Per- and Polyfluoroalkyl Substances (PFAS)

Nonpolymers

Perfluoroalkyl Substances
(all H atoms on all C atoms in alkyl chain attached to a functional group have been replaced with F)

- Perfluoroalkyl acids (PFAAs) [a]
- Perfluoroalkyl carboxylic acids/ Perfluoroalkyl carboxylates (PFCAs) [1, a, 5]
- Perfluoroalkane sulfonic acids/ Perfluoroalkane sulfonates (PFSAs) [1, b]
- Perfluoroalkane sulfinic acids (PFSiAs) [2, b]
- Perfluoroalkyl phosphonic acids (PFPAs) [1, c]
- Perfluoroalkyl phosphinic acids (PFPiAs) [1, c]
- Perfluoroalkyl Dicarboxylic acids (PFdiCAs) [b]
- Perfluoroalkane Disulfonic acids (PFdiSAs) [b]
- Perfluoroalkyl ether acids (PFEAs) [d]
- Perfluoroalkyl ether sulfonic acids (PFESAs) [5, d]
- Perfluoroalkyl ether carboxylic acids (PFECAs) [5, d]
- Perfluoroalkane sulfonyl fluorides (PASFs) [3, b]
- Perfluoroalkane sulfonamides (FASAs) [2, b]
- Perfluoroalkanoyl fluorides (PAFs or PACFs) [3, b]
- Perfluoroalkyl iodides (PFAIs) (Telomer A) [7, c]
- Perfluoroalkyl aldehydes (PFALs) [2, c]

Polyfluoroalkyl Substances
(all H atoms on at least one (but not all) C atoms have been replaced with F)

- Polyfluoroalkyl ether acids (PolyFEAs) [d]
- Polyfluoroalkyl ether sulfonic acids (PFESAs) [5, d]
- Polyfluoroalkyl ether carboxylic acids (PFECAs) [5, d]
- Polyfluoroalkyl carboxylic acids (PolyFCAs)
- Chloropolyfluoroalkyl ether acids [2,5,d]
- Chloropolyfluoroalkyl acids [1, d]
- Fluorotelomer substances [c]
- n:2 Fluorotelomer sulfonic acids (FTSs) [1, 2, c]
- n:2 or n:3 Fluorotelomer carboxylic acids and unsaturated carboxylic acids (FTCAs and FTUCAs) [2, (2), c]
- n:2 Fluorotelomer alcohols (FTOHs) [7, (2), c]
- n:2 Unsaturated Fluorotelomer alcohols (FTUOHs) [(2), c]
- n:2 Fluorotelomer iodides (FTIs) (Telomer B) [7, c]
- n:2 Fluorotelomer olefins (FTOs) [4, c]
- Semifluorinated N-alkanes (SFAs) / alkenes (SFenes) [6, c]
- n:2 Fluorotelomer acrylates/methacrylates (FTACs/FTMACs) [7, c]
- n:2 Fluorotelomer aldehydes and unsaturated aldehydes (FTALs and FTUALs) [2, (2), c]
- n:3 Saturated acids and n:3 unsaturated acids [2, c]
- n:2 Polyfluoroalkyl phosphoric acid esters, polyfluoroalkyl phosphates, fluorotelomer phosphates (PAPs) [1, 10, c]
- Perfluoroalkane sulfonamido substances [2, 3, b]
- N-Alkyl perfluoroalkane sulfonamides (MeFASAs, EtFASAs, BuFASAs) [3, b]
- Perfluoroalkane sulfonamido ethanols (FASEs) and N-Alkyl perfluoroalkane sulfonamido ethanols (MeFASEs, EtFASEs, BuFASEs) [3, b]
- N-Alkyl perfluoroalkane sulfonamidoethyl acrylates/methacrylates (MeFAS(M)ACs,EtFAS(M)ACs, BuFAS(M)ACs) [3,b]
- Perfluoroalkane sulfonamido acetic acids (FASAAs) and N-Alkyl perfluoroalkane sulfonamido acetic acids (MeFASAAs, EtFASAAs, BuFASAAs) [2, b]

Polymers

- Fluoropolymers [8]
- Polymeric Perfluoropolyethers (PFPE) [9]
- Side-chain fluorinated polymers [10]
- Fluorinated urethane polymers
- Fluorinated acrylate/ methacrylate polymers
- Fluorinated oxetane polymers

Family Hierarchy Legend

- Family
- Class
- Subclass
- Group
- Subgroup

Precursor Key (Buck et al. 2011[156])

- Potential PFCA precursors
- Potential PFSA precursors
- Potential PFSA and PFCA precursors

Manufacturing Process Legend

(a) Manufactured by either ECF or fluorotelomerization
(b) Manufactured by ECF
(c) Manufactured by fluorotelomerization
(d) Other process

Notes

The acronym PFECA is utilized for both per and polyfluoroalkyl ether carboxylic acids and the acronym PFESA is utilized for both per and polyfluoroalkyl ether sulfonic acids. When using these acronyms, it is important to be clear as to the specific group of chemicals being referenced (i.e., per or poly).

FASAs biodegrade to PFSAs, with the potential to degrade to PFSAs and PFCAs in the atmosphere – see Figure 2-11.

The family tree is based on the PFAS definition provided in Buck et al. 2011[156] and OECD 2021[2318]

PFAS Use Legend

(1) Surfactants
(2) Intermediate transformation product
(3) Major raw material for ECF-based surfactants and surface protection products
(4) Raw material for surfactants and surface protection products
(5) Includes some fluoropolymer polymerization aids
(6) Ski wax, medical applications
(7) Major raw material for fluorotelomer-based surfactants and surface protection products
(8) High molecular weight polymeric plastics such as PTFE
(9) A broad class of polymers used largely as lubricants
(10) Used for surface protection