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PFAS and Alternatives in Food Packaging (Paper and Paperboard): Hazard Profile

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PFAS and Alternatives in Food Packaging (Paper and Paperboard): Hazard Profile

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INTER-ORGANIZATION PROGRAMME FOR THE SOUND MANAGEMENT OF CHEMICALS
A cooperative agreement among FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank and OECD

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Executive Summary

As part of the collaborative work of the OECD/UNEP Global PFC Group, a report on "PFASs and alternatives in food packaging (paper and paperboard): Commercial availability and current uses" was published in 2020 and summarised the commercial availability and current uses of short-chain PFAS and non-fluorinated alternatives in paper and paperboard food packaging. The report highlighted that both groups of substances can meet the high grease and water repellence performance specifications required for common food and pet food packaging uses. The report also identified that for some applications, non-fluorinated alternatives have a performance advantage over short-chain PFAS, and that the major barrier to uptake of non-fluorinated alternatives is cost.

Given the technical suitability of some of the alternatives highlighted by the OECD (2020) report, it is important to also understand their hazard profiles. The likelihood of regrettable substitution could be high if the health and environmental hazards of these alternatives are not understood and communicated. This study aims to complement the 2020 report by compiling information on the hazard profile of the alternatives identified in terms of hazard classifications from authorities and industry and available assessments from authorities on persistence, bioaccumulation, environmental and health hazards.

This study demonstrates that the hazard profiles of the many of the alternatives to long-chain PFAS for paper and paperboard food packaging are not available. Out of the 58 alternatives examined, only ten alternatives have been classified by authorities and 26 by industry, while published assessments by authorities were available for just over half of the fluorinated alternatives and a significantly lower proportion of non-fluorinated alternatives. No classifications or hazard assessments were identified for 18 alternatives.

Table of contents

TABLES

List of Abbreviations and Acronyms

BAuA	Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (German Federal Institute for Occupational Safety and Health)
CEPA	Canadian Environmental Protection Act, 1999
CLP	Classification, Labelling and Packaging (Regulation (EC) No 1272/2008)
CMR	Carcinogenic, Mutagenic or Reprotoxic
CoRAP	Community Rolling Action Plan
DSL	Canadian Domestic Substances List
ECCC	Environment and Climate Change Canada
ECHA	European Chemicals Agency
EEA	European Environment Agency
EFSA	European Food Safety Authority
EU	European Union
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
IARC	International Agency for Research on Cancer
IFA	Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (Institute for Occupational Safety and Health of the German Social Accident Insurance)
METI	Japanese Ministry of Economy, Trade and Industry
NICNAS	Australian National Industrial Chemicals Notification and Assessment Scheme
NITE	Japanese National Institute of Technology and Evaluation
OECD	Organisation for Economic Co-operation and Development
OSHA	US Occupational Safety and Health Administration
PBT	Persistent, Bioaccumulative and Toxic
PFAS	Per- and Polyfluoroalkyl Substances

PFC	Perfluorinated Chemicals
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals (Regulation (EC) No 1907/2006)
RIVM	Rijksinstituut voor Volksgezondheid en Milieu (Dutch National Institute for Public Health and the Environment)
RPA	Risk & Policy Analysts
SDS	Safety Data Sheet
UNEP	United Nations Environment Programme
USA	United States of America
US EPA	United States Environmental Protection Agency
US FDA	United States Food & Drug Administration

1. Introduction

1.1. Background

In 2012, the OECD/UNEP Global Perfluorinated Chemicals (PFC) Group was established in response to the International Conference on Chemicals Management (Resolution II/5), which invited intergovernmental organisations, governments and other stakeholders to develop regulatory approaches to reduce the concentration and emissions of perfluorinated chemicals of concern in products, and to work toward global elimination where appropriate and technically feasible (OECD, 2020). The objectives of the Group are to facilitate the exchange of information on per- and polyfluoroalkyl substances (PFAS) and to support the global transition to safer alternatives.

As part of the collaborative work of the OECD/UNEP Global PFC Group, a report on "PFASs and alternatives in food packaging (paper and paperboard): Commercial availability and current uses" was published (OECD, 2020) and summarised the commercial availability and current uses of short-chain PFAS and non-fluorinated alternatives in paper and paperboard food packaging. The report highlighted that both groups of substances can meet the high grease and water repellence performance specifications required for common food and pet food packaging uses. The report also identified that for some applications, non-fluorinated alternatives have a performance advantage over short-chain PFAS, and that the major barrier to uptake of non-fluorinated alternatives is cost and also time and effort to create replacements.

Given the technical suitability of some of the alternatives highlighted by the OECD (2020) report, it is important to also understand their hazard profiles. The likelihood of regrettable substitution could be high if the health and environmental hazards of these alternatives are not understood and communicated. This study aims to complement the 2020 report by compiling information on the hazard profile of the alternatives identified. To achieve this aim, this study focused on collecting information on the following aspects for each identified alternative in Annex A:

- Task 1 – GHS[1] classifications, including:
  - Authority classifications (1st Tier)[2]
  - Non-authority/industry classifications (2nd Tier)
- Task 2 – Outcomes of persistence and bioaccumulation assessments published by authorities
- Task 3 – Outcomes of environmental and human health hazard assessments published by authorities.

[1] GHS stands for Globally Harmonized System of Classification and Labelling of Chemicals. The GHS system addresses the classification of chemicals by separating them into types of hazard and proposes harmonised hazard communication elements, including labels and safety data sheets (SDS).

[2] Authority classifications refer to classifications made by the competent authorities responsible for enforcing GHS or its equivalent.

1.2. Scope

The scope of the OECD (2020) report included both short-chain PFAS and non-fluorinated alternatives used in food packaging (paper and paperboard). These chemical and material alternatives to long-chain PFAS are the focus of this study and are listed in Annex A.

Short-chain PFAS are distinguished from long-chain PFAS using the OECD's definition, which defines long-chain PFAS as:

- Perfluorocarboxylic acids (PFCAs) and their precursors with carbon chain lengths ≥ C7 (including perfluorooctanoic acid (PFOA)); and
- Perfluoroalkane sulfonic acids (PFSAs) and their precursors with carbon chain lengths ≥ C6 (including perfluorohexane sulfonic acid (PFHxS) and perfluorooctane sulfonate (PFOS)).

Short-chain PFAS[3] are defined as:

- PFCAs with carbon chain lengths < C7; and
- PFSAs with carbon chain lengths < C6.

The substances listed in Annex A were compiled in the OECD (2020) report with a focus on alternatives for paper and paperboard food packaging used for: fast food wrapping; food storage/shelf-life; food transport; and paper and paperboard requiring release properties, such as from baking moulds (i.e. for paper and board in contact with food); and pet food packaging. Alternatives used solely in items for food preparation and consumption (e.g. kitchenware, plates, utensils etc.) were considered out of scope.

In total, there are 45 fluorinated alternatives (42 of which have CAS numbers) and 13 non-fluorinated alternatives (5 of which have CAS numbers) within the scope of this study (see Annex A).

The scope of the Tier 1 classification search of Task 1 was limited to GHS classifications from countries with publicly available GHS classification databases. An example of an excluded country is the US, where GHS classifications are made by industry and the competent authority (US OSHA) does not maintain a database of classifications. However, the literature search for industry classifications was not limited in geographical scope. The scope of Tasks 2 and 3 included assessments published by authorities, while assessments published in scientific journals were out of scope of this study. The literature review for Tasks 2 and 3 was limited to assessments published in the English language, however countries that are part of the Global PFC Group were requested to supplement the desk review findings. As the focus of this study is on the collection of hazard properties, assessments reporting risk values, such as TDIs, health advisory values, cancer risk values, were excluded.

[3] It should be noted that the distinction of "long-chain" and "short-chain" PFAS based on chain length is only applicable to PFCAs, PFSAs and their precursors.

1.3. Methodology

1.3.1. Task 1 – Identification and review of GHS classifications

The United Nations' Globally Harmonised System of Classification and Labelling of Chemicals (GHS) provides a basis for globally uniform information on physical, health, safety and environment aspects of hazardous chemical substances and mixtures. The first edition of GHS was published in 2003 and has been updated with a new edition every two years, in light of experience gained from its implementation. The eighth edition was published in 2019 and is the most recent revised edition[4].

The GHS system addresses the classification of chemicals by separating them into types of hazard and proposes harmonised hazard communication elements, including labels and safety data sheets (SDS). Its purpose is to ensure that information on physical hazards and toxicity of chemicals is available during handling, transport and use to enhance the protection of human health and the environment. The GHS also provides a basis for harmonisation of rules and regulations on chemicals at national, regional, and global levels in order to assist in facilitating trade.

The identification of classifications was limited to authority classifications and industry classifications. For authority classifications, the intent was to identify where an authority had examined the available information and made a classification conclusion. As in a number of countries, GHS implementation is the legal responsibility of industry, available industry classifications were also included. Other potential sources of classifications were not considered within the scope of the report (e.g. in the scientific literature, non-governmental organisations) as additional verification of these classifications would be required.

Authority classifications

The collection of authority classifications (1st Tier GHS classifications) primarily involved reviewing the main national and regional legislation implementing GHS and searching their associated GHS classification inventories and databases. The search was limited to those countries and regions with publicly accessible classification inventories and databases. These are listed in Table 1.1 below.

[4] https://unece.org/ghs-rev8-2019

Table 1.1. Publicly available classification databases accessed for Task 1

Country / Region	Inventory / Database	Link
Australia	Hazardous Chemical Information System (HCIS)	http://hcis.safeworkaustralia.gov.au/HazardousChemical
Canada	Workplace Hazardous Materials Information System (WHMIS)	https://www.canada.ca/en/health-canada/services/environmental-workplace-health/occupational-health-safety/workplace-hazardous-materials-information-system/hazardous-substance-assessments.html
	Quebec Provincial Committee on Standards, Equity, Health and Safety at Work (Commission des normes, de l'équité, de la santé et de la sécurité du travail – CNESST)	https://reptox.cnesst.gouv.qc.ca/Pages/recherche-produit.aspx
China	NRCC National Internet Service Platform for Hazardous Chemicals	http://hxp.nrcc.com.cn/hc_safe_info_search.html
Chinese Taipei	GHS Classification Reference List	https://ghs.osha.gov.tw/CHT/intro/AnnounceData4Detail.aspx?id=282
European Union	Classification and Labelling (C&L) Inventory	https://echa.europa.eu/information-on-chemicals/cl-inventory-database
Japan	National Institute of Technology and Evaluation (NITE) classifications	https://www.nite.go.jp/chem/english/ghs/ghs_index.html
Malaysia	Chemical Information Management System (CIMS)	https://cims.dosh.gov.my/
New Zealand	Chemical Classification and Information Database (CCID)	https://www.epa.govt.nz/database-search/chemical-classification-and-information-database-ccid/
South Korea	National Chemicals Information System (NCIS)	https://ncis.nier.go.kr/en/main.do
Thailand	GHS Classification List	https://ghs.diw.go.th/knowledge.html

In addition to the information sources in Table 1.1., the GESTIS Substance Database[5] was searched. The GESTIS Substance Database contains information for the safe handling of hazardous substances and other chemical substances at work and is maintained by the Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (IFA, Institute for Occupational Safety and Health of the German Social Accident Insurance).

Non-Authority / Industry Classifications

To identify industry classifications (2nd Tier GHS classifications), an internet search using Google was performed to identify published SDSs, from which GHS classification information was extracted. The search was performed using the CAS numbers of each alternative listed in Annex A in combination with each of the following search strings: "*SDS*", "*safety data sheet*" and "*material safety data sheet*". For substances without CAS numbers, searches were performed using the substance name in combination with the above search strings.

Under the EU Classification, Labelling and Packaging (CLP) Regulation ((EC) No 1272/2008), manufacturers and importers who place any quantity of a hazardous substance (i.e. a substance meeting any of the physical, health and environmental hazards under GHS) on the market are obliged to notify the classification and

[5] https://www.dguv.de/ifa/gestis/index-2.jsp

labelling of the substance to ECHA. The notification obligation also applies to manufacturers and importers placing on the market a substance that is subject to registration under REACH (i.e. in quantities ≥ 1 tonne/year), regardless of whether the substance is hazardous or not. Notifications made by manufacturers and importers can differ for the same substance, due to different impurity profiles, interpretation differences in the process of evaluation of available data, or in the application of the classification rules for CLP. The CLP Regulation encourages agreement between notifications made by registrants and non-registrants. The most common notified classification will be reported for this Task, and in cases where there are two classifications with an equal number of notifications, both will be reported.

1.3.2. Task 2 – Review of Persistence and Bioaccumulation Assessments

To collect information on the persistence and bioaccumulation of the alternatives listed in Annex A, assessments published by national, regional, and international authorities were identified. Assessments published in scientific journals or by other third-parties were out of scope of this study as the aim was to identify authoritative assessment conclusions for these substances. To identify published assessments, the websites and webpages of the authorities listed in Table 1.2 were reviewed and searched using the CAS numbers of each alternative. Searches were conducted using CAS numbers as this identifier is unique to each substance, whereas substance names can be numerous and vary in spelling and structure across different regions. For substances with no CAS number, the substance name was used to perform the search.

Table 1.2. Authority websites and webpages accessed for Task 2

Organisation / Authority	Website / Webpage
Australian Industrial Chemicals Introduction Scheme (AICIS)	https://www.industrialchemicals.gov.au/chemical-information/search-assessments
Food Standards Australia New Zealand (FSANZ)	https://www.foodstandards.gov.au/code/Pages/default.aspx
Environment and Climate Change Canada (ECCC)	https://www.canada.ca/en/environment-climate-change.html
	https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/substances-list/domestic.html
	https://pollution-waste.canada.ca/substances-search/Substance?lang=en
European Chemicals Agency (ECHA)	https://echa.europa.eu/
ECHA PBT Assessment List	https://echa.europa.eu/pbt
European Food Safety Agency (EFSA)	https://www.efsa.europa.eu/
European Public Health Association (EUPHA)	https://eupha.org/
Japanese Ministry of Economy, Trade and Industry (METI)	https://www.meti.go.jp/english/
New Zealand Environmental Protection Administration (EPA)	https://www.epa.govt.nz/industry-areas/hazardous-substances/
US Environmental Protection Agency (US EPA)	https://www.epa.gov/
US Food & Drug Administration (US FDA)	https://www.fda.gov/
Stockholm Convention	http://www.pops.int/

In addition to the information sources in Table 1.2., the OECD's eChemPortal Database[6] was searched and an internet search using Google was performed using the CAS numbers, or substance name, of each alternative listed in Annex A in combination with each of the following search strings: "*assessment*", "*persistence assessment*" and "*bioaccumulation assessment*".

1.3.3. Task 3 – Review of Human Health and Environmental Hazard Assessments

To collect information on the human health and environmental hazards of the alternatives listed in Annex A, assessments published by national, regional, and international authorities were identified. Assessments published in scientific journals or by other third-parties were out of scope of this study as the aim was to identify authoritative assessment conclusions for these substances. To identify published assessments, the websites and webpages of the authorities listed in Table 1.3 were reviewed and searched using the CAS numbers of each alternative. Searches were conducted using CAS numbers as this identifier is unique to each substance, whereas substance names can be numerous and vary in spelling and structure across different regions. For substances with no CAS number, the substance name was used to perform the search.

Table 1.3. Authority websites and webpages accessed for Task 3

Organisation / Authority	Website / Webpage
Australian Industrial Chemicals Introduction Scheme (AICIS)	https://www.industrialchemicals.gov.au/chemical-information/search-assessments
Food Standards Australia New Zealand (FSANZ)	https://www.foodstandards.gov.au/code/Pages/default.aspx
Environment and Climate Change Canada (ECCC)	https://www.canada.ca/en/environment-climate-change.html
Canadian Environmental Protection Act (CEPA) – List of Substances	https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/substances-list.html
European Chemicals Agency (ECHA)	https://echa.europa.eu/
European Food Safety Agency (EFSA)	https://www.efsa.europa.eu/
European Public Health Association (EUPHA)	https://eupha.org/
Japanese Ministry of Economy, Trade and Industry (METI)	https://www.meti.go.jp/english/
New Zealand Environmental Protection Administration (EPA)	https://www.epa.govt.nz/industry-areas/hazardous-substances/
US Environmental Protection Agency (EPA)	https://www.epa.gov/
US Food & Drug Administration (US FDA)	https://www.fda.gov/
International Agency for Research on Cancer (IARC) Monographs	https://monographs.iarc.fr/
United Nations Environment Agency (UNEP)	https://www.unep.org/

[6] https://www.echemportal.org/echemportal/

In addition to the information sources in Table 1.3., the OECD's eChemPortal Database was searched and an internet search using Google was performed using the CAS numbers, of substance names, of each alternative listed in Annex A in combination with each of the following search strings: "assessment", "hazard assessment", "health assessment" and "environment assessment".

2. Report Findings

Annex C presents the available authority and industry GHS classifications of each alternative listed in Annex A. Industry classifications are presented when they differ from the authority classifications of the country/region in which the company resides, or when that authority classification was not available. Where multiple industry classifications were identified for a single country or region, these were amalgamated to present a worst-case classification. In addition to industry classifications obtained via SDS, the most frequently notified classifications under the EU CLP Regulation are provided.

Annex C also presents the outcomes of published persistence and bioaccumulation assessments and human health and environmental hazard assessments conducted by authorities. The outcomes of published assessments are displayed for the individual endpoints included in each assessment.

2.1. Task 1 – Identification and review of GHS classifications

For the 45 fluorinated alternatives in scope of this project, classification information was available for 21 alternatives, while no authority or industry classification data could be found for 24 fluorinated alternatives. Authority classifications were available for nine fluorinated alternatives and industry classifications were available for 20 alternatives (see Annex B).

For the 13 non-fluorinated alternatives in scope of this project, classification information was available for nine alternatives, while no authority or industry classification data could be found for four non-fluorinated alternatives. Authority classifications were available for one alternative and industry classifications were found for nine alternatives (see Annex B).

2.2. Task 2 – Review of Persistence and Bioaccumulation Assessments

Persistence and bioaccumulation assessments by authorities were available for 24 of the 45 fluorinated alternatives, and two of the 13 non-fluorinated alternatives (see Annex B). Of the 24 fluorinated alternatives for which data on persistence and bioaccumulation was available, 15 were identified as being persistent or very persistent and 5 were identified as being bioaccumulative. 7 substances were deemed to be non-persistent and 14 were deemed to be non-bioaccumulative. There was insufficient or inconclusive data to assess persistence for 3 substances and bioaccumulation for 4 substances. For another 3 substances, findings were contradictory in the assessment of bioaccumulation.

2.3. Task 3 – Review of Human Health and Environmental Hazard Assessments

Human health hazard assessments were available for 20 of the 45 fluorinated alternatives, and for one of the 13 non-fluorinated alternatives. Environmental hazard assessments were available for 24 of the 45 fluorinated alternatives, and for two of the 13 non-fluorinated alternatives (see Annex B).

The human health and environmental hazard types identified in this study included:

- Acute toxicity;

- Sub-chronic and chronic toxicity;
- Corrosion / Irritation;
- Sensitisation;
- Repeated dose toxicity;
- Carcinogenicity;
- Genotoxicity;
- Reproductive and developmental toxicity;
- Aquatic toxicity; and
- Terrestrial toxicity.

For the majority of alternatives assessed in this study for which human health hazard and environmental hazard data was available, there was generally a lack of adverse effects observed, however, the availability of information for each substance should be individually considered to draw any conclusions.

3. Data Gaps and Limitations

The findings of this study have demonstrated that the hazard profiles of the majority of alternatives to long-chain PFAS for paper and paperboard food packaging are poorly understood and/or not publicly available. Efforts to develop inventories of PFAS that are manufactured and used global have proved difficult (Wang et al., 2014) and a large majority of PFAS have not been registered or notified under chemical legislation such as REACH in the EU. Of the 58 alternatives included in the scope of this study, only nine have full registrations under REACH (CAS 2144-53-8; 17527-29-6; 121-44-8; 1314-56-3; 4767-03-7; 4098-71-9; 7473-98-5; 2855-27-8; 56773-42-3), indicating that alternatives to long-chain PFAS are likely not widely used across Europe, or are used in small quantities. Outside of Europe, alternatives may be more widely used as 24 alternatives are on Canada's DSL and 27 are listed on the US TSCA Inventory.

Only ten alternatives have been classified by authorities and 29 by industry, while published assessments by authorities were available for just over half of the fluorinated alternatives and a significantly lower proportion of non-fluorinated alternatives. No classification or hazard assessments were identified for 18 alternatives (see Annex B and Table 3-1 below).

A study limitation was the lack of available CAS numbers for some alternatives. The literature searches were led primarily by CAS number as these are unique to each chemical substance, whereas there are inconsistencies in the preference, structure and spelling of chemical substance names across different regions. Therefore, for alternatives without available CAS numbers, there is a possibility of missing hazard information. However, the vast majority of alternatives have been assigned CAS numbers, and substance names were used as search terms where CAS numbers were not available, so it is not expected that a substantial amount of critical information was missed.

It is also uncertain whether there is classification information held by industry that is not publicly accessible. In addition, due to the scope of the study, the general scientific literature was not considered.

Despite the limitations of this study, the findings are considered to accurately represent the level of currently available evidence on the hazard profile of alternatives to long-chain PFAS obtainable from authority or industry classifications or from assessments by authorities.

Table 3.1. Level of data availability for each alternative

		Authority Classifications	Industry Classifications	HH Hazard Assessments	Environmental Hazard Assessments	Persistence & Bioaccumulation Assessments
Fluorinated alternatives	Data available	9	20	20	24	24
	Data unavailable	36	25	25	21	21
Non-fluorinated alternatives	Data available	1	9	1	2	2
	Data unavailable	12	4	12	11	11
Total	Data available	**10**	**29**	**21**	**26**	**26**
	Data unavailable	**48**	**29**	**37**	**32**	**32**

4. Conclusions and Recommendations

This study examined the availability of classifications and assessment by authorities of the persistence, bioaccumulation and human health and environment hazards posed by 58 alternatives to long-chain PFAS in paper and paperboard food packaging. Based on the data available, in general, the human health hazard data for the alternatives included in this study show a lack of adverse effects, and the same is true for aquatic and terrestrial toxicity. However, there are potential human health and environmental risks for certain alternatives, and in many cases current evidence is insufficient or too inconsistent to draw solid conclusions. Therefore each substance should be considered individually, within the context of their data availability and concordance. The major concern surrounding fluorinated alternatives is persistence, as the majority of the fluorinated alternatives that have been assessed for persistence, are considered to be persistent or very persistent. This is not unexpected given the persistent nature of fluorinated substances.

This study identified no classification or authoritative hazard assessments of any kind for 18 alternatives. Therefore, significant data gaps exist in terms of classification and assessment. As this study only focused on where a classification conclusion or authoritative hazard assessment had been conducted, it is uncertain as to the level and nature of the individual studies available on these alternatives in the public domain and how much unpublished information is in the private domain. However further assessment of the potential health and environmental effects is required, given the lack of classification/assessment highlighted by this study. As already recommended by the OECD (2020), any scientifically robust information on intentionally used fluorinated and non-fluorinated PFAS alternatives in food packaging should be shared publicly. In order to support the shift towards safer substitutes, the elaboration of classification conclusions and assessment of the available persistence, bioaccumulation and hazard information on alternatives and their dissemination is needed. When authorities elaborate these, they can be shared with other stakeholders, industry and authorities in order to reduce duplication of work and to leverage the analysis that has been conducted. Guidance is available from the OECD on Key Considerations for the Identification and Selection of Safer Chemical Alternatives (OECD, 2021). Screening approaches could also be employed using high-throughput methods and in vitro models. These could be paired with grouping approaches to create efficiencies in the generation of information to support assessment.

Improving the understanding of PFAS alternatives should be a priority, as the use of PFAS in paper and paperboard packaging is open and dispersive, with a large number of consumers coming into contact with PFAS-containing products. Various studies have detected PFAS in paper food packaging (Moreta and Tena, 2013; Poothong et al., 2012; Surma et al., 2015) and it has been identified as requiring prioritisation for reducing and eliminating the use of PFAS (Glüge et al., 2020). However, the substitution has to be an informed choice based on adequate knowledge for the alternative.

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TCI. (2018a). Safety Data Sheet: 1H,1H,2H,2H-Tridecafluoro-n-octyl Methacrylate (stabilized with MEHQ). https://www.tcichemicals.com/IN/en/p/T3259#docomentsSectionPDP

TCI. (2018b). Safety Data Sheet: 1H,1H,2H,2H-Tridecafluoro-n-octyl Acrylate (stabilized with HQ + MEHQ). https://www.tcichemicals.com/GB/en/p/T3451

TCI. (2018c). Safety Data Sheet: 1,2,4-Trivinylcyclohexane (mixture of isomers). https://www.tcichemicals.com/IE/en/p/T0899
TCI. (2019a). Safety Data Sheet: Tridecafluorohexyl Iodide. https://www.tcichemicals.com/GB/en/p/T1098
TCI. (2019b). Safety Data Sheet: 2,2-Bis(hydroxymethyl)propionic Acid. https://www.tcichemicals.com/GB/en/p/B1192#docomentsSectionPDP
TCI. (2020a). Safety Data Sheet: Potassium Nonafluoro-1-butanesulfonate. https://www.tcichemicals.com/GB/en/p/N0711
TCI. (2020b). Safety Data Sheet: Tetrabutylammonium Hexafluorophosphate. https://www.tcichemicals.com/HK/en/p/T1279#docomentsSectionPDP
Thermo-Fisher Scientific. (2017). Safety Data Sheet: 2,2-Bis(hydroxymethyl)propionic acid. https://www.chemblink.com/MSDS/MSDSFiles/4767-03-7_Alfa-Aesar.pdf
Thermo-Fisher Scientific. (2020a). Safety Data Sheet: 1H,1H,2H,2H-Perfluorooctanol. https://www.fishersci.com/store/msds?partNumber=AAB2015609&productDescription=1H1H2H2H-PERFLROOCTNOL+97%25+10G&vendorId=VN00024248&countryCode=US&language=en
Thermo-Fisher Scientific. (2020b). Safety Data Sheet: Triethylamine. https://www.alfa.com/en/msds/?language=EN&subformat=AGHS&sku=A12646
Thermo-Fisher Scientific. (2021a). Safety Data Sheet: Tetra-n-butylammonium hexafluorophosphate. https://www.alfa.com/en/msds/?language=EE&subformat=CLP1&sku=A17196
Thermo-Fisher Scientific. (2021b). Safety Data Sheet: Isophorone diisocyanate, mixture of isomers. https://www.alfa.com/en/msds/?language=EE&subformat=CLP1&sku=L13759
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US EPA. (1991). IRIS Assessments - Triethylamine; CASRN 121-44-8.
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US EPA. (2018). Human Health Toxicity Values for Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3)
Verso. (2015). Safety Data Sheet: Recycle Cellulose Pulp. https://www.versoco.com/wps/wcm/connect/d639845f-81cf-42bf-9841-7fb10727c8f5/SDS+-+Verso+Recycle+Pulp.pdf?MOD=AJPERES
Wang, Z., Cousins, I.T., Scheringer, M., Buck, R.C. & Hungerbühler, K. (2014). 'Global emission inventories for C4–C14 perfluoroalkyl carboxylic acid (PFCA) homologues from 1951 to 2030, part II: The remaining pieces of the puzzle', Environment international, vol. 69, pp. 166-176
WestRock. (2019). Safety Data Sheet: Bleached Market Pulp. https://www.westrock.com/-/media/pdf/safety-data-sheets/wr002-bleached-market-pulp-1-10-2019.pdf?modified=20190429195126
Zabaleta, I., Negreira, N., Bizkarguenaga, E., Prieto, A., Covaci, A. and Zuloaga, O., 2017. Screening and identification of per-and polyfluoroalkyl substances in microwave popcorn bags. Food chemistry, 230, pp.497-506

Annex A. Substances Identified as Chemical or Material Alternatives to Long-Chain PFAS

The tables of fluorinated and non-fluorinated alternatives below were compiled by the OECD (2020) from a focus on alternatives for paper and paperboard food packaging. The non-fluorinated alternatives include chemical and material alternatives without PFAS for creating physical barrier properties in paper and paperboard. The OECD's basis for inclusion of alternatives was those substances that are positively listed or authorised for use in food packaging in key regulatory regimes in OECD member countries and regions (see Section 1.2).

Fluorinated Alternatives

Substance Name	Synonyms	CAS Number
3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate		2144-53-8
3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate		17527-29-6
3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl malate		No CAS Available
3,3,4,4,5,5,6,6,7,7,8,8,8- tridecafluorooctyl sodium salt		No CAS Available
Phosphoric acid ester of ethoxylated perfluoropoly-etherdiol	Diphosphoric acid, polymers with ethoxylated reduced Me esters of reduced polymd. oxidized tetrafluoroethylene	200013-65-6
Perfluoropolyetherdicarbonic acid, ammonium salt	Ethene, 1,1,2,2-tetrafluoro-, oxidized, polymd., reduced	69991-62-4
2-Propen-1-ol, reaction products with 1,1,1,2,2,3,3,4,4,5,5,6,6- tridecafluoro-6-iodohexane, de-hydroiodinated, reaction products with epichlorohydrin and triethylenetetr-amine with a fluorine content of 54%	1,1,1,2,2,3,3,4,4,5,5,6,6-tridecafluoro-6-iodohexane	355-43-1
Reaction product of hexamethylene-1,6-diisocyanate (homopolymer), converted with 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-1-octanol with a fluorine content of 48%	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctan-1-ol	647-42-7
N-(2-Hydroxyethyl) perfluorooctyl sulphonamide	N-ethylheptadecafluoro-N-(2-hydroxyethyl)octanesulphonamide	1691-99-2
1-Butanesulfonic acid	Potassium 1,1,2,2,3,3,4,4,4-nonafluorobutane-1-sulphonate	29420-49-3
Acrylic acid, ester with N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-1-octane-sulfonamide	2-[ethyl[(heptadecafluorooctyl)sulphonyl]amino]ethyl acrylate	423-82-5
2-Propenoic acid, 2-[ethyl[(tridecafluorohexyl)sulfonyl]-amino]ethylester	2-[ethyl[(tridecafluorohexyl)sulphonyl]amino]ethyl acrylate	1893-52-3
1-Butanaminium, N,N,N-tributyl-, hexafluorophosphate(1-)	Tetrabutylammonium hexafluorophosphate	3109-63-5
1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro	N-ethylheptadecafluorooctanesulphonamide	4151-50-2
Ethanaminium, N,N,N-triethyl-, salt with 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-1-	Tetraethylammonium heptadecafluorooctanesulphonate	56773-42-3

Substance Name	Synonyms	CAS Number
octanesulfonicacid (1:1)		
2-Propanoic acid, 2-((ethyl(pentadecafluoroheptyl)-sulfonyl)amino)ethyl ester	2-[ethyl[(pentadecafluoroheptyl)sulphonyl]amino]ethyl acrylate	59071-10-2
Glycine, N-ethyl-N-[(nonafluorobutyl)sulfonyl]-, potassium salt	Potassium N-ethyl-N-[(nonafluorobutyl)sulphonyl]glycinate	67584-51-4
Glycine, N-ethyl-N-[(undecafluoropentyl)sulfonyl]-, potassium salt	Potassium N-ethyl-N-[(undecafluoropentyl)sulphonyl]glycinate	67584-52-5
Glycine, N-ethyl-N-[(tridecafluorohexyl)sulfonyl]-, potassium salt	Potassium N-ethyl-N-[(tridecafluorohexyl)sulphonyl]glycinate	67584-53-6
Acrylic acid, 2-[methyl[(nonafluorobutyl) sulfonyl] amino] ethylester	2-[methyl[(nonafluorobutyl)sulphonyl]amino]ethyl acrylate	67584-55-8
Glycine, N-ethyl-N-[(pentadecafluoroheptyl)sulfonyl]-, potassium salt	Potassium N-ethyl-N-[(pentadecafluoroheptyl)sulphonyl] glycinate	67584-62-7
Glycine, N-ethyl-N-[(heptadecafluorooctyl)sulfonyl]-, potassium salt	Potassium N-ethyl-N-[(heptadecafluorooctyl)sulphonyl]glycinate	2991-51-7
2-propenoic acid, 2-methyl-, 2-hydroxyethyl ester, polymer with 2-propenoic acid and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-methyl-2-propenoate, sodium salt		1878204-24-0
Copolymer of 2-(dimethylamino) ethyl methacrylate with 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate, N-oxide, acetate		1440528-04-0
2-Propenoic acid, 2-methyl-, 2-(dimethylamino)ethyl ester, polymer with 1-ethenyl-2-pyrrolidinone and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-propenoate, acetate		1334473-84-5
Butanedioic acid, 2-methylene-, polymer with 2-hydroxyethyl, 2-methyl-2-propenoate, 2-methyl-2-propenoic acid and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-methyl-2-propenoate, sodium salt		1345817-52-8
Hexane, 1,6-diisocyanato-, homopolymer, a-[1-[[[3-[[3 (dimethylamino)propyl]amino]propyl]amino]carbonyl]-1,2,2,2-tetrafluoroethyl]-?-(1,1,2,2,3,3,3-heptafluoropropoxy)poly[oxy[trifluoro(trifluoromethyl)-1,2-ethanediyl]]-blocked		1279108-20-1
2-propenoic acid, 2-methyl-, 2-hydroxyethyl ester polymer with 1-ethyenyl-2-pyrrolidinone, 2-propenoic acid and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-propenoate sodium salt		1206450-10-3
Diphosphoric acid, polymers with ethoxylated reduced methyl esters of reduced polymerized oxidized tetrafluoroethylene	Phosphate esters of ethoxylated perfluoroether, prepared by reaction of ethoxylated perfluoroether diol with phosphorous pentoxide or pyrophosphoric acid.	162492-15-1 1314-56-3 2466-09-3
2-propenoic acid, 2-methyl-, polymer with 2-hydroxyethyl 2-methyl-2-propenoate, a-		1158951-86-0

Substance Name	Synonyms	CAS Number
(1-oxo-2-propen-1-yl)-?-hydroxypoly(oxy-1,2-ethanediyl) and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-propenoate, sodium salt		
2-propenoic acid, 2-hydroxyethyl ester, polymer with a-(1-oxo-2-propen-1-yl)-?-hydroxypoly(oxy-1,2-ethanediyl), a-(1-oxo-2-propen-1-yl)-?-[(1-oxo-2-propen-1-yl)oxy]poly(oxy-1,2-ethanediyl) and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-propenoate		1012783-70-8
2-Propenoic acid, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl ester, polymer with a-(1-oxo-2-propen-1-yl)-?-hydroxypoly(oxy-1,2-ethanediyl)	2-Propenoic acid, ethyl ester, polymer with 4-[[(heptadecafluorooctyl) sulfonyl]methylamino]butyl 2-propenoate, 4-[methyl[(nonafluorobutyl) sulfonyl]amino]butyl 2-propenoate, alpha-(2-methyl-1-oxo-2-propenyl)-omega-hydroxypoly(oxy-1,4-butanediyl), alpha-	68228-00-2
2-propen-1-ol, reaction products with 1,l,1,2,2,3,3,4,4,5,5,6,6-tridecafluoro-6-iodohexane, dehydroiodinated, reaction products with epichlorohydrin and triethylenetetramine		464178-94-7
Copolymer of perfluorohexylethyl methacrylate, 2-N,N-diethylaminoethyl methacrylate, 2-hydroxyethyl methacrylate, and 2,2'-ethylenedioxydiethyl dimethacrylate, acetic acid salt		863408-20-2
Copolymer of perfluorohexylethyl methacrylate, 2-N,N-diethylaminoethyl methacrylate, 2-hydroxyethyl methacrylate, and 2,2'-ethylenedioxydiethyl dimethacrylate, malic acid salt		1225273-44-8
2-propen-1-ol, reaction products with pentafluoroiodoethane-tetrafluoroethylene telomer, dehydroiodinated, reaction products with epichlorohydrin and triethylenetetramine		464178-90-3
Tetrafluoroethylene, oxidized, oligomers, reduced, methyl esters, reduced		88645-29-8
Fluorinated polyurethane anionic resin prepared by reacting perfluoropolyether diol, isophorone diisocyanate, 2,2-dimethylolpropionic acid, and triethylamine		328389-91-9
		4098-71-9
		4767-03-7
		121-44-8
Hexane, 1,6-diisocyanato-, homopolymer, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-1-octanol-blocked		357624-15-8
2-propenoic acid, 2-methyl-, polymer with 2-(diethylamino)ethyl 2-methyl-2-propenoate, 2-propenoic acid and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-methyl-2-propenoate, acetate		1071022-26-8

Non-fluorinated Alternatives

Substance Name	CAS Number
TopScreenTM formulations	No CAS Available (confidential)
Natural greaseproof paper (NGP)	N/A
Silicone oils (with added preserving agents)	N/A
Silicone resins	N/A
Silicone elastomers	N/A
Natural and synthetic cellulose fibres bleached or unbleached	N/A
Wood pulp bleached or unbleached	N/A
Recycled fibres made from paper or paperboard	N/A
2-hydroxy-2-methylpropiophenone	7473-98-5
Siloxanes and Silicones, di-Me, hydrogen-terminated, reaction products with acrylic acid and 2-ethyl-2- [(2-propenyloxy)methyl]-1,3-propanediol	155419-56-0
Cyclohexane-1,2,4-triyltris(ethylene)	2855-27-8
Siloxanes and Silicones, di-Me, Me vinyl, hydroxy-terminated, reaction products with 2-((3-(trimethoxysilyl)propoxy)methyl)oxirane	102782-94-5
Siloxanes and Silicones, di-Me, Me vinyl, hydroxy-terminated, reaction products with 3-(2-(trimethoxysilyl)ethyl)bicyclo(4.1.0)heptane	917773-10-5

Annex B. Data Availability of Fluorinated and Non-fluorinated Alternatives

Fluorinated Alternatives

Substance Name	CAS	Authority Classifications	Industry Classifications	HH Hazard Assessments	Environmental Hazard Assessments	Persistence & Bioaccumulation Assessments
3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate	2144-53-8					
3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate	17527-29-6					
3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl malate	No CAS Available					
3,3,4,4,5,5,6,6,7,7,8,8,8- tridecafluorooctyl sodium salt	No CAS Available					
Phosphoric acid ester of ethoxylated perfluoropoly-etherdiol	200013-65-6					
Perfluoropolyetherdicarbonic acid, ammonium salt	69991-62-4					
2-Propen-1-ol, reaction products with 1,1,1,2,2,3,3,4,4,5,5,6,6-tridecafluoro-6-iodohexane, de-hydroiodinated, reaction products with epichlorohydrin and triethylenetetr-amine with a fluorine content of 54%	355-43-1					
Reaction product of hexamethylene-1,6-diisocyanate (homopolymer), converted with 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-1-octanol with a fluorine content of 48%	647-42-7					
N-(2-Hydroxyethyl) perfluorooctyl sulphonamide	1691-99-2					
1-Butanesulfonic acid	29420-49-3					
Acrylic acid, ester with N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-1-octane-sulfonamide	423-82-5					
2-Propenoic acid, 2-[ethyl[(tridecafluorohexyl)sulfonyl]-amino]ethylester	1893-52-3					

1-Butanaminium, N,N,N-tributyl-, hexafluorophosphate(1-)	3109-63-5	
1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro	4151-50-2	
Ethanaminium, N,N,N-triethyl-, salt with 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-1-octanesulfonicacid (1:1)	56773-42-3	
2-Propanoic acid, 2-((ethyl(pentadecafluoroheptyl)-sulfonyl)amino)ethyl ester	59071-10-2	
Glycine, N-ethyl-N-[(nonafluorobutyl)sulfonyl]-, potassium salt	67584-51-4	
Glycine, N-ethyl-N-[(undecafluoropentyl)sulfonyl]-, potassium salt	67584-52-5	
Glycine, N-ethyl-N-[(tridecafluorohexyl)sulfonyl]-, potassium salt	67584-53-6	
Acrylic acid, 2-[methyl[(nonafluorobutyl) sulfonyl] amino] ethylester	67584-55-8	
Glycine, N-ethyl-N-[(pentadecafluoroheptyl)sulfonyl]-, potassium salt	67584-62-7	
Glycine, N-ethyl-N-[(heptadecafluorooctyl)sulfonyl]-, potassium salt	2991-51-7	
2-propenoic acid, 2-methyl-, 2-hydroxyethyl ester, polymer with 2-propenoic acid and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-methyl-2-propenoate, sodium salt	1878204-24-0	
Copolymer of 2-(dimethylamino) ethyl methacrylate with 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate, N-oxide, acetate	1440528-04-0	
2-Propenoic acid, 2-methyl-, 2-(dimethylamino)ethyl ester, polymer with 1-ethenyl-2-pyrrolidinone and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-propenoate, acetate	1334473-84-5	
Butanedioic acid, 2-methylene-, polymer with 2-hydroxyethyl, 2-methyl-2-propenoate, 2-methyl-2-propenoic acid and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-methyl-2-propenoate, sodium salt	1345817-52-8	
Hexane, 1,6-diisocyanato-, homopolymer, α-[1-[[[3-[[3 (dimethylamino)propyl]amino]propyl]amino]carbonyl]-1,2,2,2-tetrafluoroethyl]-ω-(1,1,2,2,3,3,3-heptafluoropropoxy)poly[oxy[trifluoro(trifluoromethyl)-1,2-ethanediyl]]-blocked	1279108-20-1	
2-propenoic acid, 2-methyl-, 2-hydroxyethyl ester polymer with 1-ethyenyl-2-pyrrolidinone, 2-propenoic acid and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-propenoate sodium salt	1206450-10-3	
Diphosphoric acid, polymers with ethoxylated reduced methyl esters	162492-15-1	

of reduced polymerized oxidized tetrafluoroethylene	1314-56-3	
	2466-09-3	
2-propenoic acid, 2-methyl-, polymer with 2-hydroxyethyl 2-methyl-2-propenoate, α-(1-oxo-2-propen-1-yl)-ω-hydroxypoly(oxy-1,2-ethanediyl) and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-propenoate, sodium salt	1158951-86-0	
2-propenoic acid, 2-hydroxyethyl ester, polymer with α-(1-oxo-2-propen-1-yl)-ω-hydroxypoly(oxy-1,2-ethanediyl), α-(1-oxo-2-propen-1-yl)-ω-[(1-oxo-2-propen-1-yl)oxy]poly(oxy-1,2-ethanediyl) and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-propenoate	1012783-70-8	
2-Propenoic acid, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl ester, polymer with α-(1-oxo-2-propen-1-yl)-ω-hydroxypoly(oxy-1,2-ethanediyl)	68228-00-2	
2-propen-1-ol, reaction products with 1,l,1,2,2,3,3,4,4,5,5,6,6-tridecafluoro-6-iodohexane, dehydroiodinated, reaction products with epichlorohydrin and triethylenetetramine	464178-94-7	
Copolymer of perfluorohexylethyl methacrylate, 2-N,N-diethylaminoethyl methacrylate, 2-hydroxyethyl methacrylate, and 2,2'-ethylenedioxydiethyl dimethacrylate, acetic acid salt	863408-20-2	
Copolymer of perfluorohexylethyl methacrylate, 2-N,N-diethylaminoethyl methacrylate, 2-hydroxyethyl methacrylate, and 2,2'-ethylenedioxydiethyl dimethacrylate, malic acid salt	1225273-44-8	
2-propen-1-ol, reaction products with pentafluoroiodoethane-tetrafluoroethylene telomer, dehydroiodinated, reaction products with epichlorohydrin and triethylenetetramine	464178-90-3	
Tetrafluoroethylene, oxidized, oligomers, reduced, methyl esters, reduced	88645-29-8	
	328389-91-9	
Fluorinated polyurethane anionic resin prepared by reacting perfluoropolyether diol, isophorone diisocyanate, 2,2-dimethylolpropionic acid, and triethylamine	4098-71-9	
	1047217	
	121-44-8	
Hexane, 1,6-diisocyanato-, homopolymer, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-1-octanol-blocked	357624-15-8	
2-propenoic acid, 2-methyl-, polymer with 2-(diethylamino)ethyl 2-methyl-2-propenoate, 2-propenoic acid and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-methyl-2-propenoate, acetate	1071022-26-8	

Note: Red shading indicates no data identified and green shading represents where data was identified

Non-fluorinated Alternatives

Substance Name	CAS	Authority Classifications	Industry Classifications	HH Hazard Assessments	Environmental Hazard Assessments	Persistence & Bioaccumulation Assessments
TopScreenTM formulations	Confidential					
Natural greaseproof paper (NGP)	N/A					
Silicone oils (with added preserving agents)	N/A					
Silicone resins	N/A					
Silicone elastomers	N/A					
Natural and synthetic cellulose fibres bleached or unbleached	N/A					
Wood pulp bleached or unbleached	N/A					
Recycled fibres made from paper or paperboard	N/A					
2-hydroxy-2-methylpropiophenone	7473-98-5					
Siloxanes and Silicones, di-Me, hydrogen-terminated, reaction products with acrylic acid and 2-ethyl-2- [(2-propenyloxy)methyl]-1,3-propanediol	155419-56-0					
Cyclohexane-1,2,4-triyltris(ethylene)	2855-27-8					
Siloxanes and Silicones, di-Me, Me vinyl, hydroxy-terminated, reaction products with 2-((3-(trimethoxysilyl)propoxy)methyl)oxirane	102782-94-5					
Siloxanes and Silicones, di-Me, Me vinyl, hydroxy-terminated, reaction products with 3-(2-(trimethoxysilyl)ethyl)bicyclo(4.1.0)heptane	917773-10-5					

Note: Red shading indicates no data identified and green shading represents where data was identified

Annex C. Hazard Classifications and Assessments of Chemical or Material Alternatives to Long-chain PFAS

This Annex contains the findings of Tasks 1, 2 and 3 and presents them for each alternative. For group entries containing multiple CAS numbers, findings are displayed for each constituent CAS number. Alternatives for which no information was available are not displayed, and data gaps under each Task (i.e. where classifications or published assessments were not identified) are indicated as such for alternatives included in this Annex. Only those authorities listed in Table 2-1 which have published GHS classifications are shown for each alternative. Where multiple industry classifications were available for a country or region, these were combined to represent a worst-case classification. In addition to classifications obtained through industry SDS, the most commonly notified classifications under the EU CLP Regulation are displayed. Human health hazard assessments, environmental hazard assessments, and persistence and bioaccumulation assessments are displayed in separate tables for each substance. Assessments are displayed in chronological descending order. The outcomes of published assessments are displayed for the individual endpoints included in each assessment.

3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate: CAS 2144-53-8

Authority Classifications
None found.

Industry Classifications (SDS)

EU	Brazil	China	Japan	Korea	USA
Skin Irrit. 2 Eye Irrit. 2 STOT RE 2 STOT SE 3 ***Notified*** STOT RE 2 Aquatic Chronic 1	Skin Irrit. 2 Eye Irrit. 2A STOT SE 3	Skin Irrit. 2 Eye Irrit. 2A	Skin Irrit. 2 Eye Irrit. 2A STOT SE 3	Skin Irrit. 2 Eye Irrit. 2 STOT SE 3	Skin Irrit. 2 Eye Irrit. 2A

Source: ECHA (2020i; 2020j); Santa Cruz Biotechnology (2015a); TCI (2018a)

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
NICNAS (2019a)	Acute toxicity	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate has low toxicity following oral and dermal exposure. The substance has very low toxicity following inhalation exposure (based on rat studies).
	Corrosion / Irritation	No evidence of skin irritation has been observed (based on skin irritation studies on rabbits). 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is considered to be a slight eye irritant.
	Sensitisation	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is not considered to be a skin sensitiser
	Repeated dose toxicity	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is not considered to be hazardous following repeated short-term or long-term oral exposure. Repeated inhalation exposure to 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate has not caused any serious toxicological effects. Therefore, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is not considered to be hazardous following repeated inhalation exposure.
	Genotoxicity	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is not mutagenic.
Ramboll Environ (2014, 2016)	Corrosion / Irritation	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is not a significant skin irritant. 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is not a significant eye irritant as it causes minimal reversible eye irritation.
	Sensitisation	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is not a significant skin sensitiser.
	Genotoxicity	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is not genotoxic based on the weight of evidence.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
NICNAS (2019c)	Aquatic toxicity	Insufficient data is available to classify for aquatic hazards under GHS. 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is not considered to be toxic (based on data for PFHxA and PFBA).
Ramboll Environ (2014, 2016)	Aquatic toxicity	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is not significantly toxic to aquatic organisms.
ECCC (2006)	Aquatic toxicity	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is inherently toxic to aquatic organisms

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
ECHA (2020i)	Persistence	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate does not meet the criteria for being persistent or very persistent specified in REACH Annex XIII. However, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is currently undergoing PBT assessment under the Community Rolling Action Plan (CoRAP) by BAuA. CoRAP prioritises substances for evaluation where there is a concern that the manufacture and/or use of these substances could pose a risk to human health or the environment.
	Bioaccumulation	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate does not meet the criteria for being bioaccumulative or very bioaccumulative specified in REACH Annex XIII. However, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is currently undergoing PBT assessment under the Community Rolling Action Plan (CoRAP) by BAuA. CoRAP prioritises substances for evaluation where there is a concern that the manufacture and/or use of these substances could pose a risk to human health or the environment.
METI (2019b)	Bioaccumulation	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is not readily biodegradable and has low bioconcentration (BCF = 12).
Ramboll Environ (2014, 2016)	Persistence	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is unlikely to meet the criteria for persistence specified in Annex D of the Stockholm Convention.
	Bioaccumulation	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate does not meet the criteria for bioaccumulation specified in Annex D of the Stockholm Convention.
ECCC (2006)	Persistence	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is not persistent
	Bioaccumulation	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate is bioaccumulative.

3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate: CAS 17527-29-6

Authority Classifications
None found.

Industry Classifications (SDS)

EU	USA
Skin Irrit. 2 Eye Irrit. 2 STOT RE 2 STOT SE 3 ***Notified*** STOT RE 2	Acute Tox. 4 (oral) Skin Irrit. 2 Eye Irrit. 2A STOT SE 3

Source: ECHA (2020j); Oakwood (2020); Sigma-Aldrich (2020); (TCI, 2018b)

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
Ramboll Environ (2014, 2016)	Corrosion / Irritation	3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate is not a significant skin irritant. 3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate is not a significant eye irritant as it causes minimal reversible eye irritation.
	Sensitisation	3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate is not a significant skin sensitiser.
	Sub-chronic toxicity	3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate has been observed to increase liver weights.
	Genotoxicity	3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate is not genotoxic (based on lack of effects in bacteria and mammalian cells).

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
Ramboll Environ (2014, 2016)	Aquatic toxicity	3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate is not significantly toxic to aquatic organisms (based on lack of effects seen in acute toxicity test).
ECCC (2006)	Aquatic toxicity	3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate is inherently toxic to aquatic organisms

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
ECHA (2020d)	Persistence	3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate is considered to meet the criteria for persistence specified in REACH Annex XIII. However, 3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate is currently undergoing PBT assessment under the Community Rolling Action Plan (CoRAP) by BAuA. CoRAP prioritises substances for evaluation where there is a concern that the manufacture and/or use of these substances could pose a risk to human health or the environment.
	Bioaccumulation	3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate is considered to be non-bioaccumulative. However, 3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate is currently undergoing PBT assessment under the Community Rolling Action Plan (CoRAP) by BAuA. CoRAP prioritises substances for evaluation where there is a concern that the manufacture and/or use of these substances could pose a risk to human health or the environment.
Ramboll Environ (2014, 2016)	Persistence	3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate is unlikely to meet persistence criteria specified in Annex D of the Stockholm Convention.
	Bioaccumulation	3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate does not meet criteria for bioaccumulation specified in Annex D of the Stockholm Convention.
METI (2019a)	Bioaccumulation	3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate is not readily biodegradable and has low bioconcentration.
ECCC (2006)	Persistence	3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate is not persistent
	Bioaccumulation	3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctyl acrylate is not bioaccumulative

Phosphoric acid ester of ethoxylated perfluoropoly-etherdiol: CAS 200013-65-6

Authority Classifications
None found.

Industry Classifications (SDS)

EU
Notified
Eye Irrit. 2

Source: ECHA (2020j)

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments
None found.

Persistence and Bioaccumulation Assessments
None found

Perfluoropolyetherdicarbonic acid, ammonium salt: CAS 69991-62-4

Authority Classifications
None found.

Industry Classifications (SDS)

EU
Notified
Acute Tox. 4 (oral)
Skin Irrit. 2
Eye Dam. 1
STOT RE 1

Source: ECHA (2020j)

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments
None found.

Persistence and Bioaccumulation Assessments
None found.

2-Propen-1-ol, reaction products with 1,1,1,2,2,3,3,4,4,5,5,6,6- tridecafluoro-6-iodohexane, de-hydroiodinated, reaction products with epichlorohydrin and triethylenetetr-amine with a fluorine content of 54%: CAS 355-43-1

Authority Classifications

Chinese Taipei
Eye Irrit. 2A
STOT SE 3
Aquatic Chronic 1

Industry Classifications (SDS)

EU	USA
Skin Irrit. 2	Skin Irrit. 2
Eye Irrit. 2	Eye Irrit. 2
STOT SE 3	STOT SE 3
Aquatic Chronic 4	
Notified	
Aquatic Chronic 4	

Source: Alfa-Aesar (2012); Combi-Blocks (2019); ECHA (2020j); Sigma-Aldrich (2019a); TCI (2019a)

Human Health Hazard Assessments

None found.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
Environment Agency (2010)	Aquatic toxicity	The substance is considered to meet the criteria for aquatic toxicity.
Danish EPA (2001)	Aquatic toxicity	The substance is predicted to meet the criteria for aquatic toxicity.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
Environment Agency (2010)	Persistence	The substance is considered to meet the criteria for persistence.
	Bioaccumulation	The substance is considered to meet the criteria for being very bioaccumulative.

Reaction product of hexamethylene-1,6-diisocyanate (homopolymer), converted with 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-1-octanol with a fluorine content of 48%: CAS 647-42-7

Authority Classifications
None found.

Industry Classifications (SDS)

EU	Brazil	Canada	China	Japan	Korea	Malaysia	USA
Acute Tox. 4 (oral) Skin Irrit. 2 Eye Irrit. 2 STOT RE 2 STOT SE 3 ***Notified*** Acute Tox. 4 (oral) STOT RE 2 Skin Irrit. 2 Eye Irrit. 2 STOT SE 3	Flam Liq. 4 Skin Irrit. 2 Eye Irrit. 2A STOT SE 3	Flam Liq. 4 Skin Irrit. 2 Eye Irrit. 2A STOT SE 3	Flam Liq. 4 Skin Irrit. 2 Eye Irrit. 2A	Flam. Liq. 4 Skin Irrit. 2 Eye Irrit. 2 STOT SE 3	Flam Liq. 4 Skin Irrit. 2 Eye Irrit. 2 STOT SE 3	Skin Irrit. 2 Eye Irrit. 2 STOT SE 3	Flam Liq. 4 Skin Irrit. 2 Eye Irrit. 2 STOT SE 3

Source: ECHA (2020j); Santa Cruz Biotechnology (2015b); Sigma-Aldirch (2019b); Thermo-Fisher Scientific (2020a)

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
NICNAS (2019a)	Acute toxicity	The substance has low toxicity following oral and dermal exposure.
	Corrosion / Irritation	No evidence of skin irritation has been observed (based on skin irritation studies on rabbits). The substance is considered to be a slight eye irritant (based on studies on rabbits).
	Sensitisation	The substance is not considered to be a skin sensitiser
	Repeated dose toxicity	The substance is not considered to be hazardous following repeated short-term or long-term oral exposure. Increases in kidney and liver weights were observed but no histological changes were observed. Repeated inhalation exposure to chemicals did not cause any serious toxicological effects.
	Genotoxicity	The substance is not mutagenic.

	Reproductive and developmental toxicity	The substance is not a reproductive toxicant. No NOAEL was established for reproductive toxicity (based on lack of effects from rat studies).
Ramboll Environ (2014, 2016)	Corrosion / Irritation	The substance is considered to be a slight eye irritant (based on studies on rabbits).
	Sensitisation	The substance is not a skin sensitiser.
	Sub-chronic toxicity	Effects in liver and blood have been observed in rat studies.
	Genotoxicity	The substance is not mutagenic (based on lack of effects in bacteria and mammalian cells). Evidence for genotoxicity is largely negative.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
NICNAS (2019c)	Aquatic toxicity	Insufficient data is available to classify for aquatic hazards under GHS. The substance is not considered to be toxic, based on data for PFHxA and PFBA.
Ramboll Environ (2014, 2016)	Aquatic toxicity	The substance is expected to have low toxicity to aquatic organisms.
ECCC (2006)	Aquatic toxicity	The substance is inherently toxic to aquatic organisms

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
Ramboll Environ (2014, 2016)	Persistence	The substance does not meet persistence criteria specified in Annex D of the Stockholm Convention.
	Bioaccumulation	The substance does not meet bioaccumulation criteria specified in Annex D of the Stockholm Convention. The substance is rapidly eliminated in aquatic and mammalian systems and does not bioaccumulate in terrestrial plants.
METI (2013)	Bioaccumulation	The substance is not highly bioaccumulative and has low bioconcentration (BCF = 58).
ECCC (2006)	Persistence	The substance is persistent.
	Bioaccumulation	The substance is bioaccumulative.

N-(2-Hydroxyethyl) perfluorooctyl sulphonamide: CAS 1691-99-2

Authority Classifications
None found.

Industry Classifications (SDS)

EU	Brazil	Canada	Japan	Korea	USA
Acute Tox. 3 (oral) Acute Tox. 4 (inhal) Carc. 2 Repr. 1B STOT RE 1 Aquatic Chronic 2 ***Notified*** Non-hazardous (no classification)	Skin Irrit. 2 Eye Irrit. 2A STOT SE 3	Skin Irrit. 2 Eye Irrit. 2A STOT SE 3	Skin Irrit. 2 Eye Irrit. 2A STOT SE 3	Skin Irrit. 2 Eye Irrit. 2 STOT SE 3	Acute Tox. 4 (oral) Acute Tox. 4 (dermal) Acute Tox. 4 (inhal) Skin Irrit. 2 Eye Irrit. 2A STOT SE 3

Source: Apollo (2014a); ECHA (2020j); LGC (2020); Santa Cruz Biotechnology (2020); SynQuest (2017)

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
NICNAS (2016a)	Not specified	Limited data is available for the substance. The primary health risks are expected to arise from secondary exposure to PFOS, to which the substance is an indirect precursor.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
NICNAS (2019b)	Not specified	The primary environmental effects are expected to result from the cumulative release of PFOS into the environment, to which the substance is an indirect precursor. Insufficient data is available to classify the aquatic hazards of the substance according to GHS.

Persistence and Bioaccumulation Assessments

Publication	Hazard(s) Assessed	Conclusions on Persistence and Bioaccumulation
RIVM (2011)	Persistence	N-(2-Hydroxyethyl) perfluorooctyl sulphonamide is persistent (P-score of 0.99).
	Bioaccumulation	N-(2-Hydroxyethyl) perfluorooctyl sulphonamide is bioaccumulative (B-score of 0.97).
ECCC (2006)	Persistence	N-(2-Hydroxyethyl) perfluorooctyl sulphonamide is persistent.
	Bioaccumulation	N-(2-Hydroxyethyl) perfluorooctyl sulphonamide is bioaccumulative.

1-Butanesulfonic acid: CAS 29420-49-3

Authority Classifications

Australia
Eye Irrit. 2A

Industry Classifications (SDS)

EU	Brazil	China	Japan	Korea	USA
Skin Irrit. 2 Eye Dam. 1 STOT SE 3 ***Notified*** Eye Dam. 1	Non-hazardous (no classification)	Skin Irrit. 2 Eye Irrit. 2A	Non-hazardous (no classification)	Non-hazardous (no classification)	Skin Irrit. 2 Eye Irrit. 2A STOT SE 3

Source: Apollo (2018a); ECHA (2020j); Santa Cruz Biotechnology (2017a); Sigma-Aldrich (2020b); TCI (2020a)

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
NICNAS (2019d)	Acute toxicity	1-Butanesulfonic acid is not considered to be acutely toxic following oral exposure (based on data from KPFBS) and dermal exposure (based on data from potassium PFBS and PFBSF). 1-Butanesulfonic acid is not considered as classifiable as acutely toxic following inhalation exposure, as inhalation effects are only observed at relatively high doses.
	Corrosion / Irritation	1-Butanesulfonic acid is considered an eye irritant. There is a lack of evidence of skin irritation / corrosion effects of 1-Butanesulfonic acid, but they can't be ruled out because of the irritating effects of potassium PFBS, to which 1-Butanesulfonic acid is a direct precursor.
	Sensitisation	1-Butanesulfonic acid is not considered a skin sensitiser (based on negative effects observed for potassium PFBS, to which 1-Butanesulfonic acid is a direct precursor).
	Repeated dose toxicity	1-Butanesulfonic acid is not considered to cause serious health effects from repeated oral or inhalation exposure, based on the data available.
	Genotoxicity	1-Butanesulfonic acid is not considered to be genotoxic, based on the results from negative in vitro genotoxicity studies.

	Reproductive and developmental toxicity	1-Butanesulfonic acid is not considered to cause reproductive or developmental toxicity.
US EPA (2018)	Thyroid effects	The available evidence supports a hazard and the thyroid is considered a potential target organ for PFBS toxicity in humans.
	Reproductive and developmental toxicity	The available evidence supports a development hazard, and the developing offspring is considered a potential target for PFBS toxicity in humans. The available evidence for reproductive effects is equivocal.
	Renal effects	The available evidence supports a hazard and indicates the kidney as a target organ of PFBS toxicity.
	Hepatic effects	The available evidence for hepatic effects is equivocal.
	Effects on lipid or lipoprotein homeostasis	The available evidence for effects on lipid or lipoprotein homeostasis is equivocal.
	Immune effects	The available evidence for immune effects is equivocal
NICNAS (2005)	Acute toxicity	Potassium PFBS is of low toxicity via the oral and dermal route
	Corrosion / Irritation	Potassium PFBS is non-irritating to skin and the eye.
	Sensitisation	There is no evidence that potassium PFBS causes skin sensitisation.
	Repeated dose toxicity	Potassium PFBS does not cause serious damage to health by prolonged exposure.
	Genotoxicity	Potassium PFBS is not mutagenic.
	Reproductive and developmental toxicity	Potassium PFBS is not toxic to reproduction and development.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
NICNAS (2015e)	Aquatic and terrestrial toxicity	1-Butanesulfonic acid is not considered to have high toxicity to aquatic organisms or bird.
ECHA (2020e)	Aquatic toxicity	1-Butanesulfonic acid does not meet the criteria for aquatic toxicity specified in REACH Annex XIII.
ECCC (2006)	Aquatic toxicity	1-Butanesulfonic acid, 1,1,2,2,3,3,4,4,4-nonafluoro-, potassium salt is not inherently toxic to aquatic organisms.
NICNAS (2005)	Aquatic and terrestrial toxicity	Potassium PFBS has low ecotoxicity and is not toxic to aquatic organisms.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
	Persistence	1-Butanesulfonic acid is persistent (based on the expected non-degradability of PFBS, and the expectation that all chemicals

NICNAS (2015e)		in this group will release PFBS in the environment).
	Bioaccumulation	1-Butanesulfonic acid is not bioaccumulative (based on the available measured BCF values in fish for potassium PFBS, and data which indicate comparatively rapid elimination of PFBS in mammals).
ECHA (2020e)	Persistence	1-Butanesulfonic acid meets the criteria for being persistent and very persistent specified in REACH Annex XIII.
	Bioaccumulation	1-Butanesulfonic acid does not meet the criteria for being bioaccumulative or very bioaccumulative specified in REACH Annex XIII.
ECCC (2006)	Persistence	1-Butanesulfonic acid, 1,1,2,2,3,3,4,4,4-nonafluoro-, potassium salt is persistent.
	Bioaccumulation	1-Butanesulfonic acid, 1,1,2,2,3,3,4,4,4-nonafluoro-, potassium salt is not bioaccumulative.
NICNAS (2005)	Persistence	Potassium PFBS is persistent in the environment (based on non-degradability of PFBS).
	Bioaccumulation	The bioaccumulation potential of potassium PFBS is low.

Acrylic acid, ester with N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-1-octane-sulfonamide: CAS 423-82-5

Authority Classifications
None found.

Industry Classifications (SDS)

EU	USA
Skin Irrit. 2 Eye Irrit. 2 STOT SE 3 ***Notified*** Non-hazardous (no classification)	Acute Tox. 4 (oral) Acute Tox. 4 (dermal) Skin Irrit. 2 Eye Irrit. 2A STOT SE 3 Aquatic Acute 2 Aquatic Chronic 2

Source: Apollo (2018b); ECHA (2020j); SynQuest (2018)

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
NICNAS (2016a)	Not specified	Limited data is available for the substance. The primary health risks are expected to arise from secondary exposure to PFOS, to which the substance is an indirect precursor.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
NICNAS (2019b)	Not specified	The primary environmental effects are expected to result from the cumulative release of PFOS into the environment, to which the substance is an indirect precursor. Insufficient data is available to classify the aquatic hazards of the substance according to GHS.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
NICNAS (2019b)	Persistence	Insufficient data is available to assess the substance's persistence.
	Bioaccumulation	Insufficient data is available to assess the substance's bioaccumulation.
Environment Canada (2006)	Bioaccumulation	The weight of evidence suggests that PFOS, its salts and precursors (inc. CAS 423-82-5) are bioaccumulative.

2-Propenoic acid, 2-[ethyl[(tridecafluorohexyl)sulfonyl]-amino]ethylester: CAS 1893-52-3

Authority Classifications
None found.

Industry Classifications (SDS)
None found.

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
NICNAS (2015d)	Not specified	No toxicological data is available for the substance. The primary health risks are expected to arise from secondary exposure to PFSAs, to which the substance is an indirect precursor.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
NICNAS (2015c)	Not specified	The primary environmental effects of the substance are expected to result from the cumulative release of C_5 to C_7 perfluoroalkyl sulfonates into the environment. Insufficient data is available to classify the aquatic hazards of the substance according to GHS.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
NICNAS (2015c)	Persistence	Insufficient data is available to assess the substance's persistence. However, it has the potential to breakdown into persistent perfluoroalkyl sulfonates.
	Bioaccumulation	Insufficient data is available to assess the substance's bioaccumulation. However, it has the potential to breakdown into perfluoroalkyl sulfonates, which are known to be, or may be, bioaccumulative.
RIVM (2011)	Persistence	The substance is persistent (P-score of 0.97).
	Bioaccumulation	The substance is bioaccumulative (B-score of 0.91).

1-Butanaminium, N,N,N-tributyl-, hexafluorophosphate(1-): CAS 3109-63-5

Authority Classifications
None found.

Industry Classifications (SDS)

EU	Brazil	China	Japan	Korea	USA
Notified Skin Irrit. 2 Eye Irrit. 2 STOT SE 3	Acute Tox. 4 (oral) Skin Irrit. 2 Eye Irrit. 2A STOT SE 3	Acute Tox. 4 (oral) Skin Corr. 1C Eye Dam. 1	Acute Tox. 4 (oral) Skin Irrit. 2 Eye Irrit. 2A STOT SE 3	Acute Tox. 4 (oral) Skin Irrit. 2 Eye Irrit. 2 STOT SE 3	Acute Tox. 4 (oral) Skin Corr. 1C Eye Dam. 1

Source: ECHA (2020j); TCI (2016; 2020b); Thermo-Fisher Scientific (2021a)

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments
None found.

Persistence and Bioaccumulation Assessments
None found.

1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro: CAS 4151-50-2

Authority Classifications
None found.

Industry Classifications (SDS)

EU	USA
Acute Tox. 4 (oral) Acute Tox. 4 (dermal) Acute Tox. 4 (inhal) Skin Irrit. 2 Eye Irrit. 2 Carc.2 Repr. 1B STOT SE 3 STOT RE 1 Aquatic Chronic 2 ***Notified*** Acute Tox. 4 (oral) Acute Tox. 4 (dermal) Aquatic Chronic 2	Acute Tox. 4 (oral) Acute Tox. 4 (dermal) Aquatic Acute 2 Aquatic Chronic 2

Source: Apollo (2014b); ECHA (2020j); LGC (2018); Sigma-Aldrich (2020c)

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments

Environmental Hazard Assessments		
Publication	**Hazard Assessed**	**Conclusions on Environmental Effects**

ECCC (2006)	Aquatic toxicity	It is uncertain whether 1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro is inherently toxic to aquatic organisms.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
RIVM (2011)	Persistence	The substance is persistent (P-score of 0.93).
	Bioaccumulation	The substance is bioaccumulative (B-score of 0.87).
ECCC (2006)	Persistence	1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro is persistent.
	Bioaccumulation	1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro is bioaccumulative.

Ethanaminium, N,N,N-triethyl-, salt with 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-1-octanesulfonicacid (1:1): CAS 56773-42-3

Authority Classifications

Australia
Acute Tox. 3 (oral) Acute Tox. 4 (inhal) Carc. 2 Repr. 1B Lact. STOT RE 1

Industry Classifications (SDS)

EU	Brazil	Canada	China	Japan	Korea	USA
Acute Tox. 3 (oral) Acute Tox. 4 (inhal) Carc. 2 Lact. STOT RE 1 Aquatic Chronic 3 ***Notified*** Acute Tox. 3 (oral) Acute Tox. 4 (inhal) Carc. 2 Repr. 1B Lact. STOT RE 1	Acute Tox. 3 (oral) Carc. 2 Repr. 1B Lact. STOT RE 1	Acute Tox. 3 (oral) Acute Tox. 4 (inhal) Carc. 2 Repr. 1B Lact. STOT RE 1	Acute Tox. 3 (oral) Acute Tox. 4 (inhal) Carc. 2 Repr. 1B Lact. STOT RE 1	Acute Tox. 3 (oral) Acute Tox. 4 (inhal) Carc. 2 Repr. 1B Lact. STOT RE 1	Acute Tox. 3 (oral) Acute Tox. 4 (inhal) Carc. 2 Repr. 1B Lact. STOT RE 1	Acute Tox. 3 (oral) Acute Tox. 4 (inhal) Carc. 2 Repr. 1B Lact. STOT RE 1 Aquatic Acute 3 Aquatic Chronic 3

Source: Apollo (2016); ECHA (2020j); Sigma-Aldrich (2014a); SynQuest (2016)

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
NICNAS (2015f)	Acute toxicity	PFOS salts have moderate acute toxicity following oral exposure.
	Reproductive and developmental toxicity	PFOS salts do not have an adverse effect on the reproductive parameters but are toxic to development.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
ECHA (2020f)	Aquatic toxicity	The substance meets the aquatic toxicity criteria specified in REACH Annex XIII.
NICNAS (2015a)	Aquatic and terrestrial toxicity	The substances will release PFOS in the environment and this is expected to have long-term toxic effects in many aquatic and terrestrial organisms.
ECCC (2006)	Aquatic toxicity	The substance is inherently toxic to aquatic organisms.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
ECHA (2020f)	Persistence	The substance meets the criteria for persistence specified in REACH Annex XIII.
	Bioaccumulation	The substance does not meet criteria for bioaccumulation specified in REACH Annex XIII.
NICNAS (2015a)	Persistence	The substance is categorised as persistent (based on the non-degradability of PFOS, and the expectation that the substance will release PFOS in the environment).
	Bioaccumulation	The substance is categorised as bioaccumulative (based on the bioaccumulation properties of PFOS, and the expectation that the substance will release PFOS in the environment).
ECCC (2006)	Persistence	The substance is persistent.
	Bioaccumulation	It is uncertain whether the substance is bioaccumulative.

2-Propanoic acid, 2-((ethyl(pentadecafuloroheptyl)-sulfonyl)amino)ethyl ester: CAS 59071-10-2

Authority Classifications
None found.

Industry Classifications (SDS)
None found.

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
NICNAS (2015d)	Not specified	No toxicological data is available for the substance. The primary health risks are expected to arise from secondary exposure to PFSAs, to which the substance is an indirect precursor.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
NICNAS (2015c)	Not specified	The primary environmental effects of the substance are expected to result from the cumulative release of C_5 to C_7 perfluoroalkyl sulfonates into the environment. Insufficient data is available to classify the aquatic hazards of the substance according to GHS.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
NICNAS (2015c)	Persistence	Insufficient data is available to assess the substance's persistence. However, it has the potential to breakdown into persistent perfluoroalkyl sulfonates.
	Bioaccumulation	Insufficient data is available to assess the substance's bioaccumulation. However, it has the potential to breakdown into perfluoroalkyl sulfonates, which are known to be, or may be, bioaccumulative.
RIVM (2011)	Persistence	The substance is persistent (P-score of 0.99).
	Bioaccumulation	The substance is bioaccumulative (B-score of 0.94).

Glycine, N-ethyl-N-[(nonafluorobutyl)sulfonyl]-, potassium salt: CAS 67584-51-4

Authority Classifications
None found.

Industry Classifications (SDS)
None found.

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
NICNAS (2015g)	Not specified	No hazard data is available for the substance. The primary health risks for the substance are expected to be caused by secondary exposure to PFBS. Classification of the substance under GHS is not recommended.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
NICNAS (2015b)	Aquatic toxicity	The primary environmental effects of the substance are expected to result from the cumulative release of PFBS into the environment. Insufficient data is available to classify the aquatic hazards of the substance according to GHS.
ECCC (2006)	Aquatic toxicity	Glycine, N-ethyl-N-[(nonafluorobutyl)sulfonyl]-, potassium salt is not inherently toxic to aquatic organisms.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
NICNAS (2015b)	Persistence	Insufficient data is available to classify for persistence.
	Bioaccumulation	Insufficient data is available to classify for bioaccumulation.
ECCC (2006)	Persistence	Glycine, N-ethyl-N-[(nonafluorobutyl)sulfonyl]-, potassium salt is persistent.
	Bioaccumulation	Glycine, N-ethyl-N-[(nonafluorobutyl)sulfonyl]-, potassium salt is not bioaccumulative.

Glycine, N-ethyl-N-[(undecafluoropentyl)sulfonyl]-, potassium salt: CAS 67584-52-5

Authority Classifications
None found.
Industry Classifications (SDS)
None found.

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
NICNAS (2015d)	Not specified	No hazard data is available for the substance. The primary health risks for the substance are expected to be caused by secondary exposure to PFSAs. Classification of the substance under GHS is not recommended.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
NICNAS (2015c)	Aquatic toxicity	The primary environmental effects of the substance are expected to result from the cumulative release of C_5 to C_7 perfluoroalkyl sulfonates into the environment. Insufficient data is available to classify the aquatic hazards of the substance according to GHS.
ECCC (2006)	Aquatic toxicity	Glycine, N-ethyl-N-[(undecafluoropentyl)sulfonyl]-, potassium salt is not inherently toxic to aquatic organisms.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
NICNAS (2015c)	Persistence	Insufficient data is available to classify for persistence.
	Bioaccumulation	Insufficient data is available to classify for bioaccumulation.
RIVM (2011)	Persistence	Glycine, N-ethyl-N-[(undecafluoropentyl)sulfonyl]-, potassium salt is persistent (P-score of 0.92).
	Bioaccumulation	Glycine, N-ethyl-N-[(undecafluoropentyl)sulfonyl]-, potassium salt is bioaccumulative (B-score of 0.92).
ECCC (2006)	Persistence	Glycine, N-ethyl-N-[(undecafluoropentyl)sulfonyl]-, potassium salt is persistent.
	Bioaccumulation	Glycine, N-ethyl-N-[(undecafluoropentyl)sulfonyl]-, potassium salt is not bioaccumulative.

Glycine, N-ethyl-N-[(tridecafluorohexyl)sulfonyl]-, potassium salt: CAS 67584-53-6

Authority Classifications
None found.
Industry Classifications (SDS)
None found.

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
NICNAS (2015d)	Not specified	No hazard data is available for the substance. The primary health risks for the substance are expected to be caused by secondary exposure to PFSAs. Classification of the substance under GHS is not recommended.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
NICNAS (2015c)	Aquatic toxicity	The primary environmental effects of the substance are expected to result from the cumulative release of C_5 to C_7 perfluoroalkyl sulfonates into the environment. Insufficient data is available to classify the aquatic hazards of the substance according to GHS.
ECCC (2006)	Aquatic toxicity	Glycine, N-ethyl-N-[(tridecafluorohexyl)sulfonyl]-, potassium salt is inherently toxic to aquatic organisms.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
NICNAS (2015c)	Persistence	Insufficient data is available to classify for persistence.
	Bioaccumulation	Insufficient data is available to classify for bioaccumulation.
RIVM (2011)	Persistence	The substance is persistent (P-score of 0.96).
	Bioaccumulation	The substance is bioaccumulative (B-score of 0.97).
ECCC (2006)	Persistence	Glycine, N-ethyl-N-[(tridecafluorohexyl)sulfonyl]-, potassium salt is persistent.
	Bioaccumulation	Glycine, N-ethyl-N-[(tridecafluorohexyl)sulfonyl]-, potassium salt is not bioaccumulative.

Acrylic acid, 2-[methyl[(nonafluorobutyl) sulfonyl] amino] ethylester: CAS 67584-55-8

Authority Classifications
None found.

Industry Classifications (SDS)

EU
Notified
Skin Sens. 1B
Aquatic Chronic 2

Source: ECHA (2020j)

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
BAuA (2019)	Aquatic toxicity	The substance does not fulfil the T criteria specified in REACH Annex XIII for short-term toxicity, and there is not sufficient data to assess whether the T criteria is fulfilled for long-term toxicity.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
BAuA (2019)	Persistence	The substance is expected to be very persistent.
	Bioaccumulation	The substance is not considered to be bioaccumulative for aquatic organisms. The substance has low bioaccumulation potential in terrestrial organisms.

Glycine, N-ethyl-N-[(heptadecafluorooctyl)sulfonyl]-, potassium salt: CAS 2991-51-7

Authority Classifications
None found.

Industry Classifications (SDS)
None found.

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
NICNAS (2016a)	Not specified	Limited data is available for the substance. The primary health risks are expected to arise from secondary exposure to PFOS, to which the substance is an indirect precursor.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
NICNAS (2019b)	Not specified	The primary environmental effects are expected to result from the cumulative release of PFOS into the environment, to which the substance is an indirect precursor. Insufficient data is available to classify the aquatic hazards of the substance according to GHS.
ECCC (2006)	Aquatic toxicity	Glycine, N-ethyl-N-[(heptadecafluorooctyl)sulfonyl]-, potassium salt is not inherently toxic to aquatic organisms.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
ECCC (2006)	Persistence	Glycine, N-ethyl-N-[(heptadecafluorooctyl)sulfonyl]-, potassium salt is persistent.
	Bioaccumulation	Glycine, N-ethyl-N-[(heptadecafluorooctyl)sulfonyl]-, potassium salt is not bioaccumulative

Glycine, N-ethyl-N-[(pentadecafluoroheptyl)sulfonyl]-, potassium salt: CAS 67584-62-7

Authority Classifications
None found.

Industry Classifications (SDS)
None found.

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
NICNAS (2015d)	Not specified	No hazard data is available for the substance. The primary health risks for the substance are expected to be caused by secondary exposure to PFSAs. Classification of the substance under GHS is not recommended.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
NICNAS (2015c)	Aquatic toxicity	The primary environmental effects of the substance are expected to result from the cumulative release of C_5 to C_7 perfluoroalkyl sulfonates into the environment. Insufficient data is available to classify the aquatic hazards of the substance according to GHS.
ECCC (2006)	Aquatic toxicity	Glycine, N-ethyl-N-[(pentadecafluoroheptyl)sulfonyl]-, potassium salt is inherently toxic to aquatic organisms.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
NICNAS (2015c)	Persistence	Insufficient data is available to classify for persistence.
	Bioaccumulation	Insufficient data is available to classify for bioaccumulation.
RIVM (2011)	Persistence	The substance is persistent (P-score of 0.98).

	Bioaccumulation	The substance is bioaccumulative (B-score of 0.98).
ECCC (2006)	Persistence	Glycine, N-ethyl-N-[(pentadecafluoroheptyl)sulfonyl]-, potassium salt is persistent.
	Bioaccumulation	Glycine, N-ethyl-N-[(pentadecafluoroheptyl)sulfonyl]-, potassium salt is not bioaccumulative.

Copolymer of 2-(dimethylamino) ethyl methacrylate with 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate, N-oxide, acetate CAS 1440528-04-0

Authority Classifications
None found.

Industry Classifications (SDS)
None found.

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
ECCC (2021)	Not specified	The substance not likely to pose a significant risk to human health.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
ECCC (2021)	Aquatic toxicity	The substance is expected to have low toxicity in aquatic organisms.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
ECCC (2021)	Bioaccumulation	The substance is not expected to bioaccumulate

Diphosphoric acid, polymers with ethoxylated reduced methyl esters of reduced polymerized oxidized tetrafluoroethylene

CAS 162492-15-1

Authority Classifications
None found.

Industry Classifications (SDS)

EU	Canada	China	Japan	Korea	Malaysia	USA
Non-hazardous (no classification)	Non-hazardous (no classification)	Non-hazardous (no classification)	Non-hazardous (no classification)	Non-hazardous (no classification)	Non-hazardous (no classification)	Non-hazardous (no classification)

Source: Alfa-Aesar (2021); ECHA (2020j)

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments
None found.

Persistence and Bioaccumulation Assessments
None found.

CAS 1314-56-3

Authority Classifications

EU	Australia	Canada	China	Japan	Korea	New Zealand	Thailand
Harmonised Skin Corr. 1A	Skin Corr. 1A	Skin Corr. 1 Eye Dam. 1	Skin Corr. 1A Eye Dam. 1	Acute Tox. 2 (inhal) Skin Corr. 1 Eye Dam. 1	Acute Tox. 2 (inhal) Skin Corr. 1	Skin Corr. 1B Eye Dam. 1	Non-hazardous (no classification)

Industry Classifications (SDS)

EU	China	Japan	Korea	USA
Notified Skin Corr. 1A Eye Dam. 1	Acute Tox. 2 (inhal) Skin Corr. 1A Eye Dam. 1	Acute Tox. 2 (inhal) Skin Corr. 1A Eye Dam. 1	Acute Tox. 2 (inhal) Skin Corr. 1A Eye Dam. 1	Acute Tox. 2 (inhal) Skin Corr. 1A Eye Dam. 1 STOT SE 3

Source: ECHA (2020j); Merck (2019); Santa Cruz Biotechnology (2018a)

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
ECCC (2006)	Aquatic toxicity	Phosphorus oxide is not inherently toxic to aquatic organisms.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
ECCC (2006)	Persistence	Phosphorus oxide is persistent.
	Bioaccumulation	Phosphorus oxide is not bioaccumulative.

CAS 2466-09-3

Authority Classifications

Australia
Acute Tox. 4 (inhal) Skin Corr. 1

Industry Classifications (SDS)

EU	China	Canada	USA	Japan	Korea
Acute Tox. 4 (oral) Skin Corr. 1B ***Notified*** Skin Corr. 1B	Acute Tox. 4 (oral) Skin Corr. 1B Eye Dam. 1	Acute Tox. 4 (oral) Skin Corr. 1B Eye Dam. 1	Acute Tox. 4 (oral) Acute Tox. 2 (Inhal) Skin Corr. 1A Eye Dam. 1	Acute Tox. 4 (oral) Skin Corr. 1B Eye Dam. 1	Acute Tox. 4 (oral) Skin Corr. 1B Eye Dam. 1

Source: ECHA (2020j); Santa Cruz Biotechnology (2019); Sigma-Aldrich (2020d)

Human Health Hazard Assessments

Human Health Hazard Assessments		
Publication	**Hazard Assessed**	**Conclusions on Human Health Effects**
NICNAS (2016b)	Acute toxicity	Expected to have low acute oral toxicity, low to moderate acute dermal toxicity, and moderate to high acute inhalation toxicity.
	Corrosion / Irritation	Expected to be corrosive and, depending on the concentration, irritating to the respiratory tract, eye, and skin, based on information from phosphoric acid.
	Sensitisation	No data is available

Environmental Hazard Assessments

None found.

Persistence and Bioaccumulation Assessments
None found

2-propen-1-ol, reaction products with pentafluoroiodoethane-tetrafluoroethylene telomer, dehydroiodinated, reaction products with epichlorohydrin and triethylenetetramine: CAS 464178-90-3

Authority Classifications
None found.

Industry Classifications (SDS)
None found.

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
ECCC (2015)	Acute toxicity	The substance is expected to show low acute oral toxicity.
	Sub-chronic toxicity	The substance is likely to display moderate sub-chronic oral toxicity, with possible effects on the thyroid, liver, and kidney.
	Corrosion / Irritation	The substance is expected to show low skin and eye irritation potential.
	Reproductive and developmental toxicity	The substance is expected to show low reproductive and developmental toxicity.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
ECCC (2015)	Aquatic toxicity	The substance is not considered to be toxic or cause adverse effects to the environment.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
METI (2019c)	Persistence	The substance is not readily biodegradable.
	Bioaccumulation	The substance has low bioconcentration.
ECCC (2015)	Persistence	The substance is expected to degrade and release PFCA precursors which are expected to further degrade to the highly persistent PFCAs.

Tetrafluoroethylene, oxidized, oligomers, reduced, methyl esters, reduced: CAS 88645-29-8

Authority Classifications

EU
Harmonised
Non-hazardous (no classification)

Industry Classifications (SDS)
None found.

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments
None found.

Persistence and Bioaccumulation Assessments
None found.

Propanoic acid, 3-hydroxy-2-(hydroxymethyl)-2-methyl-, polymers with 5-isocyanato-1-(isocyanatomethyl)-1,3,3-trimethylcyclohexane and reduced Me esters of reduced polymd. oxidized tetrafluoroethylene, compds. with triethylamine: CAS 328389-91-9

Authority Classifications
None found.

Industry Classifications (SDS)
None found.

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
NICNAS (2013)	Acute toxicity	The substance is not acutely toxic.
	Corrosion / Irritation	The substance is non-irritating.
	Sensitisation	There is no evidence of sensitisation.
	Genotoxicity	The substance is non-mutagenic.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
NICNAS (2013)	Aquatic toxicity	The substance may be harmful to fish, aquatic invertebrates and algae.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
NICNAS (2013)	Persistence	The substance is expected to degrade via biotic or abiotic pathways
	Bioaccumulation	The substance is not expected to bioaccumulate

Isophorone diisocyanate: CAS 4098-71-9

Authority Classifications

EU	Australia	Canada	China	Japan	Korea	Thailand
Harmonised	Acute Tox. 3 (inhal)	Acute Tox. 1 (inhal)	Acute Tox. 3 (inhal)	Acute Tox. 1 (inhal)	Acute Tox. 3 (inhal)	Acute Tox. 4 (oral)
Acute Tox. 3 (inhal)	Skin Irrit. 2	Skin Irrit. 2	Skin Irrit. 2	Skin Corr. 1	Skin Irrit. 2	Acute Tox. 4 (dermal)
Skin Irrit. 2	Eye Irrit. 2	Eye Irrit. 2	Eye Irrit. 2	Eye Irrit. 2A	Eye Irrit. 2	Acute Tox. 3 (inhal)
Eye Irrit. 2	Skin Sens. 1	Skin Sens. 1	Skin Sens. 1	Resp. Sens. 1	Skin Sens. 1	Skin Corr. 1A
Skin Sens. 1	Resp. Sens. 1	Resp. Sens. 1	Resp. Sens. 1	Skin Sens. 1	Resp. Sens. 1	Eye Dam. 1
Resp. Sens. 1	STOT SE 3	STOT SE 3	STOT SE 3	STOT SE 1	STOT SE 3	Skin Sens. 1
STOT SE 3	Aquatic Chronic 2		Aquatic Acute 2	STOT RE 1	STOT RE 1	STOT SE 3
Aquatic Chronic 2			Aquatic Chronic 2	Aquatic Acute 3	Aquatic Chronic 3	STOT RE 1
				Aquatic Chronic 3		Aquatic Acute 3
						Aquatic Chronic 3

Industry Classifications (SDS)

EU	China	Japan	Korea	USA
Acute Tox. 1 (inhal)	Acute Tox. 4 (oral)	Acute Tox. 4 (oral)	Acute Tox. 4 (oral)	Acute Tox. 4 (oral)
Skin Corr. 1C	Acute Tox. 4 (dermal)	Acute Tox. 4 (dermal)	Acute Tox. 4 (dermal)	Acute Tox. 4 (dermal)
Eye Irrit. 2	Acute Tox. 3 (inhal)	Acute Tox. 3 (inhal)	Acute Tox. 3 (inhal)	Acute Tox. 1 (inhal)
Skin Sens. 1	Skin Corr. 1	Skin Corr. 1	Skin Corr. 1	Skin Corr. 1C
Resp. Sens. 1	Eye Irrit. 2	Eye Irrit. 2A	Eye Irrit. 2	Eye Dam. 1
STOT SE 3	Skin Sens. 1	Skin Sens. 1	Skin Sens. 1	Skin Sens. 1
Aquatic Chronic 2	Resp Sens. 1	Resp Sens. 1	Resp Sens. 1	Resp. Sens 1
	Aquatic Acute 3	STOT SE 1	STOT SE 3	STOT SE 3
Notified	Aquatic Chronic 2	STOT RE 1	STOT RE 1	STOT RE 1
Skin Irrit. 2		Aquatic Acute 3	Aquatic Chronic 2	Aquatic Acute 3
Eye Irrit. 2		Aquatic Chronic 3		Aquatic Chronic 2
Skin Sens. 1				
Acute Tox. 1 (inhal)				
STOT SE 3				
Resp. Sens. 1				
Aquatic Chronic 2				

Acute Tox. 1 (inhal) Skin Corr. 1C Skin Sens. 1 Resp. Sens. 1 Aquatic Chronic 2				

Source: ECHA (2020j); Sigma-Aldrich (2020e); TCI (2013); Thermo-Fisher Scientific (2021b)

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
OECD (2012)	Acute toxicity	Isophorone diisocyanate is acutely toxic following inhalation exposure, with effects mainly on the respiratory tract. Isophorone diisocyanate has low acute oral toxicity (based on data from rat studies).
	Corrosion / Irritation	Isophorone diisocyanate is corrosive to skin and causes eye damage (based on data from rabbit studies).
	Sensitisation	Isophorone diisocyanate is a skin sensitiser. Isophorone diisocyanate is predicted to be a respiratory tract sensitizer because it is a diisocyanate.
	Genotoxicity	Isophorone diisocyanate is not considered to be genotoxic (based on in vitro studies).
	Reproductive and developmental toxicity	Isophorone diisocyanate does not exhibit adverse reproductive or developmental effects (based on animal studies).

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
ECHA (2020h)	Aquatic toxicity	Isophorone diisocyanate does not meet the aquatic toxicity criteria specified in REACH Annex XIII.
ECCC and Health Canada (2019)	Aquatic toxicity	Isophorone diisocyanate has moderate toxicity to aquatic (based on a reactive mode of action and a moderate potential to cause adverse effects in aquatic foodwebs given its bioaccumulation potential).
OECD (2012)	Aquatic toxicity	Isophorone diisocyanate has properties which indicate acute aquatic toxicity to invertebrates.
ECCC (2006)	Aquatic toxicity	Isophorone diisocyanate is not inherently toxic to aquatic organisms.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
ECHA (2020h)	Aquatic toxicity	Isophorone diisocyanate does not meet the aquatic toxicity criteria specified in REACH Annex XIII.
ECCC and Health Canada (2019)	Aquatic toxicity	Isophorone diisocyanate has moderate toxicity to aquatic (based on a reactive mode of action and a moderate potential to cause adverse effects in aquatic foodwebs given its bioaccumulation potential).
OECD (2012)	Aquatic toxicity	Isophorone diisocyanate has properties which indicate acute aquatic toxicity to invertebrates.
ECCC (2006)	Aquatic toxicity	Isophorone diisocyanate is not inherently toxic to aquatic organisms.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
ECHA (2020h)	Persistence	Isophorone diisocyanate is very persistent.
	Bioaccumulation	Isophorone diisocyanate is not bioaccumulative.
METI (2019a)	Persistence	Isophorone diisocyanate is not readily biodegradable.
	Bioaccumulation	Isophorone diisocyanate has low bioconcentration.
OECD (2012)	Bioaccumulation	Isophorone diisocyanate has low bioaccumulation potential.
ECCC (2006)	Persistence	Isophorone diisocyanate is persistent.
	Bioaccumulation	Isophorone diisocyanate is not bioaccumulative.

2,2-Bis(hydroxymethyl)propionic acid: CAS 4767-03-7

Authority Classifications

Chinese Taipei
Eye Irrit. 2A STOT SE 3

Industry Classifications (SDS)

EU	Brazil	Canada	China	Japan	Korea	USA
Acute Tox. 4 (oral) Eye Irrit. 2 Skin Irrit. 2 STOT SE 3 ***Notified*** Eye Irrit. 2 STOT SE 3	Acute Tox. 4 (oral) Eye Irrit. 2A STOT SE 3	Acute Tox. 4 (oral) Eye Irrit. 2A STOT SE 3	Acute Tox. 4 (oral) Eye Irrit. 2A	Acute Tox. 4 (oral) Eye Irrit. 2A STOT SE 3	Acute Tox. 4 (oral) Eye Irrit. 2 STOT SE 3	Acute Tox. 4 (oral) Skin Irrit. 2 Eye Irrit. 2A STOT SE 3

Source: ECHA (2020j); Santa Cruz Biotechnology (2018b); Sigma-Aldrich (2020f); TCI (2019b); Thermo-Fisher Scientific (2017)

Human Health Hazard Assessments

None found.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
ECHA (2020c)	Aquatic toxicity	2,2-Bis(hydroxymethyl)propionic acid does not meet the aquatic toxicity criteria specified in REACH Annex XIII.
ECCC (2006)	Aquatic toxicity	2,2-Bis(hydroxymethyl)propionic acid is not inherently toxic to aquatic organisms.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
ECHA (2020c)	Persistence	2,2-Bis(hydroxymethyl)propionic acid is readily biodegradable and does not meet the criteria for being persistent or very persistent as specified in REACH Annex XIII.
	Bioaccumulation	2,2-Bis(hydroxymethyl)propionic acid is readily biodegradable and does not meet the criteria for being bioaccumulative or very bioaccumulative as specified in REACH Annex XIII.
ECCC (2006)	Persistence	2,2-Bis(hydroxymethyl)propionic acid is not persistent.
	Bioaccumulation	2,2-Bis(hydroxymethyl)propionic acid is not bioaccumulative.

Triethylamine: CAS 121-44-8

Authority Classifications

EU	Australia	Canada	China	Japan	Korea	New Zealand	Thailand
Harmonised Flam. Liq. 2 Acute Tox. 4 (oral) Acute Tox. 4 (dermal) Acute Tox. 4 (inhal) Skin Corr. 1A	Flam. Liq. 2 Acute Tox. 4 (oral) Acute Tox. 3 (dermal) Acute Tox. 3 (inhal) STOT SE 3 Skin Corr. 1A	Flam. Liq. 2 Acute Tox. 4 (oral) Acute Tox. 3 (dermal) Acute Tox. 3 (inhal) Skin Corr. 1 Eye Dam. 1	Flam. Liq. 2 Acute Tox. 4 (oral) Acute Tox. 4 (dermal) Acute Tox. 4 (inhal) Skin Corr. 1A Eye Dam. 1 Aquatic Acute 3	Flam. Liq. 2 Acute Tox. 4 (oral) Acute Tox. 3 (dermal) Acute Tox. 4 (inhal) Skin Corr. 1 Eye Dam. 1 STOT SE 1 STOT RE 2 Aquatic Acute 2 Aquatic Chronic 3	Flam. Liq. 2 Acute Tox. 4 (oral) Acute Tox. 3 (dermal) Acute Tox. 3 (inhal) Skin Corr. 1	Flam. Liq. 2 Acute Tox. 4 (oral) Acute Tox. 3 (dermal) Acute Tox. 4 (inhal) Skin Corr. 1B Eye Dam. 1 Aquatic Chronic 4	Flam. Liq. 2 Acute Tox. 4 (oral) Acute Tox. 3 (dermal) Acute Tox. 3 (inhal) Skin Corr. 1A Eye Dam. 1 STOT SE 1 STOT RE 1 Aquatic Acute 2 Aquatic Chronic 2

Industry Classifications (SDS)

EU	USA
Flam. Liq. 2 Acute Tox. 4 (oral) Acute Tox. 3 (dermal) Acute Tox. 3 (inhal) Skin Corr. 1A Eye Dam. 1 STOT SE 3 ***Notified*** Flam. Liq. 2 Acute Tox. 4 (oral) Acute Tox. 3 (dermal) Acute Tox. 3 (inhal) Skin Corr. 1A Eye Dam. 1 STOT SE 3	Flam. Liq. 2 Acute Tox. 4 (oral) Acute Tox. 3 (dermal) Acute Tox. 3 (inhal) Skin Corr. 1A Eye Dam. 1 STOT SE 1 STOT RE 1 Aquatic Acute 2 Aquatic Chronic 2

Source: ECHA (2020j); Sigma-Aldrich (2020g); Thermo-Fisher Scientific (2020b)

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
ECHA (2019)	Acute toxicity	Triethylamine was agreed to be classified as Acute Tox 4 for acute oral toxicity. Triethylamine was assigned an Acute Toxicity Estimate (ATE) value of 500 mg/kg bw. Triethylamine was agreed to be classified as Acute Tox 3 for acute dermal toxicity. Triethylamine was assigned an Acute Toxicity Estimate (ATE) value of 420 mg/kg bw. Triethylamine was agreed to be classified as Acute Tox 3 for acute inhalation toxicity. Triethylamine was assigned an Acute Toxicity Estimate (ATE) value of 7.2 mg/kg bw.
	Corrosion / Irritation	Triethylamine has shown severe effects in the eyes of rabbits. It is therefore an eye corrosive and is classified as Eye Dam. 1
OECD (2012a)	Acute toxicity	Triethylamine has acute dermal toxicity.
	Corrosion / Irritation	Triethylamine is corrosive to skin and eyes.
	Repeated dose toxicity	Triethylamine is expected to have repeated dose toxicity with effects on the respiratory and gastrointestinal tract.

	Genotoxicity	Triethylamine is not considered to be genotoxic.
	Reproductive and developmental toxicity	Triethylamine may cause developmental effects by the oral route.
US EPA (1991)	Chronic toxicity	Triethylamine has chronic effects on the respiratory system and has a RfC of 0.007 mg/m^3.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
ECHA (2020g)	Aquatic toxicity	Triethylamine does not meet the aquatic toxicity criteria specified in REACH Annex XIII.
OECD (2012a)	Aquatic toxicity	Triethylamine has properties indicating acute aquatic toxicity.
ECCC (2006)	Aquatic toxicity	Triethylamine is not inherently toxic to aquatic organisms.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
ECHA (2020g)	Persistence	Triethylamine does not meet the criteria for being persistent or very persistent as specified in REACH Annex XIII.
	Bioaccumulation	Triethylamine has negligible bioaccumulation potential and does not meet the criteria for being bioaccumulative or very bioaccumulative as specified in REACH Annex XIII.
OECD (2012a)	Bioaccumulation	Triethylamine is not expected to bioaccumulate.
ECCC (2006)	Persistence	Triethylamine is not persistent.
	Bioaccumulation	Triethylamine is not bioaccumulative.
METI (1990)	Bioaccumulation	Triethylamine was determined to be non or not highly bioaccumulative.

2-propenoic acid, 2-methyl-, polymer with 2-(diethylamino)ethyl 2-methyl-2-propenoate, 2-propenoic acid and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-methyl-2-propenoate, acetate: CAS 1071022-26-8

Authority Classifications
None found.

Industry Classifications (SDS)

EU
Acute Tox. 3 (inhalation)

Source: Fila Industria Chimica (2017)

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments
None found.

Persistence and Bioaccumulation Assessments
None found.

Annex C.1 : Hazard Classifications and Assessments of Non-Fluorinated PFAS Alternatives

Silicone oils (with added preserving agents)

Authority Classifications
None found.

Industry Classifications (SDS)

EU	USA
STOT SE 3 Aquatic Chronic Tox. 2	Aquatic Acute Tox. 2 Aquatic Chronic Tox. 2

Source: Electrolube (2017a); Sigma-Aldrich (2014b)

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments
None found.

Persistence and Bioaccumulation Assessments
None found.

Silicone Resins

Authority Classifications
None found.

Industry Classifications (SDS)

EU
Not classified (non-hazardous)

Source: Electrolube (2017b)

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments
None found.

Persistence and Bioaccumulation Assessments
None found.

Silicone Elastomer

Authority Classifications
None found.

Industry Classifications (SDS)

US
Not classified (non-hazardous)

Source: Dow (2019)

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments
None found.

Persistence and Bioaccumulation Assessments
None found.

Natural and synthetic cellulose fibres bleached or unbleached: CAS N/A

Authority Classifications
None found.

Industry Classifications (SDS)

EU	USA
Non-hazardous (no classification)	Non-hazardous (no classification)

Source: Cellucomp (2018); Fisher Scientific (2014); Merck (2020)

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments
None found.

Persistence and Bioaccumulation Assessments
None found.

Wood pulp bleached or unbleached: CAS N/A

Authority Classifications
None found.

Industry Classifications (SDS)

EU	USA
Non-hazardous (no classification)	Non-hazardous (no classification)

Source: International Paper (2017); Resolute Forest Products (2015); Verso (2015); WestRock (2019)

Human Health Hazard Assessments

Publication	Hazard Assessed	Conclusions on Human Health Effects
US EPA (1990)	Carcinogenicity	There is a significant lifetime cancer risk due to concentrations of dioxin in paper food contact materials.

Environmental Hazard Assessments
None found.

Persistence and Bioaccumulation Assessments
None found.

Recycled fibres made from paper or paperboard: CAS N/A

Authority Classifications
None found.

Industry Classifications (SDS)

EU	USA
Non-hazardous (no classification)	Non-hazardous (no classification)

Source: Monarch Green Inc (n.d.); Sundeala (2018)

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments
None found.

Persistence and Bioaccumulation Assessments
None found.

2-Hydroxy-2-methylpropiophenone: CAS 7473-98-5

Authority Classifications

New Zealand	Chinese Taipei
Acute Tox. 4 (oral) Aquatic Acute 1 Aquatic Chronic 1	Acute Tox. 4 (oral)

Industry Classifications (SDS)

EU	China	Japan	Korea	USA
Acute Tox. 4 (oral) Acute Tox. 4 (dermal) Acute Tox. 4 (inhal) Aquatic Chronic 3 ***Notified*** Acute Tox. 4 (oral) Aquatic Chronic 3	Acute Tox. 4 (oral)	Acute Tox. 4 (oral)	Acute Tox. 4 (oral)	Acute Tox. 4 (oral)

Source: Apollo (2015); ECHA (2020j); Santa Cruz Biotechnology (2017b); Sigma-Aldrich (2015)

Human Health Hazard Assessments

None found.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
ECHA (2020b)	Aquatic toxicity	2-Hydroxy-2-methylpropiophenone does not meet the aquatic toxicity criteria specified in REACH Annex XIII.
ECCC (2006)	Aquatic toxicity	2-Hydroxy-2-methylpropiophenone is not inherently toxic to aquatic organisms.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
ECHA (2020b)	Persistence	2-Hydroxy-2-methylpropiophenone is not expected to be persistent or very persistent.
	Bioaccumulation	2-Hydroxy-2-methylpropiophenone is not expected to be bioaccumulative or very bioaccumulative.
ECCC (2006)	Persistence	2-Hydroxy-2-methylpropiophenone is not persistent.
	Bioaccumulation	2-Hydroxy-2-methylpropiophenone is not bioaccumulative.

Siloxanes and Silicones, di-Me, hydrogen-terminated, reaction products with acrylic acid and 2-ethyl-2- [(2-propenyloxy)methyl]-1,3-propanediol: CAS 155419-56-0

Authority Classifications
None found.

Industry Classifications (SDS)

EU
Notified
Non-hazardous (no classification)

Source: ECHA (2020i)

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments
None found.

Persistence and Bioaccumulation Assessments
None found.

Cyclohexane-1,2,4-triyltris(ethylene): CAS 2855-27-8

Authority Classifications
None found.

Industry Classifications (SDS)

EU	Brazil	China	Japan	Korea	USA
Flam. Liq. 3 Asp. Tox. 1 Skin Irrit. 2 Eye Irrit. 2 Skin Sens. 1 Carc. 1A Muta. 1B STOT SE 3 Aquatic Acute 1 Aquatic Chronic 1 ***Notified*** Flam. Liq. 3 Asp. Tox. 1 Skin Irrit. 2 Skin Sens. 1 Carc. 1A Muta. 1B STOT SE 3 Aquatic Acute 1 Aquatic Chronic 1	Flam. Liq. 4 Skin Irrit. 2 Eye Irrit. 2A STOT SE 3	Flam. Liq. 4 Skin Irrit. 2 Eye Irrit. 2A	Flam. Liq. 4 Skin Irrit. 2 Eye Irrit. 2A STOT SE 3	Flam. Liq. 4 Skin Irrit. 2 Eye Irrit. 2 STOT SE 3	Flam. Liq. 4 Skin Irrit. 2 Eye Irrit. 2A STOT SE 3

Source: ECHA (2020j); Santa Cruz Biotechnology (2017c); TCI (2018c)

Human Health Hazard Assessments
None found.

Environmental Hazard Assessments

Publication	Hazard Assessed	Conclusions on Environmental Effects
ECHA (2020)	Aquatic toxicity	The substance does not meet the aquatic toxicity criteria specified in REACH Annex XIII.

Persistence and Bioaccumulation Assessments

Publication	Hazard Assessed	Conclusions on Persistence and Bioaccumulation
ECHA (2020a)	Persistence	Based on the available information, a definitive conclusion on persistency cannot be drawn.
	Bioaccumulation	The substance is considered to potentially fulfil the bioaccumulation criteria, but not the very bioaccumulative criteria, specified in REACH Annex XIII.