The PFAS breakdown

What are PFAS and how do we classify them?

PFAS stands for "per- and polyfluoroalkyl substances"

PFAS are a large and complex class of chemicals.

Scientists and regulators group PFAS in many different ways. The terms they choose depend on what information they wish to convey.

10,000+

unique PFAS exist, according to the federal Environmental Protection Agency (EPA) "PFAS Master List"

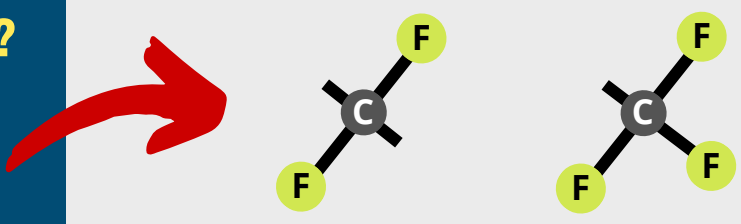
Here we're going to break down the terms used to describe the PFAS chemical class so that you can better understand PFAS as a whole.

But first, one technical definition of PFAS:

Any chemical "with at least a perfluorinated methyl group (-CF_2-) or a perfluorinated methylene group (-CF_3-)" (OCED 2021).

What does *THAT* mean?

It means ANY chemical with a carbon atom bonded to two or three fluorine atoms.



Also known as a "fluorinated carbon"

The bond between a carbon atom and a fluorine atom is extremely strong. That's why many PFAS are so persistent in the environment. This is also one reason why PFAS are known as "forever chemicals".

Within the PFAS chemical class, there are multiple “subclasses":

PFAAs (perfluoroalkyl acids)

Most of the well-studied PFAS are PFAAs. The most well-known PFAAs are PFOS and PFOA. Within the PFAA subclass there are multiple groups, including PFCAs and PFSAs (see definition below).

Precursors

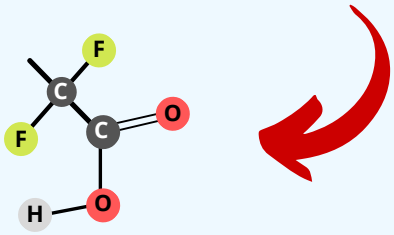
These PFAS may transform and become PFAAs in the environment or in plants and animals.

Other PFAS

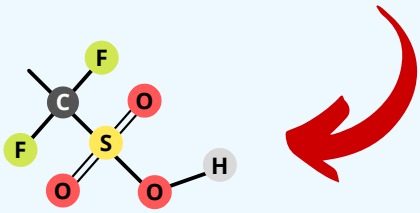
The rest of the PFAS are largely polymers, including PTFE (used in non-stick cookware coating).

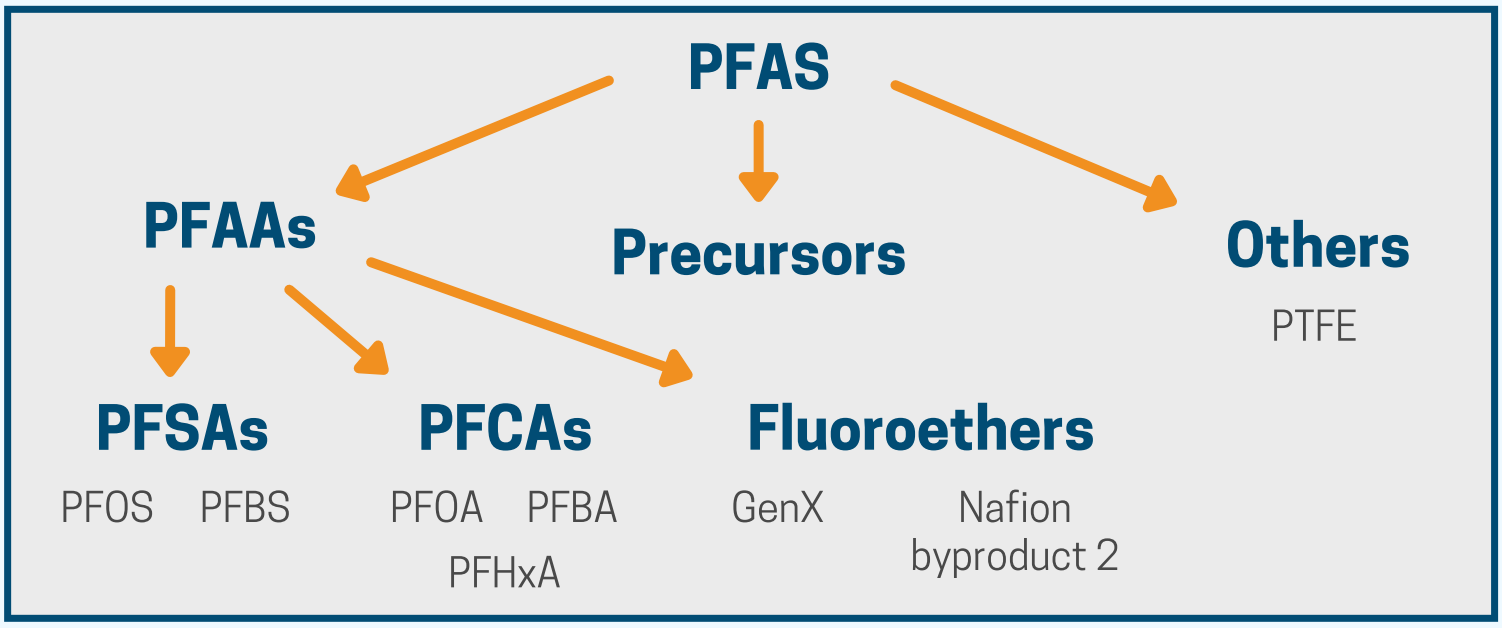
What are PFCAs and PFSAs?

PFCAs stand for perfluoroalkyl carboxylic acids. They are PFAAs where a terminal carbon atom is bonded to two oxygen atoms.



PFSAs stand for perfluoroalkyl sulfonic acids. They are PFAAs with a sulfur atom bonded to three oxygen atoms at the end.



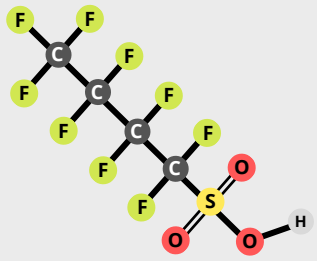


Fluoroethers have an oxygen atom between some of the carbon atoms.

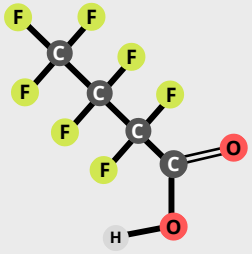
Short-chain and long-chain PFAS

Some common PFAS (PFSAs and PFCAs) are also categorized by length and sometimes divided into "short-chain" and "long-chain". The carbon atoms in PFAS are connected to each other like links in a chain.

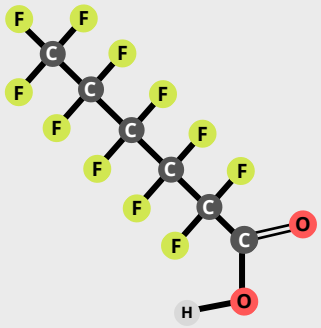
Short-chain PFAS include PFCAs with fewer than seven fluorinated carbons atoms and PFSAs with fewer than six fluorinated carbons atoms. For example:



PFBS
4 fluorinated carbons

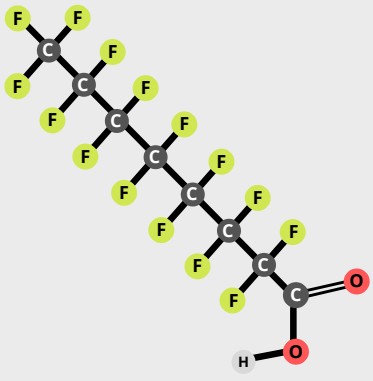


PFBA
3 fluorinated carbons

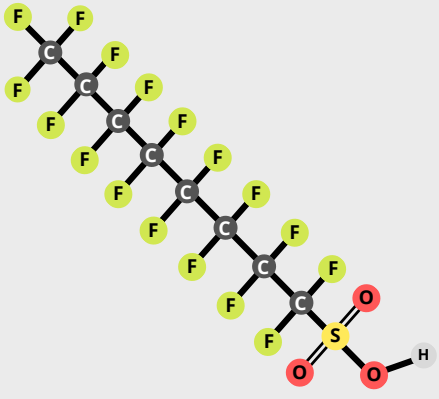


PFHxA
5 fluorinated carbons

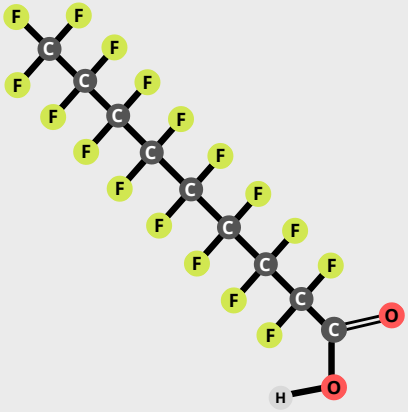
Long-chain PFAS include PFCAs with seven or more fluorinated carbons atoms and PFSAs with six or more fluorinated carbons atoms. For example:



PFOA
7 fluorinated carbons



PFOS
8 fluorinated carbons



PFNA
8 fluorinated carbons

Legacy PFAS and Novel PFAS

PFAS can also be categorized by how long they have been in use.

Legacy PFAS were used in industry for decades. However, they have mostly been phased out or decreased in use.

- Usually have more health data available than novel PFAS
- Many are “long-chain PFAS”
- Include most of the well-studied PFAS, like PFOA and PFOS

Used for decades

Decreased in use

Have more data

Novel PFAS include understudied PFAS or those that replaced legacy PFAS (otherwise known as "replacement PFAS").

- Chosen as replacements because they were thought to have fewer health effects and/or shorter half-lives (which means that they stay in the human body for shorter periods of time)
- Often “short-chain PFAS” (like PFBS, a PFOS replacement) or fluoroethers (like GenX, a PFOA replacement)

Newer PFAS

May stay in the human body for less time

Have less data

Sources:

1. EPA. PFAS Master List of PFAS Substances.
2. Kwiatkowski, et al. Scientific Basis for Managing PFAS as a Chemical Class, 2020.
3. Fenton, et al. Per- and Polyfluoroalkyl Substance Toxicity and Human Health Review, 2020.
4. OCED. Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance, 2021.

Center for Environmental and Health Effects of PFAS

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