# An Electro-coagulation and Electro-oxidation Treatment Train to Degrade Perfluoroalkyl Substances in Groundwater and Liquid Waste

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**Background/Objectives.** This study is aimed at developing a novel treatment train that combines electrocoagulation (EC) with electrochemical oxidation (EO) treatment to remove and degrade perfluoroalkyl acids (PFAAs) and their organic co-contaminants in groundwater and waste streams. PFAAs are extremely persistent because of their unique molecular structures, and currently, there is no cost-effective technology that is applicable for on-site PFAA destruction. This study is of great societal and environmental significance by providing a technology potentially practical for eliminating and destructing PFAAs in groundwater and liquid waste.

**Approach/Activities.** This study examined a three-step treatment train to couple EC/EO processes for treatment of PFAAs in groundwater and liquid waste.

(1) Separate the PFAAs from the extracted groundwater and pre-enrich the PFAAs on zinc hydroxide flocs via EC;
(2) Separate the PFAAs from the flocs via pH adjustment, which releases the PFAAs back into small volumes of water at higher concentrations; and
(3) Destroy the PFAAs via EO.

**Results/Lessons Learned.** We have found that PFAAs, such as PFOA and PFOS, can be quickly sorbed on the surface of zinc hydroxide flocs generated by EC, mainly via hydrophobic interaction. The study indicated that the zinc hydroxide flocs had a sorption capacity ($q_e$) up to 5.74/9.69 mmol $g^{-1}$ (Zn) for PFOA/PFOS at the initial concentration of 0.5 mM with an initial sorption rate of $1.01 \times 10^3$/$1.81 \times 10^3$ mmol $g^{-1}$ $h^{-1}$. The sorption of PFOA/PFOS reached equilibrium within < 10 min. The EC-generated zinc hydroxide flocs have a much higher sorption capacity and faster sorption rate than other sorbents reported in previous studies or preformed zinc hydroxide. For example, the sorption capacity and rate of PFOA on GAC were reported to be 0.39 mmol $g^{-1}$ and $1.06 \times 10^{-2}$ mmol $g^{-1}$ $h^{-1}$, respectively. These advantages enable EC-generated zinc hydroxide flocs to effectively adsorb PFAAs from water within a short hydraulic retention time. In our most recent study, we have found that Magnéli phase $Ti_4O_7$ material can be used as anodes to effectively degrade both PFOA and PFOS. The $Ti_4O_7$ electrode showed a much faster PFOA decay rate than the Ce-$PbO_2$ electrode and Ti/BDD electrode under the same conditions, while the latter two electrodes are well-known “non-active” anodes that have been proven effective for PFOA degradation.