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An Inorganic Nanofiber/Polymeric Microfiber Network Membrane for High-Performance Oil/Water Separation

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Abstract : It has been highly desired to develop a high-performance membrane for separating oil/water emulsions with the combined features of high water flux, high oil separation efficiency, and high mechanical stability. Here, we demonstrated a design for high-performance membranes constructed with ultra-long titanate nanofibers (over 30 μm in length)/cellulose microfibers. An integrated network membrane was achieved with these ultra-long nano/microfibers, contrast to the non-integrated membrane constructed with carbon nanotubes (5 μm in length)/cellulose microfibers. The morphological properties of the prepared membranes were characterized by A FEI Quanta 400 (Hillsboro, OR, United States) environmental scanning electron microscope (ESEM). The hydrophilicity, underwater oleophobicity and oil adhesion property of the membranes were examined using an advanced goniometer (Rame-hart model 500, Succasunna, NJ, USA). More specifically, the hydrophilicity of membranes was investigated by analyzing the spreading process of water into membranes. A filtration device (Nalgene 300-4050, Rochester, NY, USA) with an effective membrane area of 11.3 cm^2 was used for evaluating the separation properties of the fabricated membranes. The prepared oil-in-water emulsions were poured into the filtration device. The separation process was driven under vacuum with a constant pressure of 5 kPa. The filtrate was collected, and the oil content in water was detected by a Shimadzu total organic carbon (TOC) analyzer (Nakagyo-ku, Kyoto, Japan) to examine the separation efficiency. Water flux (J) of the membrane was calculated by measuring the time needed to collect some volume of permeate. This network membrane demonstrated good mechanical flexibility and robustness, which are critical for practical applications. This network membrane also showed high separation efficiency (99.9%) for oil/water emulsions with oil droplet size down to 3 μm, and meanwhile, has high water permeation flux (6.8×10^3 L m^{-2} h^{-1} bar^{-1}) at low operation pressure. The high water flux is attributed to the interconnected scaffold-like structure throughout the whole membrane, while the high oil separation efficiency is attributed to the nanofiber-made nanoporous selective layer. Moreover, the economic materials and low-cost fabrication process of this membrane indicate its great potential for large-scale industrial applications.

Keywords : membrane, inorganic nanofibers, oil/water separation, emulsions
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