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Synthesis of High-Antifouling Ultrafiltration Polysulfone Membranes Incorporating Low Concentrations of Graphene Oxide

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Abstract : Membrane treatment for desalination and wastewater treatment is one of the promising solutions to affordable clean water. It is a developing technology throughout the world and considered as the most effective and economical method available. However, the limitations of membranes' mechanical and chemical properties restrict their industrial applications. Hence, developing novel membranes was the focus of most studies in the water treatment and desalination sector to find new materials that can improve the separation efficiency while reducing membrane fouling, which is the most important challenge in this field. Graphene oxide (GO) is one of the materials that have been recently investigated in the membrane water treatment sector. In this work, ultrafiltration polysulfone (PSF) membranes with high antifouling properties were synthesized by incorporating different loadings of GO. High-oxidation degree GO had been synthesized using a modified Hummers' method. The synthesized GO was characterized using different analytical techniques including elemental analysis, Fourier transform infrared spectroscopy - universal attenuated total reflectance sensor (FTIR-UATR), Raman spectroscopy, and CHNSO elemental analysis. CHNSO analysis showed a high oxidation degree of GO represented by its oxygen content (50 wt.%). Then, ultrafiltration PSF membranes incorporating GO were fabricated using the phase inversion technique. The prepared membranes were characterized using scanning electron microscopy (SEM) and atomic force microscopy (AFM) and showed a clear effect of GO on PSF physical structure and morphology. The water contact angle of the membranes was measured and showed better hydrophilicity of GO membranes compared to pure PSF caused by the hydrophilic nature of GO. Separation properties of the prepared membranes were investigated using a cross-flow membrane system. Antifouling properties were studied using bovine serum albumin (BSA) and humic acid (HA) as model foulants. It has been found that GO-based membranes exhibit higher antifouling properties compared to pure PSF. When using BSA, the flux recovery ratio (FRR %) increased from 65.4 ± 0.9 % for pure PSF to 84.0 ± 1.0 % with a loading of 0.05 wt.% GO in PSF. When using HA as model foulant, FRR increased from 87.8 ± 0.6 % to 93.1 ± 1.1 % with 0.02 wt.% of GO in PSF. The pure water permeability (PWP) decreased with loadings of GO from 181.7 $L.m^{-2}.h^{-1}.bar^{-1}$ of pure PSF to 181.1, and 157.6 $L.m^{-2}.h^{-1}.bar^{-1}$ with 0.02 and 0.05 wt.% GO respectively. It can be concluded from the obtained results that incorporating low loading of GO could enhance the antifouling properties of PSF hence improving its lifetime and reuse.

Keywords : antifouling properties, GO based membranes, hydrophilicity, polysulfone, ultrafiltration
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