PFAS Removal from Groundwater through TiO_2/Zeolite and H_2O_2 Photocatalysis based on Solar Energy

Chi-An Tseng [1,2] , Chih-Yu Chen [1,2], Feng-Chih Chou[1,2], Yuan-Chung Lin[1,2,3,4*]

[1]*Institute of Environmental Engineering, National Sun Yat-Sen University, Kaohsiung 804, Taiwan.*
[2] *Center for Emerging Contaminants Research, National Sun Yat-Sen University, Kaohsiung 804, Taiwan.*
[3]*Net Zero Emissions and Resource Recycling Technology Research Center, National Sun Yat-Sen University, Kaohsiung 804, Taiwan.*
[4]*Department of Public Health, College of Health Science, Kaohsiung Medical University, Kaohsiung 804, Taiwan.*

Abstract

Per- and polyfluoroalkyl substances (PFAS) are a class of persistent organic pollutants characterized by highly stable carbon–fluorine (C–F) bonds. Ubiquitously present in groundwater, PFAS exhibit strong resistance to conventional water treatment processes. This study targets perfluorooctanoic acid (PFOA), a representative PFAS compound, and develops a dual-functional photocatalytic membrane composed of ZSM-5 zeolite and titanium dioxide (TiO_2). Polydopamine (PDA) was employed as an interfacial adhesive to immobilize the composite on a hydrophilic polyvinylidene fluoride (PVDF) membrane substrate. Material characterization using XRD, SEM, BET, and FTIR confirmed the crystal structure and catalytic composition of the composite. A solar-driven continuous-flow photocatalytic system was subsequently constructed for PFOA degradation, integrating UV irradiation and hydrogen peroxide (H_2O_2) as oxidative enhancers. pH and oxidation-reduction potential (ORP) were continuously monitored to assess the redox environment. Preliminary results demonstrate stable removal efficiency of PFOA, up to 78.5%, with low energy consumption, minimal by-product formation, and high operational potential. This system offers a promising solution for in-situ groundwater remediation and sustainable water purification, contributing to Taiwan's 2050 net-zero carbon emission targets.

Keywords: Per- and polyfluoroalkyl substances, Perfluorooctanoic acid, Photocatalysis, ZSM-5 zeolite, Titanium dioxide.