**PFOA, ITS SALTS AND PFOA-RELATED COMPOUNDS**

**DRAFT RISK MANAGEMENT EVALUATION**

**BACK GROUND DOCUMENT**

15 March 2017

Contents

[1 List of Acronyms 3](#_Toc477340223)

[2 Additional Annex E information 4](#_Toc477340224)

[2.1 Production data, including quantity and location 4](#_Toc477340225)

[2.2 Uses 5](#_Toc477340226)

[2.3 Releases, such as discharges, losses and emissions 8](#_Toc477340227)

[3 Summary of alternatives according to ECHA 12](#_Toc477340228)

[4 Information related to adverse effects of alternatives 14](#_Toc477340229)

[5 References considered for adverse effects of alternatives as summarized in table 6 20](#_Toc477340230)

# List of Acronyms

Table 1: List of acronyms used in the draft risk management evaluation

|  |  |
| --- | --- |
| AFFF | Aqueous film-forming foams  |
| CEPA | Canadian Environmental Protection Act |
| CLP | Classification, Labelling and Packaging  |
| CMP | Chemical Management Plan |
| EAA | Environment Agency Austria |
| EC50 | Half maximal effective concentration |
| ECF | Electrochemical fluorination  |
| ECHA | European Chemicals Agency |
| EPA | Environmental Protection Agency |
| FFFC | Fire Fighting Film Coalition |
| ICT | Information and Communications Technology  |
| LC | Long chain |
| LC/MS-MS | Liquid chromatography/tandem mass spectrometry |
| LC50 | Median lethal concentration |
| MCCP | Medium-chain chlorinated paraffin |
| NHANES | National Health and Nutrition Examination Survey |
| NOEC | Non-observed adverse effect level |
| NRL | United States Naval Research Laboratory |
| OECD | Organisation for Economic Co-operation and Development |
| OSPAR | Oslo/Paris Commission for the Protection of Marine Environment of the North East Atlantic |
| PBT | Persistence, Bioaccumulation, Toxicity |
| POPRC | Persistent Organic Pollutants Review Committee |
| PPA | Polymerization processing aids |
| RAC | Committee for Risk Assessment |
| REACH | REACH is a regulation of the European Union, adopted to improve the protection of human health and the environment from the risks that can be posed by chemicals |
| SAICM | Strategic Approach to International Chemicals Management  |
| SCCP | Short-chain chlorinated paraffin |
| SEAC | Committee for Socio-economic Analysis |
| SVHC | Substances of Very High Concern  |
| TSCA | Toxic Substances Control Act |
| UCMR | Unregulated Contaminant Monitoring Rule |
| US EPA | United States Environmental Protection Agency |
| ZDHC | Zero Discharge of Hazardous Chemicals |

# Additional Annex E information

1. Several parties and observers submitted additional Annex E information related to production, use or releases. . Information from Annex E related submissions are compiled in the present background document to the draft risk management evaluation.

## Production data, including quantity and location

1. The following table summarizes additional Annex E information on production data, including quantity and location submitted by reviewing parties and countries.

Table 2: Additional Annex E information on production data, including quantity and location

| **Submission** | **Information** |
| --- | --- |
| Australia 2016 | Chemicals in this group are not currently imported into or manufactured in Australia. In July 2006, NICNAS collected information on the manufacture, importation and uses of perfluorinated chemicals including PFOA-related substances and products/mixtures containing these substances for the calendar years 2004 and 2005. Information provided to NICNAS indicated that:* No PFOA-related chemicals are manufactured in Australia.
* PFOA containing products were imported into Australia. These were:
1. An antifoam product containing <10% of a PFOA-related chemical (CAS Nr not specified) was imported in 2005 for use in a dyeing process with sulfur dyes. The total quantity imported was approximately 10 kg.
2. A de-dusting product for industrial use and a consumer paint product, both containing less than 100 ppm of a PFOA salt, were imported. The total volumes of PFOA salt in both products were 10 kg and 71 kg in 2004 and 2005, respectively. The concentration of PFOA salts in these products was reduced to less than 10 ppm in 2006.
 |
| Austria 2016a | There is currently no production of PFOA in Austria |
| Canada 2016a | "[In 2000] No manufacturing or import of PFOA or long-chain PFCAs in Canada were reported above the 100 kg reporting threshold. However, the import of several long-chain PFCA precursors into Canada was reported in quantities greater than 100 kg.In 2005, a second industry survey regarding PFA/FA substances was conducted by Environment Canada under the authority of section 71 of CEPA 1999 (Canada 2005). Long-chain PFCAs were not reported to be manufactured in Canada for the 2004 calendar year. However, some PFOA salts and long-chain PFCAs precursors were imported into Canada in quantities greater than the reporting threshold of 100 kg. " |
| Denmark 2016 | The report “PFOS, PFOA and other perfluoralkyl and polyfluoroalkyl substances”, Environmental Project 1475, 2013, which is part of the Danish review of the national list of unwanted substances (LOUS) may contain relevant information for Annex E, but also relevant information for Annex F. This publication covers relevant Danish information on regulation, use, waste issues, environmental and health issues and alternatives. The report is available at:<http://www2.mst.dk/Udgiv/publications/2013/04/978-87-93026-03-2.pdf>  |
| Monaco 2016 | This chemical is not produced nor used in Monaco |
| FluoroCouncil 2016a | FluoroCouncil companies have phased out the use, manufacture, and sale of PFOA and PFOA-related compounds in accordance with the U.S. EPA Product Stewardship Program. This phase out has been accomplished globally, including e.g. China, for all FluoroCouncil companies. There are currently small amounts of PFOA related chemicals that are produced as a bi-product of short-chain fluorochemical production. They are captured and destroyed or converted to non-PFOA-related chemicals.  |
| IP Europe 2016a | Member companies do not manufacture PFOA, its salts or related substances, and must purchase the necessary materials from suppliers (EU and non-EU).From the purchased PFOA-related substances photographic product manufacturers then create mixtures, for internal use only. The photographic industry does not sell PFOA, its salts or PFOA-related substances nor preparations containing these materials, although some companies may transport mixtures between plant sites.Imaging industry member companies use certain PFOA-related substances in critical manufacturing operations for a small number of traditional and digital imaging products manufactured predominantly in the USA, Europe, China, and Japan.  |

## Uses

1. The following table summarizes additional Annex E information on the uses of PFOA, its salts and PFOA related compounds submitted by reviewing parties and countries.

Table 3: Additional Annex E information on uses of PFOA, its salts and related

| **Submission** | **Information** |
| --- | --- |
| Australia 2016 | The following Australian industrial uses were reported under previous mandatory and/or voluntary calls for information:* As a primer for non-stick metal cookware
* As fluoropolymer dispersion polymers in paints
* In fire-fighting foams
* In textile and carpet protection
 |
| Austria 2016a | Currently several uses are possible.  |
| Canada 2016a | Please refer to section 2.2 of the Regulatory Impact Analysis Statement (RIAS), Regulations Amending the Prohibition of Certain Toxic Substances Regulations, 2012. Available at: http://www.gazette.gc.ca/rp-pr/p2/2016/2016-10-05/html/sor-dors252-eng.php"PFOA and LC-PFCAs are primarily used as water, oil and grease repellants; as surfactants; and as spreading and wetting agents. PFOA and LC-PFCAs were historically imported and may continue to be imported for use in the following manufacturing sectors: textile mills, paper and packaging, paints and coatings, inks and photo media, chemical manufacturing, electrical and electronics, cleaning products, plastic and rubber products. A study conducted for the Department estimated that approximately 308 t of PFOA and LC-PFCAs were imported into Canada in 2010."Please refer to section 4 of the Proposed Risk Management Approach for Perfluorooctanoic Acid (PFOA), its Salts, and its Precursors and Long-Chain (C9-C20) Perfluorocarboxylic Acids (PFCAs), their Salts, and their Precursors. 2012. Available at: <http://www.ec.gc.ca/ese-ees/default.asp?lang=En&n=451C95ED-1> "Manufacturing was the main industrial sector using these substances according to the reported North American Industry Classification System (NAICS) codes. The manufacturing sub-sectors identified include:• Textile Mills• Paper Manufacturing• Chemical Manufacturing• Plastic and Rubber Products ManufacturingHistorical uses of PFOA include applications in industrial processes and in commercial and consumer products. PFOA and its salts are used as polymerization aids in the production of fluoropolymers and fluoroelastomers. APFO (PFOA ammonium salt), the most common commercially used salt form of PFOA, is the ammonium salt, is used primarily as a commercial polymerization aid in the manufacture of fluoropolymers such as polytetrafluoroethylene and polyvinylidene fluoride (US Government 2003; OECD 2006; Prevedouros et al. 2006), which are used in various sectors, including the automotive, electronics, construction and aerospace industries. Fluoropolymers are used in the manufacture of stain- and water-resistant coatings on textiles and carpet; hoses, cable and gaskets; non-stick coatings on cookware; and personal care products (US Government 2003). APFO is also used as a constituent in aqueous fluoropolymer dispersions, which are formulated into paints, photographic film additives and in the textile finishing industry (OECD 2006). Aqueous fire-fighting foams may also contain APFO as a component (OECD 2006; Prevedouros et al. 2006). Fluorochemicals that are potential PFOA precursors are used in the treatment of food packaging materials to enhance their properties as a barrier to moisture and grease (Begley et al. 2005). Thus, although APFO is typically not intended to remain in manufactured articles, trace amounts may be present as a contaminant or degradation product."Please refer to section 2.1 of the Consultation document - Proposed Risk Management Measure for Perfluorooctanoic Acid (PFOA) Its Salts, and Its Precursors and Long-Chain (C9-C20) Perfluorocarboxylic Acids (PFCAs), their Salts, and their Precursors. 2014. Available at: http://www.ec.gc.ca/ese-ees/default.asp?lang=En&n=2A11BA77-1#s2\_1"PFOA, itself, is not manufactured in Canada. However, quantities of the ammonium salt are imported. LC-PFCAs are not manufactured in Canada; however, several precursors to the long-chain (C9-C20) perfluorocarboxylic acids were reported to be imported into Canada.PFOA, its salts and its precursors and LC-PFCAs, their salts and their precursors were historically used, and may continue to be used, in the following industry sectors and are potentially contained in the associated products (OECD 2013).• Films, paints and coatings: paint, photographic film, water-based inks• Fire-Fighting: aqueous fire-fighting foams• Electrical and Electronics: cables, wiring, semiconductors• Product components and finished products: hoses, gaskets, non-stick cookware, personal care products• Paper and packaging: oil and grease repellent• Polymerization: polymerization processing aids (surfactants)• Textiles: protective clothing, oil and water repellent and stain release fabrics, carpetOther industry sectors would be implicated if they use product components or finished products identified in the list above. "A recent report Occurrence and use of highly fluorinated substances and alternatives by KEMI, Swedish Chemicals Agency (2015), is available at: http://www.kemi.se/en/global/rapporter/2015/report-7-15-occurrence-and-use-of-highly-fluorinated-substances-and-alternatives.pdf. The objectives of this report are ‘to give a clearer picture of where highly fluorinated substances (including PFOA) are currently used and what alternative substances, materials and technologies are available.’ |
| India 2017 | The uses of PFOA in India are; textile and leather treatment, paper treatment, firefighting agents, paints and inks, photo industry, semiconductor industry, production of fluoropolymer, surface coatings etc. |
| Japan 2016 | There are identified uses in Japan as follows:PFOA and its salts･Photo-resist and anti-reflective coatings for semi-conductors･Bleed inhibitors in bonding agents for semi-conductors･Surfactant for enzyme electrodes of clinical analyzer･Water-repellent agents for textiles･Electric insulator and moisture-proof coating agent for printed circuit boardPFOA-related compounds･Photo-resist and anti-reflective coatings for semi-conductors･Dispersant to adjust the electrical characteristics of polymers･Water-repellent agents for glass products･Coatings and levelling agentsPerfluorooctyl iodide (CAS:507-63-1)Intermediate in production of perfluorooctyl bromide which is used as solvent in pharmaceuticals manufacturing process. |
| Monaco 2016 | This chemical is not produced nor used in Monaco |
| VTB SWT 2016 | Professional, technical protective textiles which must meet durable repellency performance standards. |
| FluoroCouncil 2016a | Some PFOA Related Chemicals are produced as bi-products of other fluorochemical production which may be used as raw materials for, e.g. artificial blood  |
| TM 2016 | Professional, technical and protective textiles which must meet durable repellency performance standards. |
| IP Europe 2016a | PFOA-related substances are essential for the application of coating layers during the manufacture of some remaining conventional photographic products, i.e. products in which the image formation is based on silver halide technology: they have multiple functions, serving* as surfactants,
* as static control agents,
* as dirt repellents during coating operations,
* as friction control agents,
* and to provide adhesion control of coated layers.

PFOA-related substances are unique in that they provide the combination of all these properties in one molecule, without any adverse effects on photographic performance.As static control agents, PFOA-related substances are needed to prevent damage to the sensitized photographic layers and thus prevent product damage or even waste.These substances not only provide performance features necessary for the manufacture and use of conventional photographic products, they also provide important safety features by controlling the build-up and discharge of static electricity.The ability of PFOA-related substances to control surface tension is a critical aspect of the use of these materials as coating aids. In order to function, imaging materials must be coated with multiple thin layers at high speed – some having as many as 18 thin layers containing up to 200 chemicals and with an overall total thickness of about 0.11 mm. During the coating process the chemicals in these layers should not mix. The PFOA related materials play a key role in minimizing manufacturing waste by contributing to the technology for creating coatings of high complexity in a highly consistent manner. The coating aid must allow the rapid uniform spreading of the layers so that irregularities in the coatings are avoided. Any irregularity in coating thickness makes conventional imaging materials unusable and increases manufacturing waste significantly. Coating aids must also not be photoactive and thus not interfere with the imaging process, otherwise unacceptable fogging or speed effects may occur in the end material. |
| IPEN 2016 | PFOA-related compounds have been widely used in consumer products and in industrial applications, including as surfactants and/or fluorinated polymers for treatments for leather, textiles particularly for all weather outdoor clothing, carpets, paper packaging and ski waxes. PFOA and its salts have been used in the manufacture of fluoropolymers to produce hoses, cable and gaskets; non-stick coatings on cookware; and personal care products. PFOA is also used as a surfactant and processing aid in the manufacture of semi-conductors used in the photolithographic process. PFOA-related compounds are used as a surface treatment for stone and tiles, in medical devices, in paints and inks, floor waxes and stone/wood sealants and as an antifoam products for use in the dyeing process using sulfur dyes. PFOA-related compounds are also used as non-polymeric substances for firefighting foams, wetting agents or cleaners. |
| SIA 2016 | The semiconductor industry uses PFOA and related chemical substances during photolithography and related processes. These chemicals provide critical acidity, surfactancy and anti-reflectivity properties for photoresists, anti-reflective coatings, immersion topcoats, and overcoats used in the photolithographic process. In 2015, SIA conducted a survey of the ten major semiconductor lithography chemical suppliers. All ten suppliers responded and provided data on 2014 sales of PFOA and related substances. The total amount of PFOA and related chemical substances in semiconductor photolithography formulations sold in North America in 2014 was 532 kg. A second survey was conducted in 2016 and the total amount of PFOA and related substances in semiconductor photolithography formulations sold in North America in 2015 was 720 kg.PFOA may also be contained in semiconductor manufacturing equipment, parts, fab infrastructure and ancillary equipment. SIA conducted a survey of its members in 2016 and found that legacy PTFE is installed in facilities that were made with PFOA. The association of the industry’s suppliers, SEMI, estimates that the mass / weight of PFOA introduced into the EU annually by all semiconductor manufacturing equipment is no more than 8.40 kg per year. This represent a marginal source (0.1%) of PFOA, even in the category Articles, as the total PFOA present in articles is estimated to be <10 ton/year by the Dossier Submitter as indicated in the background document. We do not have available estimates for uses in other geographies. |

## Releases, such as discharges, losses and emissions

1. The following table summarizes additional Annex E information on releases, such as discharges, losses and emissions submitted by reviewing parties and countries.

Table 4: Additional Annex E information on releases, such as discharges, losses and emissions

| **Submission** | **Information** |
| --- | --- |
| Australia 2016 | Discharges from use of existing stockpiles of fire-fighting foams is possible. Chemicals in this group are likely to be present in the environment due to historic use, release from pre-treated articles, or the use of other chemicals. In particular, the use of fluoropolymers (which may contain PFOA residues) has previously been reported in the manufacture of non-stick metal cookware, in paints, in fire-fighting foams, and in textile and carpet protection.Articles testing undertaken in 2013 found PFOA in a range of imported articles such as carpets, cookware, clothing, umbrellas and fabric. |
| Canada 2016a | Please refer to section 2.2.2 of the Regulatory Impact Analysis Statement (RIAS), Regulations Amending the Prohibition of Certain Toxic Substances Regulations, 2012. Available at: http://www.gazette.gc.ca/rp-pr/p2/2016/2016-10-05/html/sor-dors252-eng.php"PFOA and LC-PFCAs may be found in the environment due to releases from manufacturing or processing facilities, effluent releases from wastewater treatment plants, landfill leachate, and the degradation and transformation of precursor compounds. No data are available on the actual release of these substances to the Canadian environment."Please refer to section 2.1 of the Consultation document - Proposed Risk Management Measure for Perfluorooctanoic Acid (PFOA) Its Salts, and Its Precursors and Long-Chain (C9-C20) Perfluorocarboxylic Acids (PFCAs), their Salts, and their Precursors. 2014. Available at: http://www.ec.gc.ca/ese-ees/default.asp?lang=En&n=2A11BA77-1#s2\_1"Both PFOA and LC-PFCAs may be found in the environment due to releases from fluoropolymer manufacturing or processing facilities, effluent releases from wastewater treatment plants, landfill leachates and due to degradation / transformation of PFOA precursors and precursors to LC-PFCAs." Please refer to Section 3 ‘Comprehensive overview of global and regional emissions of C4-C14 PFCAs’ on page 27 through 45 in OECD/UNEP Global PFC Group, Working towards a Global Emission Inventory of PFASs: Focus on PFCAs – Status Quo and the Way Forward. Available at: http://www.oecd.org/chemicalsafety/risk-management/Working%20Towards%20a%20Global%20Emission%20Inventory%20of%20PFASS.pdfPlease refer to Section 4.2 ‘Critical data and knowledge gaps that prevent quantification of overlooked sources’ on page 48 thought 49 in OECD/UNEP Global PFC Group, Working towards a Global Emission Inventory of PFASs: Focus on PFCAs – Status Quo and the Way Forward. Available at: http://www.oecd.org/chemicalsafety/risk-management/Working%20Towards%20a%20Global%20Emission%20Inventory%20of%20PFASS.pdf |
| Monaco 2016 | This chemical is not produced nor used in Monaco  |
| Norway 2016 | Long range transport seems to be the main source of PFOA in the Norwegian environment. "Survey of national sources, PFOA in Norway".http://www.miljodirektoratet.no/old/klif/publikasjoner/2354/ta2354.pdfPotential PFOA Precursors: Literature study and theoretical assessment of abiotic degradation pathways leading to PFOA. M-231/2014http://www.miljodirektoratet.no/Documents/publikasjoner/M231/M231.pdfPFOA isomers salts and precursors- Literature study and evaluation of physico chemical properties (TA-2944/2012):http://www.miljodirektoratet.no/old/klif/publikasjoner/2944/ta2944.pdfInvestigation of outdoor textiles with respect to determine the content of ionic perfluorinated substances (PFASs)http://www.miljodirektoratet.no/Documents/publikasjoner/M306/M306.pdfAnalysis of per- and polyfluorinated compounds in articles:http://www.miljodirektoratet.no/Documents/publikasjoner/M360/M360.pdfForest soil were able to degrade precursors to PFOA: Dasu K, Lee LS. Aerobic biodegradation of toluene-2,4-di(8:2 fluorotelomer urethane) and hexamethylene-1,6-di(8:2 fluorotelomer urethane) monomers in soils. Chemosphere. 2016 Feb;144:2482-8. doi: 10.1016/j.chemosphere.2015.11.021. |
| VTB SWT 2016 | PFOA: Approx. 50-75 g/annum in Bavaria (VTB) and Baden-Württemberg (SWT)Approx. 2-3 kg/annum in Europe |
| IP Europe 2016a | Potential for Environmental Release of PFOA during Manufacturing.Environmental releases from the manufacturing of conventional photographic products are estimated to be extremely low for a number of reasons including:1. the small amounts of PFOA related materials added during the coating stage of the photographic product (0.1-0.8 μg/cm2) have beneficial effects throughout the life of the product. Therefore the PFOA related material must predominantly remain in the product for the product to perform adequately;2. manufacturing facilities for photographic materials either have incineration capability on-site or use incineration facilities available through off-site contracts. Wastes containing PFOA’s may arise from a variety of sources. In all cases, these waste streams are managed appropriately to minimize the potential for exposure and release to the environment.Wastes from Coating OperationsWastes from coating are disposed of through high temperature incineration. This waste category has been estimated as 1-3% of the total PFOA material in analogy with former data for PFOS developed in the course of the former regulatory process for PFOS. Coating materials that are unused but excess are sent for silver recovery by incineration at high temperature. This category of waste may account for 5-28% of the total amount of PFOA’s used, again in analogy with former PFOS data.Some companies may use PFOA related substances in the overcoat layer. Whereas the overcoat does not contain silver (as opposed to photographic emulsion layers), any excess is not sent for silver recovery by incineration but rather treated in a large STP. This quantity of PFOA-related substance is estimated to be well below 1 kg per year and is further declining because of market trends.Wastes from Finishing OperationsThe finishing stage involves slitting the rolls of film that are up to several metres wide into sizes appropriate for the product type. The wastes from this process are all solid and are either incinerated directly or incinerated after recovery of silver and PET (polyethylene terephthalate) film base and other materials. Ultimately, all waste from finishing is incinerated, accounting for an estimated 5-25% of the total of PFOA chemicals.Wastes from Photo-processing OperationsI&P Europe member companies no longer use PFOA’s in their photo-processing solutions.During the wet processing of any photographic film or paper containing PFOA’s, we would anticipate very little PFOA chemical being released.This is confirmed by analytical data yielding a PEC/PNEC of 0.000 24 << 1 in the wash section of a wet film processor for medical film, which constitutes a worst case example, and a PEC/PNEC = 0. 000 000 010 << 1 at the emission point of that processor in a typical hospital setting in Germany (\*\* annex 2).\*\*: reference “Use of PFOA in critical photographic applications” – presentation at the Workshop on PFOA and its Ammonium salt. Production, use, risk – 4 May 2010, slide 10 (see annex 2)Potential for Environmental Release of PFOA during Product Use.Environmental releases originating from photographic products are estimated to be very low. The imaging industry aggressively recycles hundreds of millions of kilograms of manufacturing and post-customer waste annually, including solvents, PET, and silver. Because of the high value of silver, I&P Europe members have developed highly effective processes to recover as much used and waste photographic material as possible in order to recover the precious metal.Consumer film and paper (except for small amounts of materials returned by photofinishers) are usually not returned to the manufacturer. Consumers typically store their film and printed images indefinitely and usually across generations. Materials that are discarded are usually disposed of in municipal solid waste systems. The proportion of municipal waste that is incinerated will vary considerably on a national and local level.Recycling of commercial film may be carried out with several goals in mind: recovery of silver; recovery of film base material (PET); and protection of intellectual property or sensitive information. For film that is constructed on a PET base, the emulsion layers are separated using enzymes or chemicals, the PET base is separated and sent for recovery, and the emulsion solutions are either biologically treated or chemically treated with a flocculant, precipitated, dried and are in both cases subsequently incinerated at high temperature to produce an ash that is used for recovery of silver. Film that is not on a PET base is incinerated directly at high temperature to recover the silver. For commercial (e.g., entertainment, industrial x-ray, graphics arts, and printing) and medical imaging industries, film materials are collected by a small number of registered organizations who are responsible for the secure destruction of the film in order to protect private information or intellectual property. The materials are incinerated and the silver and other raw materials are recycled as described above.Any waste solvents are incinerated in hazardous waste incinerators. To treat wastewaters, most recyclers have primary treatment facilities on-site so as to maximize silver recovery; sludges from primary treatment facilities are collected and used for silver recovery. Recycling operations located at manufacturing sites also have secondary wastewater treatment systems where sludges are collected and incinerated at high temperatures. |
| IPEN 2016 | PFOA is released into the air and water from waste sites, manufacturing facilities, sewerage treatment works and fire-fighting operations. They migrate out of consumer products like all-weather clothing, carpets and camping gear finding their way into household air and dust, soil, ground and surface water and food. Additionally, many PFOA-related substances (e.g. fluoropolymers) can degrade to PFOA under certain conditions. Researchers in 2015[[1]](#footnote-1) concluded that emissions from consumer products imported from China were responsible for 1.5% of PFOA discharges to wastewater. DuPont is reported to have released approximately 1,136,364 kg of PFOA into the air and water around its West Virginia plant between 1951 and 2003.[[2]](#footnote-2) In 2004, DuPont settled a class-action covering 80,000 people affected by PFOA contamination of their drinking water. The U.S. military is currently assessing 664 sites where the military has conducted fire or crash training using PFC based firefighting foams.PFOA has been found in drinking water collected from 34 locations including capital cities and regional centers in Australia. PFOA and PFOS were the most commonly detected; 44% and 49% of all samples respectively. While the maximum concentration in any sample was PFOS at 16 ng /l, the second highest maximums were for PFHxS and PFOA measured at 13 and 9.7 ng/l.[[3]](#footnote-3) In Australian water reclamation and recycling plants, PFOS, PFOA, PFHxS and perfluorohexanoic acid (PFHxA) were the most frequently detected PFCs. Only those recycling plants using reverse osmosis (RO) technology were shown to reduce PFC concentrations to below detection and reporting limits (0.4–1.5 ng/l). [[4]](#footnote-4) In an Australian study of leachate from landfills, evaporation and aeration ponds, PFOA was found in every sample. (0.5-0.88ug/l) with 6 samples returning measurements of PFOA greater than 0.5ug/l. [[5]](#footnote-5)The use of PFOA in fire-fighting foams has resulted in direct releases to the environment resulting in contamination of groundwater in Germany, Sweden, the US and Australia. In Italy in 2013, surface, groundwater and tap water were found to be contaminated downstream from a PFC/PFAS production plant. As PFOA does not degrade, once released to aquifers they are transported along with the groundwater, [[6]](#footnote-6) with the concentrations decreasing only due to diffusion and dispersion. In Australia, preliminary sampling of national defence sites, detected PFOA at RAAF Base Townsville in both groundwater (<0.05 – 4.84 ug/l) and surface water (<0.01-1.74ug/l); in surface water at RAAF Base Amberley (<0.01- 0.12 ug/l) and HMAS Creswell, Jervis Bay Range Facility (<0.01 - 0.2 ug/l); and in groundwater at HMAS Stirling WA (<0.02 - 22.6 ug/l). [[7]](#footnote-7) At the Army Aviation Centre Oakey, 63 groundwater samples returned PFOA detections from <LOR to 45.5 ug/l. Of the 25 surface water samples taken from drainage lines, PFOA ranged from <LOR to 15.5 ug/l. [[8]](#footnote-8)Groundwater sampling at the regional Gold Coast airport over 6 years has consistently detected PFOA up to 64.6 ug/l. [[9]](#footnote-9) Airservices Australia have advised that its investigations identified 36 sites that have, or are suspected of having, perfluorinated compounds (PFCs) residues as a result of AFFF use.[[10]](#footnote-10) |
| SIA 2016 | PFOA and related substances are used in both organic and aqueous formulations. For organic formulations, the majority of waste is collected and disposed via incineration or fuel blending; we estimate that approximately 3 percent is emitted to wastewater. This estimate is consistent with the conclusions in the OECD Emission Scenario Document (ESD) on Photoresist Use in Semiconductor Manufacturing and the Opinion of the SEAC and RAC in Europe. Aqueous wastes are incinerated/fuel blended or sent to industrial wastewater. Additional data collection is needed to understand the amount of PFOA from aqueous formulations that may be disposed to industrial wastewater and potentially released to the environment. |

# Summary of alternatives according to ECHA

1. The following table summarizes some fluorinated and non-fluorinated alternatives for different industry branches (ECHA, 2015a).

Table 5: Fluorinated and non-fluorinated alternatives for different branches





# Information related to adverse effects of alternatives

1. A key consideration for alternatives to PFOA is the Stockholm Convention POPRC “General guidance on considerations related to alternatives and substitutes for listed persistent organic pollutants and candidate chemicals” (UNEP/POPS/POPRC.5/10/Add.1). The POPRC Guidance deals with the issue of “regrettable substitution”, stating that a safer alternative should not, “have hazardous properties that raise serious concern, such as mutagenicity, carcinogenicity or adverse effects on the reproductive, developmental, endocrine, immune or nervous systems” and that “attention should be paid to the potential for harm under actual conditions of use by consumers and indications that the processing or manufacturing conditions of the alternative might increase health risks of factory workers (IPEN, 2017[[11]](#footnote-11)).
2. Article 3 of the Stockholm Convention is also pertinent to discussion of alternatives and possible exemptions. Article 3, paragraph 3 obligates Parties obligates Parties with regulatory and assessment schemes to take measures to regulate with the aim preventing the production and use of new pesticides or new industrial chemicals that exhibit the characteristics of POPs. Article 3 also obligates Parties to consider POPs characteristics when conducting assessments of pesticides or industrial chemicals currently in use (IPEN, 201711).
3. The following table summarizes information related to adverse effects of alternatives. Information were mainly provided by IPEN. Additional information related to adverse effects of alternatives support the assessment of alternatives performed in the draft risk management evaluation (see chapter 2.3).

Table 6: Information related to adverse effects of alternatives according to information provided by IPEN. The information supports the assessment of alternatives mentioned in the draft risk management evaluation

| **Alternative** | **Information on possible adverse effects** | **Reference** | **Party/observer** |
| --- | --- | --- | --- |
| 6:2 FTOH | Unlike PFOA, which is known to not be metabolized in vivo, 6:2 FTOH has been demonstrated in several rat oral and inhalation metabolism studies to metabolize rapidly. Furthermore, in vitro studies using isolated hepatocytes from mice, rats, and humans showed half-lives of 6:2 FTOH to be 22, 30, and 100 minutes, respectively. Majority of the parent 6:2 FTOH compound is metabolized to 5:3 fluorotelomer acid and the PFCAs (PFBA, PFHxA, and PFHpA). However, there is a lack of data on the excretion of these metabolites, thus not knowing whether these metabolites could cause harm if they remain in the body for an extended period of time. Fluorine retention in liver and fat has been observed in one rat metabolism study via gavage. | ECHA, 2015a |  |
| 6:2 FTOH | One study using isolated rat hepatocytes showed 6:2 FTOH to be less cytotoxic than the other fluorotelomer alcohols (e.g., 4:2 and 8:2 FTOHs) with a LC50 of 3.7±0.54 mM.  | Martin et al., 2009 |  |
| 6:2 FTOH | Regarding genotoxicity and mutagenicity, the majority of the studies reported no significant findings.  | Oda et al., 2007; Lindeman et al., 2012 |  |
| 6:2 FTOH | At higher concentrations (e.g., 25 mg/kg/day), adverse reproductive and developmental effects such as reduction in pup survival and pup body weight in rodents have been demonstrated. Even though the severity of observed effects was greater in mice compared to rats, the derived NOAELs were identical in both species with 5 mg/kg/day for systemic toxicity and 25 mg/kg/day for offspring viability and growth. | Mukerji et al., 2015 cited by ECHA, 2015a |  |
| 6:2 FTOH | 6:2 FTOH has been shown to stimulate proliferation of resting cells by driving them to enter the S-phase of the cell cycle, and this effect might be mediated via interaction with the estrogen receptor.  | Maras et al., 2006; Vanparys et al., 2006 |  |
| 6:2 FTOH | Compared to the endogenous ligand estradiol-17β, 6:2 FTOH appears to have low binding activity to human estrogen receptor α or β  | Ishibashi et al., 2007 |  |
| 6:2 FTOH | 6:2 FTOH is considered moderately toxic to aquatic organisms but less than 8:2 FTOH, and it has a notified classification as Aquatic chronic 2. The existing data shows that short-chain PFCAs have low toxicity to aquatic organisms (except fish toxicity of PFPeA).  | ECHA, 2015a |  |
| 6:2 FTOH | 6:2 FTOH alters gene expression in the hypothalamic-pituitary-gonadal (HPG) axis and increases plasma estradiol and testosterone levels in zebra fish indicating endocrine disruption. | Liu et al., 2009 | IPEN |
| 6:2 FTOH | In male medaka fish (Oryzias latipes), 6:2 FTOH induces hepatic vitellogenin through activation of the estrogen receptor, indicating endocrine disruption. | Ishibashi et al., 2008 | IPEN |
| 6:2 FTOH | In cultured tilapia hepatocytes, 6:2 FTOH caused a dose-dependent induction of vitellogenin. | Liu et al., 2007 | IPEN |
| 6:2 FTOH | 6:2 FTOH also shows dose-dependent interaction to the human endocrine receptor in vitro. | Ishibashi et al., 2007 | IPEN |
| 6:2 FTOH | 6:2 FTOH is also found in Arctic air and in the Antarctic Peninsula raising concerns about its long-range transport properties | Bossi et al., 2016; Shoeib et al., 2006; Wang Z et al., 2015 | IPEN |
| 6:2 FTOH | 6:2 FTOH is released from textiles and found in indoor air including in office environments and shops selling outdoor clothing. | Schlummer et al., 2013; Fraser et al., 2012 | IPEN |
| 6:2 FTOH | 6:2 FTOH is also widely found in food contact materials and migrates into water and other solvents of varying polarity. | Yuang et al., 2016 | IPEN |
| 6:2 FTOH | A variety of consumer products contain and release 6:2 FTOH and it is also found in house dust. | Vestergren et al., 2015; Liu X et al., 2015; Kotthoff et al., 2015; Liu et al., 2013; Tian et al., 2016; Shoeib et al., 2016; Santen et al., 2016 | IPEN |
| 6:2 FTA | Related compounds 6:2 FTA and 6:2 FTS are not as well characterized, but show some similar characteristics as 6:2 FTOH. 6:2 FTA is found in consumer products and released from them to indoor air. | Langer et al., 2010; Santen et al., 2016 | IPEN |
| 6:2 FTS | 6:2 FTS is persistent, found in maternal and cord serum, found in the effluent of an airport industrial treatment plant, and found in outdoor consumer products. | Wang et al., 2011; Yang et al., 2016; Houtz et al., 2016; Santen et al., 2016 | IPEN |
| 6:2 FTOH | In summary, 6:2 FTOH is persistent; moderately toxic to aquatic organisms; displays a variety of adverse effects including reproductive and developmental effects and endocrine disruption; is degraded to persistent metabolites; is found in the Arctic and Antarctic; and released from products into air and dust. These characteristics are not consistent with criteria for a safer alternative to PFOA. Related compounds 6:2 FTA and 6:2 FTS are not as well-characterized but also raise concerns for their similar properties. | UNEP/POPS/POPRC.5/10/Add.1 | IPEN |
| PFHxS | Perfluorohexane sulfonate (PFHxS) is another common chemical alternative to PFOA and a widespread environmental contaminant, including in drinking water. | Gao et al., 2015; Kunacheva et al., 2011; Chen X et al., 2015; Boiteux et al., 2012; Yeung et al., 2013 | IPEN |
| PFHxS | PFHxS is found in the Arctic, including in wildlife and humans. | Zhao et al., 2012; Verreault et al., 2005; Long et al., 2015; Leter et al., 2014 | IPEN |
| PFHxS | PFHxS bioaccumulates in the food web and is found in gulls, wheat, and earthworms. | Haukås et al., 2007; Letcher et al., 2015; Vicente et al., 2015; Zhao et al., 2014 | IPEN |
| PFHxS | PFHxS causes endocrine disruption in vitro and alters the function of the thyroid hormone receptor. | Webster et al., 2016; Kjeldsen and Bonefeld-Jørgensen, 2013; Long et al., 2013 | IPEN |
| PFHxS | A variety of other PFHxS impacts include inducing apoptosis in brain cells; altering brain proteins essential for development in mice; affecting genes involved in brain development in chickens; and impairing lipoprotein production in rats. | Lee et al., 2014; Lee and Viberg, 2013; Cassone et al., 2012; Bijland et al., 2011 | IPEN |
| PFHxS | PFHxS is found in pregnant women and cord blood; efficiently transferred across the placenta; and associated with decreased birth weight in newborn humans. | Fisher et al., 2016; Lee et al., 2013; Maisonet et al., 2012; Manzano-Salgado et al., 2015; Hanssen et al., 2012 | IPEN |
| PFHxS | PFHxS is transferred to infants during breast feeding, exposing the newborn infant. | Bjermo et al., 2013; Mondal et al., 2014 | IPEN |
| PFHxS | Increasing prevalence of ADHD in children is associated with PFHxS levels. | Stein and Savitz, 2011; Hoffman et al., 2010 | IPEN |
| PFHxS | PFHxS affects blood lipids during pregnancy and alters sperm morphology in humans. | Haug et al., 2014; Toft et al., 2012 | IPEN |
| PFHxS | PFHxS is associated with impaired glucose tolerance and affects blood lipids and chlolesterol ratios in humans. | Shapiro et al., 2016; Fisher et al., 2012; Starling et al., 2014 | IPEN |
| PFHxS | There is a monotonic association between PFHxS levels and earlier menopause in women. | Taylor et al., 2014 | IPEN |
| PFHxS | PFHxS is widely found in children and adults, including in fluorochemical industry workers. | Bao et al., 2014; Alves et al., 2015; Landsteiner et al., 2014; Gyllenhammar et al., 2015; Wan et al., 2013; Cho et al., 2015; Gomez-Canela et al., 2015; Jin et al., 2011; Wang et al., 2012 | IPEN |
| PFHxS | In summary, PFHxS displays a variety of adverse effects and is a widespread environmental and human contaminant which is also found in the Arctic and appears to bioaccumulate in the food web. These characteristics are not consistent with criteria for a safer alternative to PFOA. | UNEP/POPS/POPRC.5/10/Add.1 | IPEN |
| PFHxA | Other C6 alternatives to PFOA also raise concerns. Perfluorohexanoic acid (PFHxA) is found in the Arctic and in an Antarctic marine mammal. | Zhao et al., 2012; Routti et al., 2015 | IPEN |
| PFHxA | PFHxA widely contaminates the environment, including oceans, rivers, landfill leachates, dust and drinking water. | Yamada et al., 2014; Karaskova et al., 2016; Shiwaku et al., 2016; Zafeiraki et al., 2015; Fuertes et al., 2016; Gallen et al., 2016; Houtz et al., 2016; Perkola and Sainio, 2013; Rodriguez-Jorquera et al., 2016; Brumovsky et al., 2016; Sharma et al., 2016; Lu et al., 2015; Yu et al., 2013; Shan et al., 2015; Lorenzo et al., 2016; Campo et al., 2014; Chen X et al., 2015; Sanchez-Vidal et al., 2015; Gonzalez-Gaya et al., 2014; Takemine et al., 2014; Lui et al., 2015; Pan et al., 2014; Liu WX et al., 2015 | IPEN |
| PFHxA | Fluoropolymer plants release PFHxA to drinking water resources. | Dauchy et al., 2012 | IPEN |
| PFHxA | PFHxA is efficiently translocated into plants, raising food contamination concerns. | Bizkarguenaga et al., 2016 | IPEN |
| PFHxA | PFHXA is also found in a variety of outdoor consumer products such as jackets, trousers, and boots. | Santen et al., 2016 | IPEN |
| PFHxA | PFHxA is also found in humans including in amniotic fluid and human milk and in higher concentrations in people with Gilbert Syndrome. | Zhang Tao et al., 2013; Kang et al., 2016; Gebbink et al., 2015; Wan et al., 2013; Fan et al., 2014 | IPEN |
| PFHxA | PFHxA is not well-characterized toxicologically but acts as a developmental toxicant in Xenopus embryos in vitro, decreases survival in female Sprague Dawley rats, and is negatively associated with altered testosterone levels in male adolescents | Kim et al., 2015; Klaunig et al., 2015; Zhou et al., 2016 | IPEN |
| PFBS | C4 compounds such as perfluorobutane sulfonate (PFBS) are also used as PFOA alternatives. Like the C6 compounds, PFBS is found in the Arctic and highly resistant to microbial degradation. | Zhao et al., 2012; Ochoa-Herrera et al., 2016 | IPEN |
| PFBS | PFBS is found in rivers and sediment near manufacturing plants and more widely as a contaminant in rivers and marine biota such as humpback dolphins and finless porpoises. | Chen H et al., 2015; Meng et al., 2015; Wang P et al., 2015; Zhu et al., 2015; Sharma et al., 2016; Gao et al., 2015; Zhang Y et al., 2013; Liu B et al., 2015; Lam et al., 2016; Chen X et al., 2015; Shao et al., 2016; Lorenzo et al., 2016; Pan et al., 2014; Eschauzier et al., 2010 | IPEN |
| PFBS | PFBS is also found in wastewater and drinking water treatment plants along with other PFCs where it is persistent to sludge treatment. | Gómez-Canela et al., 2012; Pan et al., 2016; Campo et al., 2014 | IPEN |
| PBFS | PFBS is readily taken up in maize. | Krippner et al., 2014 | IPEN |
| PBFS | PFBS is also widely found in outdoor consumer products such as ski waxes, jackets, trousers, and boots as well as leather samples. | Kotthoff et al., 2015; Santen et al., 2016 | IPEN |
| PBFS | PFBS contaminates drinking water and is found in humans, including in children. | Zafeiraki et al., 2015; Gyllenhammar et al., 2015; Landsteiner et al., 2014; Glynn et al., 2012; Alves et al., 2015; Bao et al., 2014 | IPEN |
| PBFS | PBFS is not well-characterized toxicologically but has been found to disrupt lipid assemblies, modulate immune response in vitro, inhibit aromatase in human placental cells, and alter heart rates and behavior in zebra fish. | Oldham et al., 2012; Corsini et al., 2012; Ulhaq et al., 2013; Hagennaars et al., 2011; Gorrochategui et al., 2014 | IPEN |
| PFBA | Perfluorobutanoic acid (PFBA) is another C4 fluorinated compound that has been used as an alternative to PFOA. Like PFBS and the C6 compounds, PFBA is found in the Arctic. | Kwok et al., 2013 | IPEN |
| PFBA | PFBA is also found on remote high-altitude glaciers and remote snow mountain snow. | Kirchgeorg et al., 2016; Cobbing et al., 2015; Wang et al., 2014 | IPEN |
| PFBA | PFBA contaminates oceans, lakes, marine fish, rivers, and lakes. | Zhou et al., 2012; Yamada et al., 2014; Lorenzo et al., 2016; Liu WX et al., 2015; Sanchez-Vidal et al., 2015 | IPEN |
| PFBA | PFBA is found in wastewater effluent of sewage treatment plants. | Houtz et al., 2016; Campo et al., 2014 | IPEN |
| PFBA | Like PFBS, PFBA is found in ski waxes, leather samples, and outdoor consumer products such as jackets, trousers, and boots. | Kotthoff et al., 2015; Santen et al., 2016 | IPEN |
| PFBA | Like PBFS, PFBA is also efficiently translocated into plants and it is transferred to crops grown in sewage treatment plant solid-amended soil. | Bizkarguenaga et al., 2016; Blaine et al., 2013; Krippner et al., 2014; Chropenova et al., 2016 | IPEN |
| PFBA | PFBA is found in humans, including in communities with known drinking water contamination. | Gebbink et al., 2015; Landsteiner et al., 2014 | IPEN |
| 4:2 FTOH | 4:2 fluorotelomer alcohol (4:2 FTOH) is another C4 fluorinated compound that has been used as an alternative to PFOA. 4:2 FTOH is not well-characterized but impairs the population growth of Tetrahymena thermophile indicating apoptosis and is toxic to rat hepatocytes in vitro. | Wang et al., 2010; Martin et al., 2009 | IPEN |
|  | A range of fluorocarbon-free, water-repellent finishing agents for textiles include commercial products such as BIONIC-FINISH®ECO and RUCO-DRY® ECO marketed by Rudolf Chemie Ltd., Geretsried/Germany; Purtex® WR, Purtex® WA, Purtex® AP marketed by the Freudenberg Group, Weinheim/Germany; and ecorepel® marketed by Schoeller Techologies AG, Sevelen/Switzerland. |  | IPEN |
|  | The possible alternatives identified for the photographic industry are:1. Digital techniques;
2. Fluor telomer-based products of various perfluoroalkyl chain length; C3- and C4-perfluorinated compounds;
3. Hydrocarbon surfactants;
4. Silicone products
 | UNEP/POPS/POPRC.12/INF/15/Rev.1 | IPEN |
|  | There are cosiderable datagaps of siloxane compounds used on the market for photographic applications | UNEP/POPS/POPRC.8/INF/17/Rev.1 | IPEN |

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