

Graphene-enabled electrochemical systems as next-generation water treatment technology

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Abstract

Electrochemical systems offer multiple advantages for water and wastewater treatment, especially at smaller scale, as decentralized and distributed treatment systems, as they do not use chemical reagents, do not form a residual waste stream, operate at ambient temperature and pressure, are robust, versatile and have a small footprint. They are even well-suited for remote, off-grid areas, as they can be fully autonomous and easily powered by renewable energy. Yet there are two long-standing challenges that must be addressed: 1) high energy consumption and low degradation efficiency of contaminants, and 2) formation of toxic halogenated byproducts in the presence of halides.

In the scope of the European Research Council (ERC) ERC Starting Grant project ELECTRON4WATER, we developed a new material, graphene sponge electrode, capable of degrading a range of organic and microbial pollutants, including highly persistent and toxic per- and polyfluoroalkyl substances (PFAS), so-called forever chemicals¹⁻⁵. We discovered that this graphene-based electrode is electrochemically inert to chloride, thus completely excluding the formation of toxic chlorinated byproducts during electrochemical water treatment¹. Moreover, graphene coating can be tailored to enhance its electrocatalytic activity and interaction with specific contaminants, for example enabling the degradation of even highly polar and persistent contaminants such as trifluoroacetic acid (TFA)⁶. We demonstrated feasibility of graphene-enabled electrochemical water treatment of a range of contaminated water matrices, from drinking water to complex waste streams such as landfill leachate. Ongoing efforts are focused on the development of second generation of graphene sponge electrodes and upscaling to technology readiness level (TRL) 6 within the European Innovation Council (EIC) Transition Grant FOREVER-WATER⁷. This highly ambitious project will deliver a new, breakthrough technology at scale, capable for the first time of destroying PFAS and other pollutants in water in an energy-efficient, sustainable manner.

References

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