Perfluorinated Chemicals (PFCs)

Many of us have probably seen news stories about something commonly referred to as PFCs or perfluorochemicals. You may not know exactly what they are, but can probably guess that they have something to do with the environment and your health. The National Institute of Environmental Health Sciences (NIEHS) and the National Toxicology Program (NTP), an interagency testing program headquartered at NIEHS, are studying many of these compounds.

What are PFCs?

PFCs are a large group of manufactured compounds that are widely used to make everyday products more resistant to stains, grease, and water. For example, PFCs may be used to keep food from sticking to cookware, to make sofas and carpets resistant to stains, to make clothes and mattresses more waterproof, and may also be used in some food packaging, as well as in some firefighting materials. Because they help reduce friction, they are also used in a variety of other industries, including aerospace, automotive, building and construction, and electronics.

PFCs break down very slowly in the environment and are often characterized as persistent. There is widespread wildlife and human exposure to several PFCs, including perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS).[1] Both PFOA and PFOS are byproducts of other commercial products, meaning they are released into the environment when other products are made, used, or discarded. PFOS is no longer manufactured in the United States, and PFOA production has been reduced and will soon be eliminated. More research is needed to fully understand all sources of human exposure, but people are most likely exposed to these compounds by consuming PFC-contaminated water or food, or by using products that contain PFCs.

Unlike many other persistent chemicals, PFCs are not stored in body fat. However, PFCs are similar to other persistent chemicals, because the half-life, or the amount of time it takes for 50% of the chemical to leave the human body, for some of these chemicals, is several years. This slow elimination time makes it difficult to determine how changes in lifestyle, diet, or other exposure-related factors influence blood levels.

The National Institute of Environmental Health Sciences and the National Toxicology Program are supporting research to better understand the potential health effects of exposure to PFCs.

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In animal studies, some PFCs disrupt normal endocrine activity; reduce immune function; cause adverse effects on multiple organs, including the liver and pancreas; and cause developmental problems in rodent offspring exposed in the womb.[2,3] Data from some human studies suggests that PFCs may also have effects on human health, while other studies have failed to find conclusive links.[4] Additional research in animals and in humans is needed to better understand the potential adverse effects of PFCs for human health.

Some of the research on PFCs has been conducted by NIEHS in-house researchers, dating back to the 1980s.[5] Today, researchers continue to study the adverse effects of PFCs in animal models. For example, a 2011 report found that prenatal exposure to PFOA delays mammary gland development in mice.[6] NIEHS is working hard to determine the unique mechanisms of action that might be causing these and other effects.

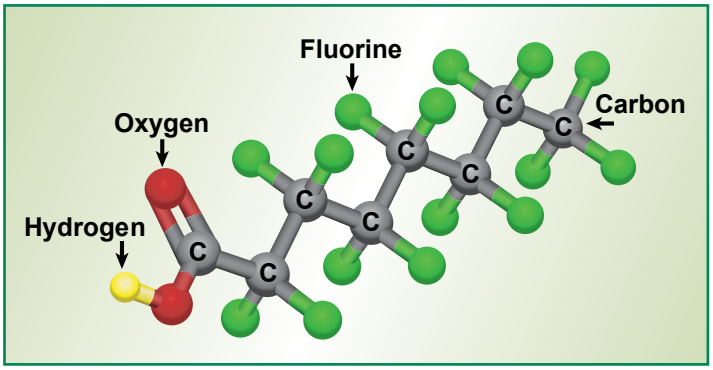
PFCs being studied by NTP

Name	Acronym
Perfluorobutane sulfonate	PFBS
Perfluorohexane sulfonate	PFHxS
Perfluorohexanoic acid	PFHxA
Perfluorooctanoic acid	PFOA
Perfluorooctane sulfonate	PFOS
Perfluorononanoic acid	PFNA
Perfluorodecanoic acid	PFDA
8+2 Fluorotelomer alcohol	8:2 FTOH

Overview of Current NTP Studies — The Long and Short of It

The U.S. Environmental Protection Agency (EPA) nominated the PFC class to the NTP for study, due to concerns of:

- Widespread exposure to humans
- Persistence in the environment
- Observed toxicity in animal models
- Insufficient information to properly assess human health risk across the entire structural class



PFOA, also known as C8, has 8 carbons.

One thing that differentiates each PFC is the size of what scientists refer to as chain length, or the number of carbon atoms in its chemical make-up. For example, PFOA has 8 carbons, which is why it is sometimes referred to as C8.

The NTP is studying PFCs as a class, due to potential similarities in chemical properties and toxicity. The scientists will be able to compare one PFC chemical to another, determine the relationship between chain length and toxicity, and work toward understanding a common basis for toxicity.

The NTP research involves a variety of short-term and long-term rodent toxicology studies, using internal dose, such as plasma levels, to relate exposure to effects. The entire research program is multifaceted.

- *In vitro* studies, using cells or components of cells to look at potential toxicity of PFCs, are being conducted. These include a study to evaluate the potential for PFOS, PFOA, and PFBS to be neurotoxic, or affect brain cells[7]; studies characterizing the immune effects of some PFCs in human blood cells[8]; and studies evaluating mitochondrial toxicity for 16 PFCs. Additionally, through a collaboration between NTP, other U.S. Department of Health and Human Services agencies, and EPA, known as Tox21, a number of PFCs are being tested for toxicity in human and animal cells at the Tox21 robotics high-throughput screening facility. A complete list of the 10,000 compound library being screened is available at http://www.epa.gov/ncct/dsstox/sdf_tox21s.html.

There is widespread wildlife and human exposure to several PFCs.

- Studies to determine how the various PFCs of different chain lengths are distributed throughout the body and excreted over time, known as toxicokinetic studies, are being conducted for PFBS, PFDA, PFHxA, PFHxS, PFOA, PFOS, and 8:2 FTOH in male and female young adult rats.
- Short-term, 28-day toxicity studies are being conducted for PFBS, PFDA, PFHxA, PFHxS, PFNA, PFOA, and PFOS in male and female young adult rats.
- A 28-day immunotoxicity study is also being conducted for PFDA in female rats.
- A two-year study is being conducted on PFOA, to evaluate its potential to cause cancer and other toxic effects. This study evaluates the effect of exposure to PFOA, beginning in the womb and continuing through adulthood, in male and female rats.
- The NTP is also planning to conduct studies in rats and mice to determine the effects of PFCs during pregnancy and on early life of the offspring, including puberty.

Additional Research on PFCs

In addition to the NTP's effort, NIEHS-funded grantees across the country are researching PFCs. For example, some are exploring a potential link between PFCs and behavioral disorders, including attention deficit hyperactivity disorder,[9] while others are evaluating the potential adverse health risks of PFCs and other chemicals on neurobehavioral development and immune function. For example, a 2012 NIEHS-funded human study found that elevated PFC exposures during development were associated with reduced vaccine-induced immune protection in children.[10]

Collectively, the NTP and NIEHS-funded studies will help determine the toxicity of these chemicals in animal models, the mechanisms of action across various species, and the potential adverse human health effects. Such data will be of value to regulatory agencies and policymakers who will use the information to protect the public's health. The information will also help members of the public make informed decisions.

Reducing Exposure

Some progress has been made in reducing PFCs. The EPA has been working with companies since 2000 to phase out PFOA and PFOS, and to reduce the environmental and human health impacts of other PFCs.[11] Also, some state agencies are reviewing current PFC research findings from NIEHS and others, to help assess and evaluate the impact of these chemicals on human health in their communities.[12]

What's in a name?

Different types of scientists may refer to the same class of chemicals by different names. This is often the case for PFCs. Some commonly used terms for PFCs that you might come across include:

- Perfluorinated chemicals
- Perfluorochemicals
- Perfluoroalkyls
- Perfluorinated alkyl acids
- Polyfluorinated chemicals
- Polyfluorinated compounds
- Polyfluoroalkyl substances

Where can I go for more information?

Agency for Toxic Substances and Disease Registry
http://www.atsdr.cdc.gov/PHS/PHS.asp?id=1115&tid=237

Centers for Disease Control and Prevention
http://www.cdc.gov/biomonitoring/PFCs_FactSheet.html

National Toxicology Program
http://ntp.niehs.nih.gov

U.S. Environmental Protection Agency
http://www.epa.gov/fedfac/pdf/emerging_contaminants_pfos_pfoa.pdf

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