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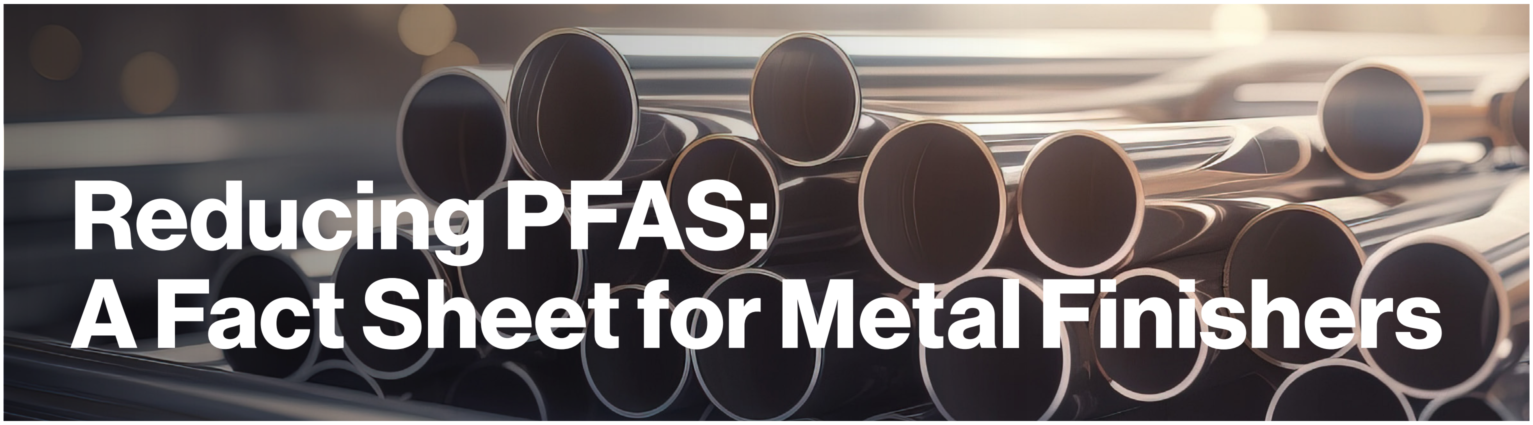
Pollution Prevention Institute



Reducing PFAS: A Fact Sheet for Metal Finishers

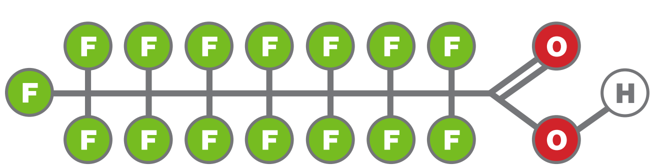
This fact sheet will help you

- understand what per- and poly-fluoroalkyl substances (PFAS) are and how they are used in the metal-finishing industries.
- appreciate the risks to human health that PFAS present when used to suppress fumes produced during *hexavalent chrome-plating*, an electroplating process.
- learn about effective strategies for reducing the use of PFAS in the hexavalent chrome-plating process.

What are PFAS?

Per- and poly-fluoroalkyl substances (PFAS) are a class of manufactured chemicals that have been in use since the 1940s. These chemicals are often used in consumer goods such as food packaging and cookware as a heat- and grease-resistant coating. PFAS may also be used in electroplating, an industrial process used to apply an anticorrosive “chrome” metal finish.

PFAS contain highly electronegative fluorine atoms that form strong bonds with carbon, which create weak intermolecular forces and low friction. This characteristic makes PFAS highly “wettable,” a property that means they are useful for lowering surface tension. PFAS can also withstand harsh conditions and are often long-lasting because of the strength of the carbon-fluorine bonding they exhibit at the molecular level.



Why reduce PFAS?

In 2016, NYSDEC designated PFOA and PFOS as hazardous substances, and in March 2023, NYSDEC announced the issuance of final water quality guidance values to regulate these two substances. The finalized GVs support the State’s ongoing efforts to protect public health and the environment and prevent exposure to emerging contaminants through the protection of drinking water sources. In 2022, the U.S. Environmental Protection Agency also proposed to designate several common PFAS as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act. The proposal recognized that the same chemical interactions that make PFAS useful in industry also make them a challenging pollutant when released into the wider environment.

Given that PFAS are persistent and mobile compounds, there are many pathways for human-PFAS exposure including municipal water sources, ingestion of fish and shellfish raised in contaminated water, and consuming products packaged with materials that contain PFAS. Research on adverse human health outcomes from PFAS exposure is ongoing and multiple sources have found associations between PFAS exposure and adverse health effects, including reduced kidney function, risk of thyroid diseases, cancer risk, and high cholesterol.

How are PFAS used in the metal-finishing industry?

PFAS are commonly used to suppress harmful fumes emitted during an electroplating process called *hexavalent chrome-plating*.

Hexavalent chrome-plating is achieved by applying an electric current to an aqueous solution of hexavalent chromium [Cr(VI)], also known as chromic acid. The electric charge induces electrolysis in which water molecules split into hydrogen and oxygen. Bubbles of gas rise and burst upon the surface of the chromium solution, creating a fine mist that makes liquid chromic acid airborne. If this mist is not properly controlled, workers may be exposed to the harmful chemical. Exposure to chromic acid may cause a variety of acute and chronic conditions that affect the respiratory system, kidneys, liver, skin, and eyes.

In order to reduce the environmental health risks of hexavalent chrome-plating, fume suppressants containing PFAS are used to suppress the release of chromic-acid-laden mist by reducing the surface tension of the process solution. Some fume suppressants also form a layer of foam on the solution's surface, which acts as a barrier to bubble-bursting and mist release.

How to reduce the use of PFAS-based fume suppressants

Depending on your company's budget and resources, one or more of the following strategies could be used to reduce the use of PFAS-based fume suppressants:

1) Replace hexavalent chrome-plating with processes that do not produce harmful fumes.

2) Substitute PFAS-based fume suppressants with PFAS-free fume suppressants.

3) Install air control technologies in the process facility.

1) Alternatives to hexavalent chrome-plating

Alternative electroplating procedures exist and may be a suitable substitute to—or even an improvement over—hexavalent chrome-plating in some circumstances. A common substitute is trivalent chrome-plating, which uses chromium sulfate [$Cr_2(SO_4)_3$] or chromium chloride ($CrCl_3$) rather than chromium trioxide (CrO_3). This process yields greater "throwing power" with less energy, but material costs may be higher. Trivalent chromium is less toxic and its use may lower overhead costs.

Ultimately, many alternative chemistries and processes present tradeoffs when compared to the traditional hexavalent-chromium version. The decision to transition to a new process depends on a manufacturer's unique needs and situation.

2) PFAS-free fume suppressants

Several PFAS-free fume suppressants are currently commercially available. In addition to reducing surface tension, suppressants may be engineered to form a dense foam layer on a solution's surface, providing another barrier to the release of chromium mist. Scientific studies have validated that these alternatives successfully eliminate PFAS from the electroplating process, and can even result in material cost savings.[1]

It should be noted that PFAS-free fume suppressants may lack the strong carbon-flourine bonds that characterize PFAS. Without such bonds, they can degrade in a hexavalent-chromium solution, which means PFAS-free suppressants may need to be added more often than traditional PFAS chemicals to maintain optimal performance through manual dosing or automatic dosing with pumps. To learn more, see the case study "NYSP2I Helps NY Manufacturer Eliminate Usage of PFAS Chemicals" linked here on the NYSP2I website.

3) Air control technologies

> Note: while air control technologies may be effective to prevent chrome emissions, there may be regulatory implications to solely relying on this method; permitting requirements as determined by the local air regulatory agency would need to be understood. Companies can contact the Small Business Environmental Assistance Program for any questions or inquiries by emailing sbeap@rit.edu.

In most air control technologies, liquid droplets are passed through a "maze" of media. The droplets are subjected to high velocities to ensure that they impact and adhere to a system's media, where they coalesce into larger drops that eventually fall into a collection unit while gases continue to rise.

Common air control technologies include:

- **Composite mesh pads (CMP):** The most common form of air control, this technology is usually a multi-stage system. Air is first treated with coarse pads that become increasingly finer as the air continues through the system. Liquid in the air contact are held by strands of mesh, and are then rinsed out by overhead sprayers and recovered. Treated gases may be vented into the local environment.
- **Packed-bed (or packed-tower) scrubbers:** A form of scrubber where chromium-laden gases rise through a tower of solvent-coated packed media and then pass through moisture-collecting media. The packed media have a complex geometry to ensure that the rising gases make contact with the solvent coating.
- **Blade mist eliminators:** A system in which chromic mist passes through a series of parallel blades. The blades induce air currents, which cause the mist to contact the surfaces of the blades. The precipitate is then collected and can be returned to the solution.
- **Emission-elimination devices (EED):** Resembling a lid over the chrome-plating tank, a portion of an EED—also known as an encapsulating tank cover—is composed of a gas-permeable membrane. As mist rises, it contacts the membrane and liquids condense and form droplets that fall back into the solution below. The heat of the plating solution also produces water vapor; as chromium passes through the vapor, it will also coalesce into droplets and return to the solution. Hydrogen and oxygen gasses are able to pass freely through the membrane.

CMP and packed-bed scrubbers are both commonly used. However, due to differences in initial cost and removal efficiency, a general preference has been shown towards CMP across industry. These technologies may be used in conjunction or as a replacement for fume suppressants.

If you would like more information about how to reduce PFAS in your facility, reach out to our team of specialists. Contact us at nysp2i.rit.edu/contact.

[1] NYSP2I worked with a New York electroplater on the transition from a traditional suppressant to a PFAS-free variety. This project identified material cost savings in switching suppressants and successfully confirmed the absence of PFAS and 1,4-dioxane in a commercially available PFAS-free fume suppressant. This study also validated the performance of a PFAS-free fume suppressant and found a comparable reduction in surface tension and formation of foam barrier when it was properly administered. Experimentation and observation of operations during the study also led to the development of a dosage schedule with a much lower rate than the manufacturer's recommendation, representing additional savings.

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