Photoelectrocatalysis of Perfluorooctanoic acid (PFOA) via TiO_2/$BiVO_4$ Nanostructured Photoanode Augmented with Carbon Quantum Dots (CQDs)

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Abstract

Per- and polyfluoroalkyl substances (PFAS) are persistent environmental contaminants that pose considerable health risks. Among the various PFAS compounds, Perfluorooctanoic acid (PFOA) is notably the most frequently detected in environmental samples. Conventional methods for the removal of PFOA often prove inadequate, thereby emphasizing the need for the development of advanced treatment technologies. Photoelectrocatalysis (PEC) has emerged as a promising strategy for the degradation of PFAS compounds, utilizing the synergistic effects of light and electrical energy. This study seeks to examine the efficacy of titanium nanorods doped with Bismuth vanadate ($BiVO_4$), which was enhanced with carbon quantum dots (CQDs), for the photoelectrocatalytic removal of PFAS from contaminated water sources. Titanium nanorods were synthesized using a hydrothermal method, and $BiVO_4$ was subsequently applied via spin coating to enhance their photocatalytic properties. CQDs were also incorporated through spin coating to improve light absorption and promote charge separation. The structural and optical characteristics of the resulting photoanodes were thoroughly characterized. The performance of the photoanode was assessed under varying conditions. Degradation efficiency was monitored utilizing liquid chromatography-mass spectrometry (LC-MS-MS) to quantify the degradation of PFOA. The research findings indicate that the innovative TNR-$BiVO_4$-CQD composite photoanode significantly improves the degradation of PFOA when compared to both pure TNR and TNR-$BiVO_4$ individually, achieving over 90% degradation within a three-hour treatment period. Mechanistic investigations revealed that the incorporation of CQDs enhances charge carrier dynamics and increases the generation of reactive oxygen species. The research underscores the efficacy of TNR-$BiVO_4$-CQD as a superior PEC material for PFOA removal.

Keywords

Carbon quantum dots, nanostructured photoanode, PFAS, Photoelectrocatalysis.