AECOM's Promising New PFAS Treatment Technology **DE-FLUORO™** Shows Complete Destruction of PFAS

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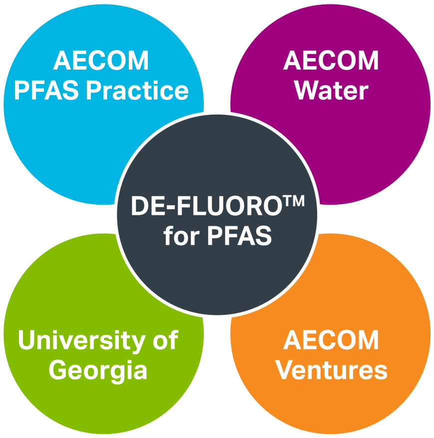
DE-FLUORO™ Pilot Reactor



Challenges of PFAS Treatment

Per- and Polyfluoroalkyl Substances (PFAS) have been widely used and released into the environment. Among the broad category of PFAS, the occurrence and environmental impact of perfluoroalkyl acids (PFAAs), such as perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) have been studied and characterized globally. PFAS have chemical structures involving the strongest bond in nature, the carbon-fluorine (C-F) covalent bond, representing a class of chemicals that are extremely challenging to remediate. Mass transfer technologies (e.g., granular activated carbon, ion exchange resin, reverse osmosis) do not destroy PFAS but concentrate PFAS on the spent media. The spent media may require off-site incineration or regeneration for filtration media reuse that will produce regenerant wastes requiring further management and treatment.

Can PFAS be Destroyed on Site?

PFAS Technology Team Dedicated to a Solution

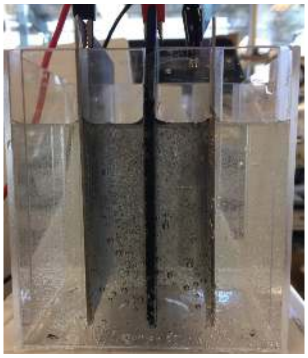
AECOM's PFAS technology development team was strategically formed to drive this promising technology from fundamental research to its maturity. All team members have been heavily involved, from the bench study and field demonstrations to commercialization. The multi-disciplinary global team has developed a platform to solve this most challenging environmental issue.

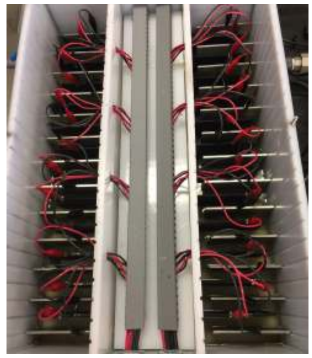
Goals of the team include:

- Destruction of PFAS through electrochemical oxidation
- Proof of treatment applications for PFAS in groundwater and wastewater
- Commercialization of this innovative treatment technology

DE-FLUORO™ Technology

As of today, electrochemical oxidation is one of the most documented PFAS destruction technologies. Our team has successfully used a proprietary electrode to complete mineralization of C_4~C_8 perfluoroalkyl acids (PFAAs) with evidence of complete defluorination and desulfurization. PFAS are destructed via direct electron transfer on "non-active" anodes under room temperature and atmospheric pressure with relatively low energy consumption. Our project team has also successfully used this proprietary electrode to treat PFAS in ion-exchange regenerant waste and other PFAS-impacted wastewater.





Pilot Reactor Testing at AECOM's Austin, TX Treatability Study Laboratory

AECOM's DE-FLUORO™ technology uses highly conductive, chemically inert, and low-cost proprietary electrodes to effectively degrade PFAAs.

Potential Applications

- Groundwater
- Industrial waste water
- Drinking water
- Investigation-derived waste water
- Liquid waste
- Surface water

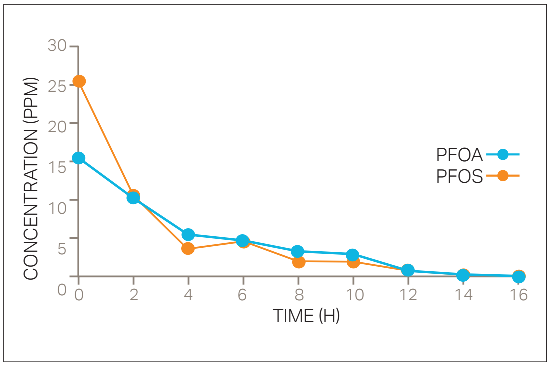
Technology Scale-Up

Scaling-up and commercialization of this DE-FLUORO™ Technology is underway. Our team has identified trial sites for the treatment of groundwater and ion exchange resin regeneration waste. The DE-FLUORO™ technology is currently protected by two pending patents.

More Innovation to Come – Technology Development and Demonstrations

1. An electrocoagulation and electrochemical oxidation treatment train to degrade perfluoroalkyl substances and other persistent organic contaminants in ground water
2. Optimizing regeneration of ion exchange resins for reducing byproduct generation from DE-FLUORO™
3. Field demonstration of coupling ion-exchange resin with electrochemical treatment for complete separation and destruction of PFOS and PFOA in groundwater
4. Field demonstration of electrochemical oxidation for PFAA destruction in groundwater

DE-FLUORO™ Treatment of PFAS in Wastewater



PFOS and PFOA degradation in ion exchange resin regeneration waste (Liang et al 2018)

Peer-Reviewed Publications from Research Collaborators

1. Niu, Junfeng, et al. "Electrochemical mineralization of perfluorocarboxylic acids (PFCAs) by Ce-doped modified porous nanocrystalline PbO2 film electrode." **Environmental Science & Technology** 46.18 (2012): 10191-10198.
2. Lin, Hui, et al. "Electrochemical degradation of perfluorooctanoic acid (PFOA) by Ti/SnO 2–Sb, Ti/SnO 2–Sb/PbO 2 and Ti/SnO 2–Sb/MnO 2 anodes." **Water Research** 46.7 (2012): 2281-2289.
3. Lin, Hui, et al. "Highly efficient and mild electrochemical mineralization of long-chain perfluorocarboxylic acids (C9–C10) by Ti/SnO2–Sb–Ce, Ti/SnO2–Sb/Ce–PbO2, and Ti/BDD electrodes." **Environmental Science & Technology** 47.22 (2013): 13039-13046.
4. Niu, Junfeng, et al. "Theoretical and experimental insights into the electrochemical mineralization mechanism of perfluorooctanoic acid." **Environmental Science & Technology** 47.24 (2013): 14341-14349.
5. Lin, Hui, et al. "Efficient sorption and removal of perfluoroalkyl acids (PFAAs) from aqueous solution by metal hydroxides generated in situ by electrocoagulation." **Environmental Science & Technology** 49.17 (2015): 10562-10569.
6. Niu, Junfeng, et al. "Electrochemical oxidation of perfluorinated compounds in water" **Chemosphere** 146 (2016) 526-538

**Sample analyses being conducted by Eurofins*

SAMPLE TYPE	ION EXCHANGE RESIN REGENERANT WASTE	OZONE OXIDATION TREATMENT	SITE GROUNDWATER
4:2 FtS	100	10	100
6:2 FtS	99.14	99.98	99.86
8:2 FtS	100	99.79	99.61
PFOSA	ND	ND	ND
PFBA	ND	13.00	51.02
PFPeA	74.36	70.73	65.63
PFHxA	56.91	99.66	98.73
PFHpA	77.78	99.96	99.50
PFOA	98.50	99.95	99.96
PFNA	ND	93.75	100
PFBS	ND	ND	71.93
PFPeS	60.25	100	99.08
PFHxS	85.24	100	99.74
PFHpS	100	100	99.81
PFOS	98.47	99.63	99.66

PFAS% reduction in wastewater and groundwater