Polyethersulfone membranes nano-modified with MoS_2-CeO_2 for effective oil in water emulsions separation

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Domestic sewage discharge, oil leaks, and industrial activities such as metallurgical and petrochemical operations are the main contributors to oily wastewater, which is essentially water contaminated with oil. The uncontrolled discharge of this wastewater not only wastes valuable resources and causes financial losses but also poses severe threats to ecosystems and public health. The challenge is further intensified because oil/water emulsions—owing to their high stability and small particle size—are extremely difficult to separate on a global scale. This urgent problem highlights the need for innovative membrane technologies that can effectively remove oil from water.

In response to this challenge, hydrophilic Molybdenum Disulphide–Cerium Dioxide (MoS_2–CeO_2) nanohybrid powder was embedded into Polyethersulfone (PES) ultrafiltration (UF) mixed matrix membranes (MMMs) via the non-solvent induced phase inversion (NIPS) method. The resulting nanocomposite membranes were comprehensively characterized using techniques such as SEM, EDS, XRD, AFM, and zeta potential analysis, while their physicochemical properties—including pore size, porosity, water contact angle (WCA), and pure water flux (PWF)—were systematically assessed. When tested against surfactant-stabilized oil-in-water emulsions at varying concentrations (100, 500, and 1000 ppm) in a dead-end UF setup, the modified membranes demonstrated a remarkable oil rejection efficiency of 98.7% and significant enhancements in PWF and permeability (65% and 153%, respectively) at a 0.5 wt.% loading of MoS_2–CeO_2. Moreover, antifouling and reusability studies over five filtration cycles confirmed the strong potential of these nanocomposite membranes for sustainable oily wastewater treatment.

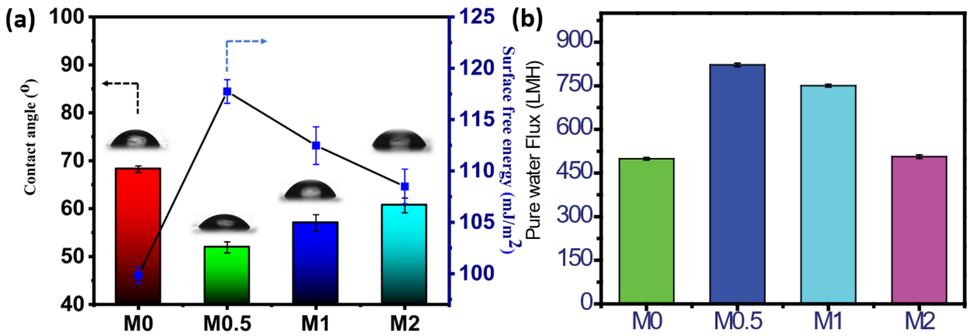

Figure 1: Characterizations of Nanocomposite membranes (a) WCA (b) PWF

The WCA is the main parameter indicating the membrane's hydrophilicity. As shown in Fig. 1(a), after embedding the nanohybrid in the membrane matrix, the WCA dropped from 68º for pristine membranes to 53º, 57º, and 61º for M-0.5, M-1, and M-2, respectively. This significant reduction is attributed to the hydrophilicity of the nanohybrid present in the nanocomposite membranes [1]. Additionally, the PWF trends shown in Fig. 1(b) indicate that the incorporation of MoS_2-CeO_2 significantly enhanced the PWF of the pristine membrane, with M-0.5 composition demonstrating the highest flux. The PWF improved by 65% from 499 (M-0) to 822 LMH (M-0.5). This shoot in flux is ascribable to the incorporation of the nanohybrid which accelerated solvent-nonsolvent exchange, resulting in membranes with increased finger-like macro-voids, higher porosity, larger mean pore size, and consequently higher water flux [2].

References

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