Vergauwen L, De Coen W and Knapen D (2011). Structure-activity relationship assessment of four perfluorinated chemicals using a prolonged zebrafish early life stage test. *Chemosphere,* **82**, pp 764-772.

Hart K, Kannan K, Isobe T, Takahasi S, Yamada TK, Miyazaki N and Tanabe S (2008). Time Trends and Transplacental Transfer of Perfluorinated Compounds in Melon-Headed Whales Stranded Along the Japanese Coast in 1982, 2002/2002, and 2006. *Environmental Science and Technology,* **42**(19), pp 7132-7137.

Hekster F, de Voogt P, Pijnenburg A and Laane R (2002). *Perfluoroalkylated substances: Aquatic environmental assessment, Report RIKZ/2002.043*. Government of the Netherlands Ministry of Infrastructure and the Environment, Amsterdam, The Netherlands. Accessed 22 December 2014 at http://repository.tudelft.nl.

Kumar KS, Zushi Y, Masunaga S, Gilligan M, Pride C and Sajwan KS (2009). Perfluorinated organic contaminants in sediment and aquatic wildlife, inculding sharks, from Georgia, USA. *Marine Pollution Bulletin,* **58**(4), pp 621-629.

Loi EIH, Yeung LWY, Taniyashu S, Lam PKS, Kannan K and Yamashita N (2011). Trophic Magnification of Poly- and Perfluorinated Compounds in a Subtropical Food Web. *Environmental Science and Technology,* **45**(13), pp 5506-5513.

Mak YL, Taniyasu S, Yeung LWY, Lu G, Jin L, Yang Y, Lam PKS, Kannan K and Yamashita N (2009). Perfluorinated Compounds in Tap Water from China and Several Other Countries. *Environmental Science and Technology,* **43**(13), pp 4824-4829.

Myers AL, Crozier PW, Helm PA, Brimacombe C, Furdui VI, Reiner J, Burniston D and Marvin CH (2012). Fate, distribution, and contrasting temporal trends of perfluoroalkyl substances (PFASs) in Lake Ontario, Canada. *Environment International,* **44**, pp 92-99.

Ng CA and Hungerbühler K (2014). Bioaccumulation of Perfluorinated Alkyl Acids: Observations and Models. *Environmental Science and Technology,* **48**(9), pp 4637-4648.

NICNAS (2013a). *PFC Derivatives and Chemicals on which they are based: Alert Factsheet*. National Industrial Chemicals Notification and Assessment Scheme, Sydney, Australia. Accessed 11 November at http://www.nicnas.gov.au.

NICNAS (2013b). *Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework*. National Industrial Chemicals Notification and Assessment Scheme, Sydney, Australia. Accessed 12 November 2013 at http://www.nicnas.gov.au.

NICNAS (2015a). *IMAP Environment Tier II Assessment of Perfluorooctanoic Acid (PFOA) and its Direct Precursors*. National Industrial Chemicals Notification and Assessment Scheme, Sydney, Australia.

NICNAS (2015b). *IMAP Human Health Tier II Assessment for Perfluorooctane Sulfonate (PFOS) and its Direct Precursors*. National Industrial Chemicals Notification and Assessment Scheme, Sydney, Australia. Accessed 21 April 2015 at http://www.nicnas.gov.au.

NICNAS (2015c). *IMAP Environment Tier II Assessment for Direct Precursors to Perfluoroheptanesulfonate (PFHpS), Perfluorohexanesulfonate (PFHxS) and Perfluoropentanesulfonate (PFPeS)*. National Industrial Chemicals Notification and Assessment Scheme, Sydney, Australia.

NICNAS (2015d). *IMAP Human Health Tier II Assessment for Perfluoroalkyl Sulfonates (PFAS) (>C8) and their Direct Precursors*. National Industrial Chemicals Notification and Assessment Scheme, Sydney, Australia. Accessed 15 May 2015 at http://www.nicnas.gov.au.

NICNAS (2015e). *NICNAS Handbook for Notifiers*. National Industrial Chemicals Notification and Assessment Scheme, Sydney, Australia. Accessed 28 January at http://www.nicnas.gov.au/regulation-and-compliance/nicnas-handbook

NICNAS (2015f). *IMAP Environment Tier II Assessment for Direct Precursors to Perfluorooctanesulfonate (PFOS)*. National Industrial Chemicals Notification and Assessment Scheme, Sydney, Australia.

Nordic Council of Ministers (2015). *Substances in Preparations in Nordic Countries (SPIN)*. Chemical Group, Nordic Council of Ministers, Copenhagen, Denmark. Accessed 17 March at http://www.spin2000.net.

OECD (2002). *Hazard Assessment of Perfluorooctane sulfonate (PFOS) and its Salts*. Organisation for Economic Cooperation and Development, Paris, France. Accessed 11 November 2014 at http://www.oecd.org.

OECD (2013a). *OECD Existing Chemicals Database*. Organisation for Economic Cooperation and Development, Paris, France. Accessed 13 November 2013 at http://webnet.oecd.org.

OECD (2013b). *OECD/UNEP Global PFC Group: Synthesis paper on per- and polyfluorinated chemicals (PFCs)*. Organisation for Economic Cooperation and Development, Paris, France. Accessed 20 March 2015 at http://www.oecd.org.

Schiavone A, Corsolini S, Kannan K, Tao L, Trivelpiece W, Torres Jr D and Focardi S (2009). Perfluorinated contaiminants in fur seal pups and penguin eggs from South Shetland, Antarctica. *Science of the Total Environment,* **407**, pp 3899-3904.

Thompson J, Roach A, Eaglesham G, Bartkow ME, Edge K and Mueller J (2011). Perfluorinated alkyl acids in water, sediment and wildlife from Sydney Harbour and surroundings. *Marine Pollution Bulletin,* **62**, pp 2869-2875.

Toschik PC, Rattner BA, McGowan PC, Christman MC, Carter DB, Hale RC, Matson CW and Ottinger MA (2005). Effect of Contaminant Exposure on Reproductive Success of Ospreys (*Pandion haliaetus*) nesting in Delaware River and Bay, USA. *Environmental Toxicology and Chemistry,* **24**(3), pp 617-628.

Ulhaq M, Carlsson G, Orn S and Norrgren L (2013). Comparison of developmental toxicity of seven perfluoroalkyl acids to zebrafish embryos. *Environmental Toxicology and Pharmacology,* **36**, pp 423-426.

UNECE (2007). *Annex 9: Guidance on Hazards to the Aquatic Environment*. United Nations Economic Commission for Europe, Geneva, Switzerland. Accessed 20 October 2014 at http://www.unece.org.

UNECE (2009). *Globally Harmonised System of Classification and Labelling of Chemicals (GHS), 3rd Revised Edition*. United Nations Economic Commission for Europe, Geneva, Switzerland. Accessed 12 November 2013 at http://www.unece.org

UNEP (1987). *The Montreal Protocol on Substances that Deplete the Ozone Layer*. United Nations Environment Programme, Ozone Secretariat, Nairobi, Kenya. Accessed 12 November 2013 at http://ozone.unep.org.

UNEP (2001). *The Stockholm Convention on Persistent Organic Pollutants*. United Nations Environment Programme, Secretariat of the Stockholm Convention, Châtelaine, Switzerland. Accessed 12 November 2013 at http://www.pops.int.

UNEP (2006). *Risk profile on perfluorooctane sulfonate*. United Nations Environment Programme, Châtelaine, Switzerland. Accessed 18 November 2014 at http://chm.pops.int.

UNEP & FAO (1998). *The Rotterdam Convention on the Prior Informed Consent procedure for Certain Hazardous Chemicals and Pesticides in International Trade*. United Nations Environment Programme and Food and Agriculture Organization of the United Nations, Châtelaine, Switzerland. Accessed 12 November 2013 at http://www.pic.int.

United States Government (2002). Perfluoroalkyl Sulfonates; Significant New Use Rule. *Federal Register,* **67**(236), pp 72854-72867.

United States Government (2007). Perfluoroalkyl Sulfonates; Significant New Use Rule. *Federal Register,* **72**(194), pp 57222-57235.

US EPA (2009). *Long-Chain Perfluorinated Chemicals (PFCs) Action Plan*. United States Environmental Protection Agency, Washington DC, USA. Accessed 10 December 2014 at http://www.epa.gov.

Wang D and Xu C-B (2007). *Compositions and processes for photolithography*. USA. Accessed 13 May 2015 at http://www.google.us.

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