Developing a Novel Superhydrophobic GO–Ni/PAN Membrane for Interfacial Solar Steam Generation

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Interfacial solar steam generation systems offer a promising solution to freshwater scarcity and energy-intensive desalination. However, most current research uses hydrophilic membranes that face poor stability due to salt accumulation, which decreases the system's performance. The purpose of this research is to develop a two-layer membrane to improve salt resistance and maintain efficient evaporation. In this study, a novel superhydrophobic GO–Ni on an electrospun nanofiber polyacrylonitrile (PAN) substrate was developed. Both the novel membrane and the hydrophilic GO/nylon benchmark membrane were fabricated 4 times and tested for direct comparison. The benchmark membrane was prepared using vacuum-assisted filtration on a nylon substrate, while the PAN nanofiber substrate for the developed membrane was fabricated via electrospinning, followed by GO–Ni deposition using vacuum-assisted filtration. This novel membrane achieved an evaporation rate of 1.09 kg/m²·h and a photothermal efficiency of 67.18%, with no salt accumulation observed over 5 days of outdoor operation, in contrast to rapid salt buildup on the benchmark membrane within 2 hours. Water quality analysis showed a 1118× reduction in conductivity, from 64.3 mS/cm to 57.5 µS/cm, confirming effective desalination. The superhydrophobic surface limited salt accumulation, while the nanofibrous PAN structure maintained continuous water transport during evaporation. In addition to improved performance and durability, the preparation cost of the developed membrane was 8.4 times lower compared to the benchmark membrane. This project presents a simple, solar-driven, and cost-effective approach for freshwater production, potentially supporting water accessibility in areas where electricity and freshwater are limited.

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