NJ Department of Environmental Protection
Division of Science and Research

A Factsheet: Development of Electrochemical Treatment Technologies for PFOA, PFOS and 1,4-Dioxane in New Jersey Drinking Water and Regional Wastewater Treatment Plants

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What was the purpose of the study?

The study aimed to improve our understanding of mechanisms to breakdown per- and polyfluoroalkyl substances (PFAS) and 1,4-dioxane and to develop an environmentally friendly and cost-effective process for their removal in water using novel electrochemical treatment technologies.

The BiOSMART Center at NJIT has created a new class of bimetallic alloy nanocatalyst materials (NcM) that show promising results for the breakdown of some PFAS. The best performing NcMs identified during this study were further characterized and tested for groundwater, drinking water, and wastewater applications. It is hoped that, if successful, such materials can be used in a device to create a point-of-use, electrochemical treatment technology for destruction and removal of PFAS and 1,4-dioxane from drinking water.

What was the general approach to this study?

The study developed a new **I**nnovative (nano) **M**aterials and **P**rocesses for **A**dvanced **C**atalytic **T**echnologies (IMPACT) system. The IMPACT system can be scaled up and was shown to be effective at removing some pollutants from the water samples. Thus, a novel electrochemical method to breakdown perfluorooctanoic acid (PFOA) and 1,4-dioxane was designed and used. The method involved the development of specialized electrodes with tunable properties to sequentially breakdown PFOA in contaminated water samples into a sustainable byproducts of carbon dioxide, water, and fluorine atoms via an indirect electrochemical method. The nanocatalytic approach can be thought of as mimicking natural enzyme processes. It is believed that a method that can breakdown PFOA can also be effective at breaking down other PFAS.

The mechanism of the detection and breakdown of PFOA using IMPACT was investigated. It was discovered that, unlike other conventional methodologies, such as Advanced Oxidative Processes (AOPs), Granulated Activated Carbon (GAC), and reverse osmosis technologies that remove and concentrate PFAS, IMPACT showed substantial removal of PFOA and 1,4-dioxane while leaving no secondary contaminants.

Overall, what did the studies show?

The study:

- critically analyzed the recently developed nanoengineered materials (i.e., IMPACT system) for PFOA and 1,4-dioxane determination, removal, and breakdown in water,
- described the electro-catalytic mechanisms involved in PFAS and 1,4-dioxane decomposition,
- developed a research analytical method with very low detection limits for PFAS and 1,4-dioxane in water,
- showed high destruction efficiency of 98.5% for PFOA at very high concentrations (100 mg/L; ppm) but did not quantify destruction at low concentrations.
- showed complete (100%) removal of 1,4-dioxane from wastewater with spiked concentrations of 90 - 300 mg/L (ppm) but did not quantify destruction at low concentrations.
- highlighted the challenges in PFAS analysis during transitioning nanotechnologies from the laboratory to the field,
- described how the IMPACT system may be incorporated into an electrochemical system to serve as a Point of Entry Technology (POET) treatment system in industrial and waste management facilities.

How will DEP use the data?

The study shows that combination of electron-induced nanocatalyzed breakdown of PFOA and 1,4-dioxane may lead to a cleaner sustainable approach to contaminant removal and water clean-up. In the long term, this technology could create a dynamic, cost-effective electrochemical treatment system that integrates novel catalysts with off-the-shelf Tangential Flow Filtration (TFF) modules for treatment of PFAS and 1,4-dioxane in drinking and wastewater samples. The results of the investigation are useful for understanding the mechanisms of PFAS and 1,4-dioxane breakdown and destruction and could lead to improvement of the water quality control strategies and treatment methods developed by NJDEP.

Please review the full report for more detailed information at https://hdl.handle.net/10929/145641

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Who to contact with further questions.

For more information on this report, feel free to contact Alexander Polissar (Alexander.Polissar@dep.nj.gov).

Peer-Reviewed Publications Associated with this Report:

Osonga, F., G. Eshun, S. Kurilla, A. Qamar, H. Xue, M.T.-A. Hassan, H. Chen, and O. Sadik. IMPACT: Innovative (nano) Materials and Process for Advanced Catalytic Technologies to Degrade PFOA in Water. Chemosphere. 2024, 264:143057. https://doi.org/10.1016/j.chemosphere.2024.143057.

Tanim-Al Hassan, M., X. Chen, P. I. J. Fnu, F. Osonga, O. Sadik, M. Li, and H. Chen. Rapid Detection of Per- and Polyfluoroalkyl Substances Using Paper Spray-based Mass Spectrometry. J. Hazardous Material. 2024, 465:133366. https://doi.org/10.1016/j.jhazmat.2023.133366.

Torabfam, M., F. Osonga, Q. Young, O. Sadik. Scalable Electrochemical Detection and Degradation of 1, 4-Dioxane in Water and Wastewater: A Core-shell Bimetallic Nanocatalyst and Simulation Study. Environmental Science & Technology Water. 2025. https://doi.org/10.1021/acsestwater.4c00912.

Yadav, M., F. Osonga, O. Sadik. Unveiling Nano-empower Catalytic Mechanisms for PFAS Sensing, Removal and Destruction in Water. Science of the Total Environment. 2024, 912:169279. https://doi.org/10.1016/j.scitotenv.2023.169279.

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