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Persistent Organic Pollutants Review Committee
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Item 5 (c) of the provisional agenda*

Technnical work: consideration of a proposal for the inclusion of pentadecafluorooctanoic acid (CAS No: 335-67-1, PFOA, perfluorooctanoic acid), its salts and PFOA-related compounds in Annexes A, B and/or C to the Convention

Proposal to list pentadecafluorooctanoic acid (CAS No: 335-67-1, PFOA, perfluorooctanoic acid), its salts and PFOA-related compounds in Annexes A, B and/or C to the Stockholm Convention on Persistent Organic Pollutants

Note by the Secretariat

I. Introduction

1. The European Union has submitted a proposal to list pentadecafluorooctanoic acid (CAS No: 335-67-1, PFOA, perfluorooctanoic acid), its salts and PFOA-related compounds in Annexes A, B and/or C to the Convention pursuant to paragraph 1 of Article 8 of the Convention (see annex). The proposal is being circulated as submitted and has not been formally edited. The Secretariat's verification of whether the proposal contains the information specified in Annex D is set out in document UNEP/POPS/POPRC.11/INF/9.

II. Possible action by the Committee

2. The Committee may wish:

(a) To consider the information provided in the present note;

(b) To decide whether it is satisfied that the proposal fulfils the requirements of Article 8 of and Annex D to the Convention**;**

(c) To develop and agree on, if it decides that the proposal fulfils the requirements referred to in subparagraph (b) above, a workplan for preparing a draft risk profile pursuant to paragraph 6 of Article 8.

* UNEP/POPS/POPRC.11/1.

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Annex

Proposal to list pentadecafluorooctanoic acid (CAS No: 335-67-1, PFOA, perfluorooctanoic acid), its salts and PFOA-related compounds in Annexes A, B and/or C to the Stockholm Convention on Persistent Organic Pollutants

1. Introduction

1. Pentadecafluorooctanoic acid (PFOA), PFOA salts and PFOA-related substances are widely used either in direct applications in the production of fluoroelastomers and fluoropolymers, with polytetrafluoroethylene (PTFE) being the most important fluoropolymer. PFOA-related substances are used in fire-fighting foams, wetting agents and cleaners. In textiles and leather, paper and cardboard (e.g. food packaging), paints and lacquers and other uses (non-woven medical garments, floor waxes and stone/wood sealants, thread sealant tapes and pastes, adhesives, products for apparel) side-chain fluorinated polymers are used. Fluorotelomers are mainly used in textiles and apparel, in carpets and carpet care products and coatings including those for paper products.

2. The nomination report specifically addresses the information requirements and screening criteria of paragraph 1 and 2 in Annex D in the Stockholm Convention on Persistent Organic Pollutants and summarizes relevant evidence relating to the screening criteria for persistence, bioaccumulation, adverse effects and long-range transport. Some additional information relating to paragraph 3 of Annex D is also provided. The report is based on existing reports prepared by OECD (OECD, 2006, 2011), EU (ECHA, 2011, 2013a, 2013b, 2014) and Canada (Environment Canada and Health Canada, 2012). In addition more recent literature from peer-reviewed scientific journals is included.

2. Chemical identity

3. The nomination concerns pentadecafluorooctanoic acid (CAS No: 335-67-1, EC No: 206-397-9, PFOA, perfluorooctanoic acid) including its salts and PFOA-related substances and any other substance having linear or branched perfluoroheptyl derivatives with the formula C7F15- as a structural element, including its and any other substance having linear or branched perfluorooctyl derivatives with the formula C8F17- as a structural element, including its salts.

4. The chemical data on PFOA and PFOA-related substances are presented in Figure 1 and in Tables 1a-c and 2a-c below. Some PFOA-related substances can be degraded to PFOA (e.g. Wang et al., 2005). Therefore these PFOA-related substances contribute to the overall PFOA exposure of humans and the environment. A grouping approach via molecular formula is therefore the most efficient and appropriate way to cover all relevant substances. Any linear or branched perfluoroheptyl derivative with the formula C7F15-X, other than PFOA and PFOA salts, and any linear or branched perfluorooctyl derivative with the formula C8F17-X are PFOA-related substances within the scope of this proposal. In Table 1c only some examples of PFOA-related substances are given (OECD 2007, 2011; Environment Canada and Health Canada, 2012).

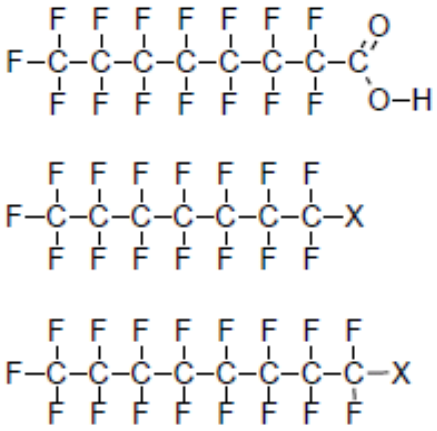


Figure 1. Structural formula of PFOA (top) and PFOA-related substances

Table 1 a. Identity of PFOA

CAS number:	335-67-1
CAS name:	Octanoic acid, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-pentadecafluoro-
IUPAC name:	Pentadecafluorooctanoic acid
EC number:	206-397-9
EC name:	Pentadecafluorooctanoic acid
Molecular formula:	$C_8HF_{15}O_2$
Molecular weight:	414.07 g/mol
Synonyms:	Perfluorooctanoic acid; PFOA; Pentadecafluoro-1-octanoic acid; Perfluorocaprylic acid; Perfluoroheptanecarboxylic acid; Perfluoro-n-octanoic acid; Pentadecafluoro-n-octanoic acid; Pentadecafluorooctanoic acid; n-Perfluorooctanoic acid; 1-Octanoic acid, 2,2,3,3,4,4,5,5,6,6, 7,7,8,8,8-pentadecafluoro

Table 1 b. Some examples of PFOA salts (e.g. Environment Canada and Health Canada, 2012, OECD 2007, 2011)

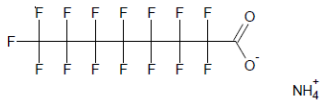
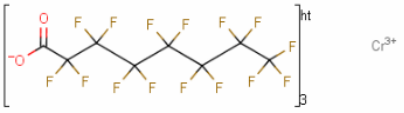
Name:	**Abbreviation / Structure:**	**CAS number:**
2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-penta-deca-fluoro-octanoic acid, ammonium salt	APFO 	3825-26-1
2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-penta¬deca¬fluoro-octanoic acid, sodium salt	Na-PFOA 	335-95-5
2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-penta-deca-fluoro-octanoic acid, potassium salt	K-PFOA 	2395-00-8
2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-penta-deca-fluoro-octanoic acid, silver salt		335-93-3
Octanoic acid, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-pentadecafluoro-, chromium(3+)		68141-02-6
Ethanaminium, N,N,N-triethyl-, salt with pentadecafluorooctanoic acid (1:1)	-	98241-25-9

Table 1 c. Examples of PFOA-related substances

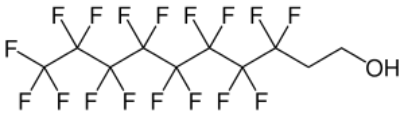
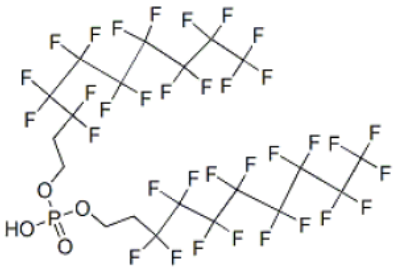
Name:	**Abbreviation / Structure:**	**CAS number:**
Fluorotelomer alcohols 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10, 10-Heptadecafluordecan-1-ol	8:2 FTOH 	678-39-7
Fluorotelomer acrylates 8:2 Fluorotelomer acrylate	8:2 FTAC 	27905-45-9
Polyfluoroalkyl phosphoric acid diesters 8:2 Fluorotelomer phosphate diester	8:2 diPAP 	678-41-1
Perfluorinated Iodides Perfluorooctyl iodide	PFOI 	507-63-1

Table 2 a. Overview of relevant physicochemical properties of PFOA

Property	**Value**	**Reference/Remark**
Physical state at 20°C and 101.3 kPa	solid	Kirk, 1995
Melting/freezing point	54.3 °C 44 - 56.5 °C	Lide, 2003 Beilstein, 2005 cited in ECHA, 2013a
Boiling point	188 °C (1013.25 hPa) 189 °C (981 hPa)	Lide, 2003 Kauck and Diesslin, 1951
Vapour pressure	4.2 Pa (25° C) extrapolated from measured data 2.3 Pa (20° C) extrapolated from measured data 128 Pa (59.3° C) measured	Kaiser et al., 2005; Washburn et al., 2005 Washburn et al., 2005 Washburn et al., 2005
Water solubility	9.5 g/L (25° C) 4.14 g/L (22°C)	Kauck and Diesslin, 1951 Prokop et al., 1989
n-Octanol/water partition coefficient, K_{ow} (log value)	2.69 at pH 7 and 25°C 6.3	Calculated using Advanced Chemistry Development (ACD/Labs) Software V11.02 (© 1994-2012 ACD/Labs). EPI suite (Syracuse_Research_Corporation, 2000-2008) models not validated for PFASs (per- and polyfluorinated alkyl substances)
Dissociation constant	<1.6, e.g. 0.5 1.5 - 2.8	Vierke et al., 2013 Kissa, 2001

Table 2 b. Overview of relevant physicochemical properties of a PFOA salt APFO

Property	Value	Reference
Physical state at 20°C and 101.3 kPa	solid	Kirk, 1994
Melting/freezing point	APFO: 157-165 °C (decomposition starts above 105 °C) APFO: 130 °C (decomposition)	Lines and Sutcliff, 1984 (IUCLID 2.2.) 3M Company, 1987 cited in ECHA, 2013b
Boiling point	Decomposition	Lines and Sutcliff, 1984 (IUCLID 2.2.)
Vapour pressure	APFO: 0.0081 Pa (6 x 10-6) at 20 °C, calculated from measured data	Washburn et al., 2005
Water solubility	concentration. at saturation (g/L) APFO: > 500	3M Company, 1987 cited in ECHA, 2013b
n-Octanol/water partition coefficient, K_{ow} (log value)	Experimental: No data Calculated: No data.	-
Dissociation constant	Dissociation Constants: pKa = 2.80 in 50% aqueous ethanol pKa = 2.5	Brace, 1962 Ylinen et al., 1990

Table 2 c. Overview of relevant physicochemical properties of 8:2 FTOH

Property	Value	Reference
Physical state at 20°C and 101.3 kPa	waxy solid	
Melting/freezing point	No information	Lines and Sutcliff, 1984 3M Company, 1987
Boiling point	No information	Lines and Sutcliff, 1984 (IUCLID 2.2.)
Vapour pressure	31 Pa at 25 ºC (Retention time method) 29 Pa at 45ºC (Headspace GC/AED method) 254 Pa at 25 ºC , volatile, 99.9 % detected mainly in the gassousphase in the atmosphere 0.227 kPa 0.023 mmHg	Vapour pressure seem sensitive to choice of method. Cobranchi et al 2006 Stock et al. 2004 Lei et al., 2004 Berti, 2002 cited in ECHA, 2014
Water solubility	1.4×10^{-4} g/L or 140 µg/L at 25 °C	Berti, 2002 cited in ECHA, 2014
n-Octanol/water partition coefficient, K_{ow} (log value)	No information	-
Dissociation constant	No information	-

3. Global consumption and use

5. PFOA, PFOA salts and PFOA-related substances have unique properties such as high friction resistance, dielectrical properties, resistance to heat and chemical agents, low surface energy, and are used as water, grease, oil and soil repellence. Therefore these substances are used in a wide variety of applications and consumer products.

6. There exist direct and indirect sources of PFOA, PFOA salts and PFOA-related substances. Direct applications of PFOA and its salts are mainly in the production of fluoroelastomers and fluoropolymers. The substances are used as a processing aid and a minor application exists in the photographic industry and as surfactants in the semiconductor industry (van der Putte et al., 2013). Polytetrafluoroethylene (PTFE) is the most important fluoropolymer in terms of volume and accounts for about 60 % of the global market of fluoropolymers (ECHA, 2014). PFOA-related substances are used either as non-polymeric substances or as part of side-chain fluorinated polymers, such as fluoroacrylate polymers (OECD, 2013; van der Putte et al., 2010) and serve as indirect sources. PFOA-related substances are used in fire-fighting foams, wetting agents and cleaners (non-polymeric uses). In textiles and leather, paper and cardboard (e.g. food packaging), paints and lacquers and other

uses (non-woven medical garments, floor waxes and stone/wood sealants, thread sealant tapes and pastes, adhesives, products for apparel) side-chain fluorinated polymers are used (ref. ECHA, 2014; U.S. EPA, 2009; van der Putte et al., 2010). Fluorotelomers are mainly used in textiles and apparel, in carpets and carpet care products and coatings incl. those for paper products (U.S. EPA, 2009).

7. From 1951 until 2004 the estimated total global production for PFOA and APFO was 3,600 – 5,700 t (Prevedouros et al., 2006). The production of PFOA is located outside the EU. For Europe, it was estimated by Germany and the Norwegian competent authority that 40 t/year PFOA and salts are imported into the EU (20 t/year as substances, 10 t/year in mixtures and 10 t/a in articles).
PFOA-related substances are manufactured in the EU and are present as constituents in UVCB substances in the range of 100 - 1000 t/year based on registrations. PFOA-related substances are imported into the EU in volumes of 100 - 1000 t/year based on the stakeholder consultation. The total volume of
PFOA-related substances in imported articles is unknown. For textiles it was estimated that imported textiles could contain 1,000 - 10,000 t/year of PFOA-related substances (ECHA, 2014).

4. National and international administrative actions on pentadecafluorooctanoic acid (PFOA), PFOA salts and PFOA-related substances

8. Pentadecafluorooctanoic acid (PFOA), PFOA salts and PFOA-related substances have been under scrutiny for its potential health and environmental impacts for some time, both within the scientific community and among regulators. At present several environmental and health risk/hazard reports and regulatory actions of PFOA, PFOA salts and PFOA-related substance have been or are at the moment ongoing on the international, regional and national levels.

9. PFOA has a harmonised classification as Carc. 2, Repr. 1B and STOT RE 1 (liver) according to Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures in the European Union:

Classification		**Labelling**		
Hazard Class and Cat. Code(s)	Hazard statement Code(s)	Hazard Statement Code(s)	Pictograms	Signal Word
Carc. 2	H351	H351	GHS07	
Rep. 1B	H360D	H360D	GHS08	Danger
Lact	H362	H362	GHS05	
STOT RE 1	H372 (liver)	H372 (liver)		
Acute Tox. 4	H332	H332		
Acute Tox. 4	H302	H302		
Eye dam. 1	H318	H318		

10. Due to its PBT and CMR properties, PFOA and its ammonium salt (APFO) have been identified as substances of very high concern (SVHC) under Regulation (EC) No 1907/2006 in the European Union (ECHA, 2013a, 2013b).

11. In the European Union a restriction on the manufacturing, use and placing on the market of Perfluorooctanoic acid (PFOA) and its salts, also including substances that may degrade to PFOA (PFOA-related substances) was proposed by Germany and Norway (ECHA, 2014).

12. The Norwegian Environment Agency has published an amendment to Norway’s consumer products regulation to ban PFOA from consumer products and textiles. This entered into application on 1st of June 2014 (Norwegian Environmental Agency, 2014). A transitional period, allowing the import and sale of products manufactured before 1 June, will last until 1 January 2018.

13. Eight major fluoropolymer and telomer manufacturers (Arkema, Asahi, BASF Corporation (successor to Ciba), Clariant, Daikin, 3M/Dyneon, DuPont, and Solvay Solexis) are committed to phase out PFOA and its salts in their operations until the end of 2015 in the context of the US EPA Stewardship Programme (US EPA, 2006) in the USA.

14. In Canada, the screening assessments of PFOA, and its salts and compounds concluded that these substances are harmful to the environment or its biological diversity as defined under paragraph 64(a) of the Canadian Environmental Protection Act, 1999 (CEPA 1999 or the Act).

5. Information on pentadecafluorooctanoic acid (PFOA), PFOA salts and PFOA-related substances in relation to the POP screening criteria

5.1 Persistence

15. PFOA is hydrolytically stable under environmental conditions. In the OECD SIDS Initial Assessment Report for PFOA a hydrolysis study of APFO conducted by 3M was cited, herein it was estimated that the hydrolytic half-life of PFOA was greater than 97 years (3M Co., 2001). Direct photolysis is expected to be very slow (Environment Canada and Health Canada, 2012). A slow indirect photodegradation in air with an atmospheric lifetime of 130 days has been reported (OECD, 2006).

16. Screening tests conducted with PFOA or APFO indicated little (max. 7% in 28 days) or no biodegradation (MITI, 2002; Stansinakis et al., 2008, OECD 2006, 3M Co., 1978). PFOA is not readily biodegradable.

17. Due to the high persistence, no environmental half-lives for PFOA are available. Nevertheless, the results of various degradation tests and field monitoring data support the conclusion that no biodegradation of PFOA and APFO occurred. Under aerobic conditions no biodegradation of PFOA occurred in sewage sludge reactor (Meesters and Schroeder, 2004; Schröder 2003), with mixed bacterial culture, with activated sludge (Wang et al., 2005), and in water (microcosm study of Hanson et al., 2005). Liou et al (2010) investigated the anaerobic biodegradability of PFOA respectively APFO with inoculums from municipal wastewater treatment plants, sediment, and soil. PFOA was used as possible electron acceptor. In addition, the possibility for co-metabolism of PFOA under various conditions was investigated. Under all tested conditions no metabolism, loss or mineralization occurred. In summary, under all investigated conditions PFOA was persistent. The reason for the high thermal and chemical stability of organic fluorine compounds has been described in detail by Siegemund et al. (2000). These inherent properties are necessary for its commercial application and uses.

18. Monitoring studies of contaminated sites (e.g. fire-training areas using AFFE-foams or perfl. chemical waste) show high levels of PFOA in soil and underlying groundwater, even when application stopped or application ceased indicating that PFOA is highly persistent in soil and water (e.g. Moody et al., 1999, 2003; Du Pont 2003). In addition it is important to note, that PFOA is mobile and can reach groundwater from contaminated soil sites (ECHA, 2013a).

19. PFOA-related substances degrade to PFOA under environmentally relevant conditions. For example the biodegradation of 8:2 FTOH with bacterial mixtures or activated sludge yielded also PFOA as transformation product. The yield of PFOA was higher in soil than in sewage sludge and very low under anaerobic conditions (e.g. Wang et al., 2005, Faesano et al., 2006, Dinglasan et al., 2004, Wang et al., 2009, Zhang et al., 2013). Aqueous phase photooxidation of 8:2 FTOH was concluded to result in close to 100% PFOA (ECHA, 2014).

Conclusion on persistence according to the Criteria of Annex D

20. APFO and PFOA are very persistent and do not undergo any further abiotic or biotic degradation under relevant environmental conditions.

5.2 Bioaccumulation

21. No measured log Kow values are reported for PFOA. Due to the formation of an emulsified layer between octanol and water surface interface, the determination of log Kow is impossible (U.S. EPA, 2014). Only estimated values (log Kow est = 2.69, log Kow = 6.3) below and above 5 exist, but models used are not validated for PFASs (ECHA, 2011). In addition, it has been shown that PFOA preferentially binds to proteins in liver and blood (e.g. Ahrens et al., 2009). Therefore, the log Kow as descriptor for the bioaccumulation potential is not appropriate for PFOA, PFOA salts and PFOA related substances. The reason is that perfluorinated substances have combined properties of oleophobicity, hydrophobicity and hydrophilicity over portions of the particular molecule (OECD, 2006).

22. Reliable Bioconcentration factors (BCFs) for PFOA have been determined in rainbow trout and fathead minnow. BCF values are far below 5000 (3M Co., 1995; Martin et al., 2003), indicating no bioaccumulation potential in aquatic organisms (uptake via gills). Reported Bioaccumulation factors (BAFs), which take all exposure routes into account are in addition below 5000 (Martin et al., 2003; Quinete et al., 2009, Morikawa et al., 2005, Loi et al., 2011). The evidence that the BCF or the BAFs in aquatic species for PFOA is greater than 5,000 is not fulfilled, but this is to be expected because PFOA exhibits a high water solubility (4-10 g/L) and the substance may be easily excreted via gill

permeation (e.g. Martin et al., 2003). BCF values are not considered as the correct end-point to assess the bioaccumulation potential of PFOA, PFOA salts and PFOA-related substances. Also for PFOS (listed in the Annex of the Stockholm Convention) a protein binding bioaccumulation mechanism other than fat partitioning was shown and therefore the BCF was considered not applicable. (UNEP/POPS/POPRC.3//INF/8, 2007).

23. For PFOA, field biomagnification factors (BMFs) were reported for several food chains including various locations [Canadian lakes, eastern artic, Atlantic, Canadian Arctic, Westerschelde Netherlands, and Brazilian river (Martin et al., 2004; Houde et al., 2006; Tomy et al., 2004; Butt et al. 2008; Tomy et al., 2009; Environment Canada and Health Canada, 2012; van den Heuvel-Greve et al., 2009, Quinete et al., 2009)] indicating BMF values above 1. In more detail, following prey/predator relationships indicated high BMF values (> 10): Dolphin /mullet; Dolphin/pinfish (Houde et al., 2006); Polar bear (liver)/ringed seal (liver) (Butt et al., 2008); Herring/harbor seal (Environment Canada and Health Canada, 2012). BMF values > 1 have been also reported for Walrus (liver)/clam, narwhal (liver)/Arctic cod, and beluga (liver)/Arctic cod (Tomy et al., 2009).

24. Concerning trophic magnification Houde et al. (2006) investigated the food web of bottlenose dolphins at two U.S. locations. TMFs (trophic magnification factors) based on liver for PFOA were greater than 1 and smaller than 1 on the basis of the whole body. Kelly et al. (2009) investigated a Canadian Arctic food web including sediment, macroalgae, bivalves, fish, seaduck and beluga whale. The protein corrected TMF values where higher than 1 and it was concluded that PFOA accumulates in protein rich compartments like blood and liver. In the case of piscivorous food webs the TMF was smaller than 1, but if air breathing organisms are included the TMF value becomes larger than one. It should be kept in mind that (TMFs) are difficult to interpret because these TMF values depend highly on the decision on inclusion of the species and their assignment to a particular trophic position. In addition TMF include seasonal and spatial variability and possible a lack of steady state. The variability of exposure is not taken into account. Corrections or better adjustments of TMF studies are not a common approach. Benchmarks with other chemicals are difficult because bioavailability might be different to the substance of interest at any location. Summarizing, TMFs of PFOA were reported by several authors (e.g. Martine et al., 2004, 2006; Houde et al., 2006; Kelly et al., 2009; Environment Canada and Health Canada, 2012; van den Heuvel Greve et al., 2009; Loi et al., 2011) some studies revealed TMFs below 1, but more studies reveal TMFs above 1. In general a TMF >1 in one study is giving sufficient evidence to conclude that a substance is bioaccumulative.

25. High tissue concentrations of PFOA have been measured in terrestrial mammals. Martin et al., 2004 investigated biota from the Canadian Artic only in liver samples from polar bear. PFOA was found above the detection limit at concentrations of 3-13 ng/g. PFASs were measured in background locations of the Norwegian Arctic and the Norwegian mainland, which are little effected by anthropogenic sources (NILU, 2013). PFOA was detected in 30% of brown trout samples, in 100% of harbour seal liver (n=10; mean: 0.8 mean ng/g wt) and 100% eider eggs (n=10; mean: 1.62 ng/g wt), 80 % of Herring gull eggs (n=10; mean: 0.11 ng/g wt), and 30% of cod liver (mean: 0.09 ng/g wt n=10).

26. In a remote Canadian terrestrial food chain (lichen, caribou and wolf) BMFs for PFOA ranged between 0.9 and 11 and TMFs for PFOA ranged from 1.1 to 2.4 (Müller et al., 2011), indicating that PFOA can biomagnify in the food chain by BMFs and TMFs larger than one.

27. PFOA is found in human blood in the general population (e.g. Fromme et al. 2007, 2009; Lau et al., 2007) and at elevated concentrations after specific exposure to PFOA (e.g. contaminated drinking water Emmet et al., 2006) or occupationally (e.g. ski wax technicans: Nilsson et al., 2010). Life style, breast feeding, diet (e.g. drinking water, shrimp) and indoor environments can influence the PFOA blood levels. Mothers excrete PFOA via breast milk and transfer PFOA to infants. After giving birth and at the end of breast feeding PFOA is re-accumulating in maternal blood (ECHA, 2013a).

28. The plasma half-life of PFOA in humans has been investigated in several studies (Olsen et al., 2007a, Bartell et al., 2010, Brede et al., 2010). Following human plasma half-lives of PFOA were reported in these studies: 3.5 years, 2.3 years, 3.3 years (geometric mean, range: 1.0 – 14.7 years). PFOA is considered as very persistent and does not undergo further transformation and due to the long half-life PFOA levels increase with age (ref. to Haug et al., 2010, 2011). Taken together, the long plasma half-life and the persistence of PFOA give enough evidence to conclude that PFOA bioaccumulates in humans.

Conclusion on bioaccumulation according to the criteria in Annex D

29. PFOA has a low to moderate potential to accumulate in aquatic species. However based on the evidence from studies using environmental measured data PFOA can be considered to accumulate and biomagnify in terrestrial and marine mammals. PFOA and its salts do not meet the bioaccumulation criterion (BCF or BAF ≥ 5000), nevertheless based on the weight of evidence PFOA and its salts accumulate and biomagnify in terrestrial and marine mammals (BMFs, TMFs > 1). PFOA accumulates in humans based on long elimination half-lives in blood, increasing levels with age, elevated levels in human body fluids in population exposed to PFOA and re-accumulation of maternal blood levels after excretion via breast milk at the end of breast feeding.

30. Therefore, PFOA, PFOA salts and PFOA related substances fulfils the criteria on bioaccumulation under Annex D of the Convention.

5.3 Potential for long-range environmental transport

31. The atmospheric lifetime of PFOA with respect to hydroxyl radicals has been predicted to be 130 days (Hurley et al., 2004).

32. Franklin (2002) calculated an atmospheric lifetime of PFOA to be in the order of days when it was emitted from a ground source, and therefore likely not subject to long-range transport. However, if PFOA is produced from an atmospheric source (i.e. via degradation of precursors) and if the major loss mechanism is wet or dry deposition, then it may have a lifetime of 20–30 days before deposition (Ellis et al., 2004). This would be sufficient time to allow transport over many thousands of kilometres, implying a long-range transport mechanism.

33. Gomis et al., 2015 used COSMOtherm and SPARC to estimate the physicochemical properties of various novel PFASs in comparison to PFOS, PFOA and 8:2 FTOH. The US-EPA Epi Suite was used to predict degradation half-lives in air, water and soil (for PFOA the estimated values were 31 days in air and 720 days in water and soil). The results were then used as input parameters for the OECD Pov and LRTP Screening Tool[1] which has been developed with the aim of using multimedia models for estimating overall persistence (Pov) and long-range transport potential (LRTP) of organic chemicals at a screening level in the context of PBTs / POPs assessments. The OECD overall persistence (Pov) and Long-Range Transport Potential (LRTP) Screening tool gave following result for PFOA: Pov = 1038 days; critical travel distance (CTD) 1745 km (both like PFOS); the travel efficiency (TE) in % was higher than for PFOS with 0,0146. The *in silico* methods predict that PFOA, like PFOS is globally distributed.

34. The presence of PFOA in remote areas at sites remote from known point sources like the (Canadian) Arctic indicates the potential for long-range transport (e.g. via ocean currents and / or via atmospheric transport of volatile precursors of PFOA (Environment Canada and Health Canada, 2012). For example, PFOA and PFOS have been detected in concentrations from the low- to mid-picograms per litre (pg/L) range in remote regions of the Arctic cap (US. EPA, 2014). PFASs were measured in background locations of the Norwegian Arctic and the Norwegian mainland, which are little effected by anthropogenic sources (NILU, 2013). PFOA was detected in all sediment, water and pooled soil samples. PFOA was detected in 30% of brown trout samples, in 100% of harbour seal liver (n=10; mean: 0.8 mean ng/g wt) and 100% eider eggs (n=10; mean: 1.62 ng/g wt), 80 % of Herring gull eggs (n=10; mean: 0.11 ng/g wt), and 30% of cod liver (mean: 0.09 ng/g wt n=10).

Conclusion on long-range transport according to the criteria in Annex D

35. Considering the estimated atmospheric half-life of PFOA (likely to be greater than two days based on the atmospheric lifetime reported), the persistence in combination with the estimated travel distance and the wide occurrence of PFOA and PFOA-related substances in remote areas PFOA and PFOA-related substances fulfill the criteria for long-range transport in Annex D to the Stockholm Convention.

5.4 Adverse effects

36. Short-term toxicity data are available and indicate a low acute toxicity for aquatic organisms (OECD, 2006). Long-term test data are available for four taxonomic groups including plant, crustaceans, fish and amphibians (e.g. OECD 2006). The lowest value has been reported for a mesocosm study on fish Pimephales promelas (39-d NOEC 0.3 mg/L) (ref. to OECD, 2006). In addition, a further low chronic NOEC has been obtained for the freshwater invertebrate *Moina macrocopa* (7-d NOEC 3.125 mg/L). (Ji et al., 2008).

[1] http://www.oecd.org/document/24/0,3343,en_2649_34379_45373336_1_1_1_1,00.html

37. In female and male rare minnows, 3–30 mg/L PFOA elicited inhibition of the thyroid hormone biosynthesis genes, induced vitellogenin expression in males, developed oocytes in the testes of male fish and caused ovary degeneration in females (Wei et al., 2008 cited in Environment Canada and Health Canada, 2012). Wei et al., 2007 cited in Environment Canada and Health Canada, 2012 showed that PFOA can disrupt the activity of estrogen by inducing hepatic estrogen-responsive genes in males, although the mechanism of development of testes-ova in rare minnows by PFOA exposure is not known. According to Environment Canada and Health Canada, 2012 there is experimental evidence showing the potential for PFOA to affect endocrine function where visible effects may not be apparent until the organisms reach adulthood.

38. The effect of PFOA on immune function and clinical blood parameters has been examined in a field study in bottlenose dolphins and sea turtles from Florida, Georgia and South Carolina. A direct cause–effect relationship could not be clearly established, as there may be other co-occurring contaminants. The results revealed that there may be increases in indicators of inflammation and immunity in bottlenose dolphin blood parameters in relation to PFOA, suggesting that PFOA may alter biomarkers of health in marine mammals (Peden-Adams et al., 2004 cited in Environment Canada and Health Canada, 2012). In northern fur seals no effects on blood chemistry parameters could be found (Flanary et al., 2010). De Witt et al., 2012 demonstrated that the serum levels associated with PFOA induced immune effects is higher than the concentrations reported for humans and wildlife. However the authors concluded that the risk of immune effects for humans and wildlife exposed to perfluorinated compounds including PFOA and PFOS cannot be discounted, especially when bioaccumulation and exposure to multiple perfluorinated compounds including PFOA and PFOS are considered.

39. Up to now, little is known about the mixture toxicity of PFASs at environmental relevant conditions. Due to the permanent release and their persistence in nature more than one generation will suffer from their exposure (Ahrens et al., 2014). Mixtures of PFOS and PFOA have been shown to exhibit toxic interactions on *Danio rerio* embryos that could not be explained by concentration addition or independent action (Ding, 2013 cited in Ahrens, 2014). In addition, ecotoxicity increased with increasing molar ratio of PFOS in binary mixture (Liu et al. (2010), cited in Ahrens, 2014).

40. Human exposure to PFOA as also to other PFASs mainly occurs via the diet. A review carried out by the European Food safety authority (EFSA) states that PFOA is the second most detected among 16 measured PFASs (in 9% of the samples after PFOS in 29% of the analysed samples). Across food groups, PFASs were reported more frequently in fish and other seafood, in meat and meat products and to a lesser extent in other food groups. The highest concentrations for the different PFASs were found in edible offal and in particular in liver. Individual quantified values ranged from a low of 0.00034 µg/kg for drinking water to a high of 3480 µg/kg for wild boar liver. The most important contributors to PFOA exposure in all age classes were 'Fruits and fruit products' (18 to 39 %) and 'Fish and other seafood' (7.6 to 27 %) but high variations were observed in relation to dietary habits (EFSA, 2012). The increasing relevance of PFOA as drinking water contaminant was also subject of a review by Post et al., 2012. Human exposure data are also reviewed in Kroismayr, 2012.

41. PFOA has in the European Union a legally binding harmonised classification as Carc. 2, Repr. 1B and STOT RE 1 (liver) according to Regulation (EU) No 944/2013 (index number: 607-704-00-2) amending Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures (see Section 4) as amended by Regulation (EU) No 944/2013 (index number: 607-704-00-2). The classification of PFOA is identical to the corresponding classification for its salt APFO considering that APFO data are directly relevant for the assessment of the systemic and local toxicity of PFOA (ECHA, 2011).

42. PFOA is dissociated under physiological conditions into perfluorooctanoate (PFO). PFOA is measured as PFO in human biomonitoring studies. In animal studies, ammonium perfluorooctanoate (APFO) is used and measured as PFO, but referred in studies as PFOA or APFOA. PFOA is fast absorbed, not metabolized and distributed in the body, transferred to foetus through placenta and infants via breast milk (ECHA, 2011). Long half-lives in humans are reported (see Section 5.2).

43. Effects of repeated oral exposure to PFOA have been identified in several studies and species. PFOA causes damage to the liver through prolonged or repeated exposure. Adverse effects that are of relevance for the oral route are mortalities, reduced body weight gain, cyanosis and liver cell degeneration and necrosis. The classification as STOT RE 1 also covers other routes of exposure (ECHA, 2011).

44. Animal studies have shown that APFO induces liver adenomas, Leydig cell adenomas, and pancreatic acinar cell tumours (PACT) in male Sprague-Dawley rats (Sibinski et al., 1987 cited in ECHA, 2011), and increase incidences of mammary fibroadenoma in the female rats (Biegel, 2001 cited in ECHA, 2011). According to the RAC there are insufficient data on the mode of action to conclude that APFO induced tumours are not relevant for humans and classified PFOA as Carc 2, H351.

45. PFOA is classified as Repr 1B, H360D "May damage the unborn child". Clear evidence exists for APFO on developmental effects from perinatal studies in mice. Gestational administration of APFO was sufficient to impair neonatal growth and development and developmental toxicity was linked to the gestational phase of exposure (ECHA, 2011).

46. APFO has also been found to be transferred to infants through breast-feeding and the RAC agreed on an additional classification on lactation effects (CLP: Lact., H 362: May cause harm to breast-fed children) (ECHA, 2011).

47. Several studies investigated exposure and related health effects in workers and different population groups.

48. The C8 Health Project was a population-wide health study to determine a probable link between PFOA exposure and human disease. Drinking water has been contaminated by PFOA from the DuPont Washington Works Plant near Peakersburg, West Virginia. This plant was existing since 1948 and its fluorotelomer production was using PFOA since 1951. 69,030 subjects residing in the 6 public water districts contaminated by PFOA were included in the study. When the association of PFOA and PFOS was investigated in a cross-sectional study including all participants aged 18+ not taking cholesterol –lowering medication all but one serum lipid showed significant increasing trends by increasing deciles of either compound (Steenland et al., 2009). Apart from serum lipids, uric acid was positively associated with both PFOA and PFOS in a subsequent study including 51,951 residents (Steenland et al., 2010). In exposed workers serum PFOA was positively associated with total cholesterol, with an increase of 1.06 mg/dL of cholesterol for each 1 ppm increase in PFOA (P 0.011) after adjusting for age, BMI, gender, and decade of hire (Sakr et al., 2007).

49. Data of this cohort (C8 Health Project) were also subject to analysis for endocrine disruption in women (Knox et al., 2011a). Serum estradiol levels and onset of menopause were assessed in 29,957 women aged 18-65 years. For women in the highest quintile of PFOA the odds of having experienced menopause were significantly higher.

50. This cohort also provided evidence for disruption of thyroid function related to PFASs (Knox et al., 2011b). A cross-sectional study amongst 52,296 adults revealed significant elevations in serum thyroxine and significant reduction in T3 uptake associated with serum PFOA in all participants. Analyses were stratified by gender and age group. Data of 3,974 adults sampled 1999-2006 in the frame of the US National Health and Nutrition Examination Survey (NHANES) were analysed in regression models for PFOS/PFOA versus thyroid disease status. The authors conclude that higher concentrations of serum PFOA and PFOS are associated with current thyroid disease in the general adult population (Melzer et al., 2010).

51. A recent published study from the C8 Health Project survey showed a dose related increase in both kidney and testicular cancer with PFOA among 32,254 participants. The strongest dose response relationship was seen for testicular cancer with a hazard ratio (HR) of 1.0, 1.04, 1.91 and 3.17 (linear trend test p=0.04) with increasing PFOA exposure quartiles. Further the C8 science panel indicated a probable link between PFOA and kidney cancer based on a worker mortality study conducted by the Science Panel (Steenland et al., 2012, ECHA, 2014).

52. A recent review concluded that developmental exposure to PFOA adversely affects human health based on sufficient evidence of decreased fetal growth in both human and nonhuman mammalian species (Lam et al., 2014).

Conclusion on adverse effects according to the criteria in Annex D

53. Available experimental and epidemiological evidence shows that PFOA, PFOA salts and PFOA-related substances can damage human health and wildlife.

5.5 Comparison of toxicity or ecotoxicity data with detected or predicted levels of PFOA

54. The most recent quantitative risk characterization for human health for PFOA is from 2014 (ECHA, 2014) and summarized below. For the exposure assessment many studies in Europe as well as around the world have measured PFOA concentrations in human serum/plasma of general populations. Concentrations in populations exposed to high drinking water concentrations are

considered relevant to include for the high exposure scenario as releases in drinking water might affect large general populations and this is not unlikely to happen, especially since not all sources and uses of PFOA are known. Serum concentrations of PFOA in the European adult population are found in the range from 0.1 to 100 ng/mL (ECHA, 2014). Mean concentrations based on the median and max concentrations reported in the single studies were calculated to be 3.5 ng/mL and 21 ng/mL, respectively. Serum levels of PFOA in children world-wide has been reported to be in the range 0.3 to 22 ng/mL, with the exception of children that have been drinking heavily contaminated drinking water. In this case the highest serum concentration was 1283 ng/mL. Mean concentrations based on the median and max concentrations reported in the single studies were calculated to be 6.4 ng/mL and 108 ng/mL, respectively (ECHA, 2014). For Inuit children geometric mean and max serum levels of 1.6 ng/ml und 11 ng/ml were measured (Environment Canada and Health Canada, 2012). PFOA concentrations in both cord blood have been measured in a few studies world-wide and the mean concentrations based on the median and max concentrations reported in the single studies were calculated to be 1.3 ng/mL and 4.1 ng/mL, respectively (ECHA, 2014).

55. Several DNELs (derived no-effect level) were estimated for the EU human health risk characterisation (ECHA, 2014): 1) A DNEL of 209 ng/mL for the general population was derived from a developmental study (Lau et al., 2006) taking into account vulnerable individuals such as the foetus and its exposure during a critical period during foetal development. 2) A DNEL of 277 ng/mL for the general population was derived from a second developmental study (Abbot et al., 2007 cited in ECHA, 2014). 3) A DNEL of 2 ng/mL for the general population was derived from a study by Macon and co-workers (Macon et al., 2011 cited in ECHA, 2014) showing stunted mammary gland development in the offspring after gestational exposure to PFOA. Several studies indicate a low dose effect, especially of the endocrine system, and a DNEL for such endpoints should be taken into considerations when evaluating the risk of PFOA (ECHA, 2014). 4) A DNEL of 0.3 ng/mL for the general population was obtained from internal dose calculations from a human cohort study showing an inverse association between PFOA and birth weight (Fei et al., 2007 in ECHA, 2014). Johnson et al. performed a meta-analysis of the available literature and concluded that there is sufficient human evidence that developmental exposure to PFOA reduces foetal growth (Johnson et al 2014 cited in ECHA, 2014). The human studies on reduced birth weight are supported by animal studies showing the same effect on foetal growth (Koustas et al., 2014 cited in ECHA, 2014).

Table 3a. RCR is calculated for internal values measured in the general adult population against the different DNELs obtained (Source: ECHA, 2014)

PFOA ng/ml		**PFOA ng/ml**	**Reference for DNEL estimation**	**RCR**	
Internal serum values		DNEL		mean	high
3.5	21	209	Lau et al. 2006	0.02	0.10
3.5	21	277	Abbot et al., 2007 cited in ECHA, 2014	0.01	0.08
3.5	21	2	Macon et al., 2011 cited in ECHA, 2014	1.8	10.5
3.5	21	0.3	Fei et al. 2007 cited in ECHA, 2014	11.7	70

Table 3b. RCR is calculated for internal values measured in children against the different DNELs obtained (Source: ECHA, 2014)

PFOA ng/ml		**PFOA ng/ml**	**Reference for DNEL estimation**	**RCR**	
Internal serum values		DNEL		mean	high
6.4	108	209	Lau et al., 2006	0.03	0.51
6.4	108	277	Abbot et al., 2007 cited in ECHA, 2014	0.02	0.39
6.4	108	2	Macon et al., 2011 cited in ECHA, 2014	3.2	54

56. When considering the adverse effects of PFOA on human health, risks (RCRs >1) have been identified for the general population and children in particular (cf. Table 3a and 3b). Also for Inuit children for the high exposure group (serum levels of 11 ng/ml) a risk can be anticipated based on the lowest DNEL. However the 2012 assessment from Environment and Health Canada identified margins of exposure greater than 660 from the comparison of the PFOA serum levels associated with adverse effects in laboratory animals (13–77 μg/mL) with the serum or plasma levels found in non-occupationally exposed adults, infants and children (0.00162–0.0195 μg/mL) and concluded that these margins are considered to be adequately protective to account for uncertainties in the hazard and exposure databases (Environment Canada and Health Canada, 2012).

57. Concerning the risk characterization for the environment the risks of PBT/vPvB substances cannot be adequately addressed in a quantitative way, due to the high uncertainties regarding long-term exposure and effects (ECHA, 2014). Therefore no PECs (predicted environmental concentrations) have been calculated and no PNECs (predicted no effect concentrations) have been derived in the recent EU risk characterisation for PFOA (ECHA, 2014). Also ECHA concluded that the information on time trends was not sufficient. The few available time trend studies indicate a decreasing trend in biota. As PFOA is not degradable this decreasing trend is not proven by water and sediment samples suggesting that oceans and sediments are sinks of PFOA (ECHA, 2014). Also in the assessment from Environment and Health Canada it is stated that quantitative risk estimates for persistent and bioaccumulative substances such as PFOA are highly uncertain and are likely to be underestimated and have limited relevance. (Environment Canada and Health Canada, 2012).

58. In the Canadian quantitative risk characterisation for the environment risk quotients for pelagic organisms indicate a low likelihood of risk from exposures at current concentrations in the aquatic environment (PEC/PNEC ratios are in the range of 0.001 – 0.6 for different exposure scenarios and species). The risk quotient for Canadian mammalian wildlife (i.e., polar bears) is less than 1; however, due to the persistence of the substance, its tendency to accumulate and biomagnify in a variety of terrestrial and marine mammals, its hepatotoxicity, and the upward temporal trend of PFOA concentrations in polar bears and some other species, PFOA concentrations in polar bears may approach exposures resulting in harm (Environment Canada and Health Canada, 2012).

6. Statement of the reasons for concern and need for global action

6.1 Reasons for global concern

59. Based on the existing data PFOA, PFOA salts and PFOA-related substances can be considered to meet the screening criteria in Annex D for persistence, bioaccumulation, long-range transport and adverse effects under the Stockholm Convention.

60. Concern stimulated some countries as well as companies to take actions to reduce emissions. However PFOA, its salts and PFOA-related substances are expected to be used by manufacturers and downstream users in many parts of the world with unknown current production volumes.

61. PFOA, PFOA salts and PFOA-related substances are highly persistent, bioaccumulating and toxic. Adding to the above concern is that PFOA, PFOA salts and PFOA-related substances are global contaminants, as PFOA and PFOA-related substances have the potential for long-range environmental transport which makes emissions of these substances a transboundary pollution problem. The occurrence and distribution of PFOA is shown for humans, biota, and the global environment. . Adverse effects on the general population and children in particular as well as wildlife cannot be excluded. Therefore international action is warranted.

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