Multi-Functional High-Flux Superhydrophilic/ Supeoleophobic ZnO-Pillared MXene Membrane With Self-Cleaning Properties for Wastewater Treatment

Alqasir, Asma (School: Riyadh School for Boys and Girls)

Wastewater is expected to increase by 24% in 2030, posing significant risks to health and the environment. Titanium carbide (2D MXene) membranes offer a potential solution for wastewater treatment due to their sieving characteristics. However, developing such membranes with efficient properties remains a challenge in addressing the discharge of complex wastewater. This project presents a novel ZnO-pillared MXene membrane for stable, environmentally friendly, cost-effective, and efficient treatment of oily and dye-contaminated wastewater. MXene was synthesized, hydroxylated, pillared, as a secondary species was inserted between layers, and deposited on an alumina ceramic support to fabricate the novel membrane. Three triplicates were conducted to prepare the membrane and all resulted in an average increase in MXene's interlayer spacing from 0.33nm to 0.55nm, representing a 66% enlargement. Membrane evaluation revealed a water flux of 7,630 LMH at 2 bar, showcasing 300% improvement in comparison to typical membranes. The synthesized membrane exhibited (>96%) and (99.4%) oil rejection and dye rejection, respectively. The anti-fouling and recycling capabilities were demonstrated over 15 oil-in-water cycles while maintaining a stable flux of 2,100 LMH and rejection above 96%, Also, 100 dye-filtration cycles were run with a flux of 2,000 LMH and average rejection of 98% resulting in a remarkable 105% increase in stability over average membranes. The membrane showcased self-cleaning properties under visible light, and the cost is less than the average membrane by 98%. The scalability allows for seamless integration into filtration systems across global water treatment facilities, contributing significantly to combat clean water scarcity challenges.