Development of a Novel and High Performance WO3/Al2O3 Ceramic Composite Membrane for Oil-Water Separation

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The process of oil extraction makes large amounts of a toxic and oil-contaminated byproduct known as produced water, with the US generating over 30 billion barrels in 2022. Oil-water (O/W) separation through membrane technology is a favorable solution, but membranes are susceptible to oil fouling, which reduces water filtration flux. While tungsten trioxide (WO3) based membranes are promising, they were not yet tested for their photocatalytic self-cleaning (i.e., anti-fouling ability). Thus, this project aimed to study the self-cleaning and O/W emulsion separation performance of novel WO3/Al2O3 composite membranes with different WO3 particle shapes (spherical nanoparticles, hexagonal nanoparticles, and nanoflakes). The three membranes were fabricated by covalently crosslinking WO3 nanomaterial to an Al2O3 support by interfacial polymerization. The super-hydrophilic and underwater super-oleophobic surface properties were confirmed through contact angle measurements. Characterized by FTIR, SEM, EDS, and XRD, the membranes were tested in O/W emulsion separation with oil concentrations ranging from 50 to 200 ppm and at pressures between 2 and 8 bar. Long-term filtration tests showed a 97% flux recovery after UV irradiation every 2 hours, which proved the membranes' self-cleaning and anti-fouling ability. Further, all membranes showed more than 99% O/W emulsion separation efficiency, which was stable for 8 hours. The nanoflake WO3-based membrane achieved the highest efficiency (99.8%), while the hexagonal WO3-based membrane exhibited the highest flux (751 LMH). The developed WO3/PA@Al2O3 membranes showed great potential for effective O/W emulsion separation with anti-fouling properties, promoting its application in oily wastewater treatment, specifically for produced water.

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