

Per- and Polyfluoroalkyl Substances (PFAS) Nonpolymers **Polymers** Polyfluoroalkyl Substances Perfluoroalkyl Substances Fluoropolymers 8 (all H atoms on all C atoms in alkyl (all H atoms on at least one chain attached to a functional group (but not all) C atoms have been Polymeric Perfluoropolyethers (PFPE)9 have been replaced with F) replaced with F) Side-chain fluorinated polymers 1 Polyfluoroalkyl ether acids Perfluoroalkyl acids (PFAAs) a (PolyFEAs)d Fluorinated urethane polymers Perfluoroalkyl carboxylic acids/ Polyfluoroalkyl ether sulfonic acids Perfluoroalkyl carboxylates (PFESAs) 5, d Fluorinated acrylate/ (PFCAs) 1, a, 5 methacrylate polymers Polyfluoroalkyl ether carboxylic Perfluoroalkane sulfonic acids/ acids (PFECAs) 5, d Fluorinated oxetane polymers Perfluoroalkane sulfonates (PFSAs) 1, b Polyfluoroalkyl carboxylic acids Perfluoroalkane sulfinic acids **Family Hierarchy Legend** (PolyFCAs) (PFSiAs)2,b **Family** Perfluoroalkyl phosphonic acids (PFPAs) 1, c Class Chloropolyfluoroalkyl ether acids 2, d Perfluoroalkyl phosphinic acids **Subclass** Chloropolyfluoroalkyl acids 1, d (PFPiAs) 1, c Group Perfluoroalkyl Dicarboxylic acids (PFdiCAs)b Fluorotelomer substances Subgroup n:2 Fluorotelomer sulfonic acids Perfluoroalkane Disulfonic acids (FTSAs) 1, 2, c Precursor Key (Buck et al. 2011[156]) (PFdiSAs)b Potential PFCA n:2 or n:3 Fluorotelomer carboxylic precursors acids and unsaturated carboxylic Perfluoroalkyl ether acids acids (FTCAs and FTUCAs) 2, (2), c (PFEAs) d Potential PFSA n:2 Fluorotelomer alcohols precursors Perfluoroalkyl ether sulfonic acids (FTOHs) 7, (2), c (PFESAs) 5, d Potential PFSA and n:2 Unsaturated Fluorotelomer PFCA precursors alcohols (FTUOHs) (2), c Perfluoroalkyl ether carboxylic acids (PFECAs) 5, d n:2 Fluorotelomer iodides (FTIs) (Telomer B) 7, c Perfluoroalkane sulfonyl fluorides n:2 Fluorotelomer olefins (FTOs) 4, c (PASFs)3, Semifluorinated N-alkanes (SFAs) / Perfluoroalkane sulfonamides alkenes (SFenes) 6, c (FASAs)2,b n:2 Fluorotelomer acrylates/methacrylates Perfluoroalkanoyl fluorides (FTACs/FTMACs) 7, c (PFAs or PACFs)3,b n:2 Fluorotelomer aldehydes Perfluoroalkyl iodides (PFAIs) and unsaturated aldehydes (Telomer A) 7, c (FTALs and FTUALs) 2, (2), c Perfluoroalkyl aldehydes (PFALs) 2, c n:3 Saturated acids and n:3 unsaturated acids 2, c

Perfluoroalkane sulfonamido substances 2, 3, b

n:2 Polyfluoroalkyl phosphoric acid esters, polyfluoroalkyl phosphates, fluorotelomer phosphates (PAPs) 1, 10, c

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}

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 2-10.

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