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Efficiently Degradation of Perfluorooctanoic Acid, an Emerging Contaminant, by a Hybrid Process of Membrane Distillation Process and Electro-Fenton

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Abstract : The widespread presence of poly- and perfluoroalkyl substances (PFAS) poses a significant concern due to their ability to accumulate in living organisms and their persistence in the environment, thanks to their robust carbon-fluorine (C-F) bonds, which require substantial energy to break (485 kJ/mol). The prevalence of toxic PFAS compounds can be highly detrimental to ecosystems, wildlife, and human health. Ongoing efforts are dedicated to investigating methods for fully breaking down and eliminating PFAS from the environment. Among the various techniques employed, advanced oxidation processes have shown promise in completely breaking down emerging contaminants in wastewater. However, the drawback lies in the relatively slow reaction rates of these processes and the substantial energy input required, which currently impedes their widespread commercial adoption. We developed a hybrid process, comprising electro-Fenton as an advanced oxidation process and membrane distillation, to simultaneously degrade organic PFAS pollutants and extract pure water from the mixture. In this study, environmentally persistent perfluorooctanoic acid (PFOA), as an emerging contaminant, was used to study the effectiveness of the electro-Fenton/membrane distillation hybrid system. The PFOA degradation studies were conducted in two modes: electro-Fenton and electro-Fenton coupled with membrane distillation. High-performance liquid chromatography with ultraviolet detection (HPLC-UV), ion-chromatography (measuring fluoride ion concentration), total organic carbon (TOC) decay, mineralization current efficiency (MCE), and specific energy consumption (SEC) were evaluated for a single EF and hybrid EF-MD processes. In contrast to a single EF reaction, TOC decay improved significantly in the EF-MD process. Overall, the MCE of hybrid processes surpassed 100% while it remained under 50% for a single EF reaction. Calculations of specific energy consumption (SEC) demonstrated a substantial decrease of nearly one-third in energy usage when integrating the EF reaction with the MD process.

Keywords : water treatment, PFAS, membrane distillation, electro-Fenton, advanced oxidation
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