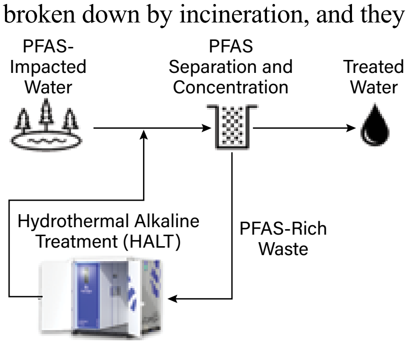
Providing Complete Hydrothermal Destruction of PFAS

Per- and polyfluoroalkyl substances (PFAS) are ubiquitous environmental contaminants found in everything from consumer goods to fire retardants to cosmetics. Their most significant use is in military-grade firefighting foams that have been used for decades, causing widespread contamination of groundwater, drinking water wells, surface water, and soil. Firefighting drills performed at military bases and airports have led to high concentrations of PFAS near military bases, airports, and industrial manufacturing facilities (where PFAS are either used or produced), as well as in landfill leachate.

PFAS have recently attracted intense regulatory scrutiny as a result of toxicological studies linking them to health problems such as cancer and reproductive issues. The U.S. Environmental Protection Agency (EPA) recently proposed drinking water maximum contaminant limits (MCLs) for six PFAS, including perfluorooctane sulfonic acid (PFOS, 4 ng/L) and perfluorooctanoic acid (PFOA, 4 ng/L).

While separation of PFAS from contaminated water can be done with existing technologies, such as carbon filtration, final destruction of PFAS remains a significant gap in the market. PFAS are not effectively broken down by incineration, and they do not have a natural half-life. The environmental remediation industry needs effective technology for on-site, end-of-life destruction of PFAS.



▲ A sample, closed-loop per- and polyfluoroalkyl substances (PFAS) treatment train integrates foam fractionation for PFAS concentration and hydrothermal alkaline treatment (HALT) for PFAS destruction.

In 2019, Timothy Strathmann's research group and collaborators at the Colorado School of Mines (CSM) demonstrated that subcritical hydrothermal processing can be used to destroy PFOS. The addition of a strong base (*e.g.,* sodium hydroxide) was shown to drive complete defluorination of the PFOS molecule, *i.e.,* cleavage of all carbon-fluorine bonds. In several subsequent studies, they demonstrated that these so-called hydrothermal alkaline treatment (HALT) conditions can be used to completely destroy and defluorinate all known PFAS through a combination of thermal, hydrolysis, and hydroxide-driven reaction mechanisms.

Hydrothermal processing is a broad term for a range of chemical processes that are performed in hot water. Hydrothermal processing can take place in subcritical water, where elevated pressure is used to keep water in a liquid phase above the atmospheric boiling temperature of 100°C, and supercritical water, where pressures above 22.1 MPa and temperatures above 374.1°C combine to create a steam-like, nonpolar reacting environment. Both subcritical and supercritical reacting environments have unique thermophysical properties, and each regime favors specific reaction mechanisms. Hydrothermal processing has historically been plagued by challenges with corrosion and component lifetimes, requiring the use of expensive alloys, replaceable system components, and/or elegant chemical corrosion prevention strategies.

With grants from the U.S. National Science Foundation (NSF), Aquagga, Inc. is addressing the challenges of system corrosion and chemical consumption in the development and scale-up of the HALT process, which will improve overall unit economics and reduce the technology's environmental footprint. The start-up company, based in Tacoma, WA, has exclusively licensed the HALT technology from CSM. With additional funding from other federal agencies, Aquagga is also currently fabricating two commercial-scale HALT systems for PFAS destruction applications.

The Aquagga team's efforts have garnered significant industry attention, with several industrial clients and solid waste managers currently contracting feasibility testing for assessing PFAS destruction with HALT. Aquagga has several funded field demonstrations of the HALT technology planned for 2023 and 2024 and expects to begin selling HALT systems in 2024.

"The HALT performance is robust in waters with complex background chemistry, and it has completely mineralized all PFAS tested to date," says Erika Houtz, Director of Contaminant Destruction Technology at Portland, ME-based ECT2 — a technology provider for PFAS separation and concentration technologies. "The fact that the Aquagga systems can be readily integrated into existing PFAS water treatment systems to create a closed-loop PFAS treatment solution is attractive, as it eliminates PFAS waste from re-entering the environment."

Aquagga and ECT2 are collaborating on several projects where ECT2 is providing a PFAS separation and concentration technology, and Aquagga is destroying the resulting PFAS-rich byproducts. CEP

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