Next Generation Ultrafiltration for Wastewater Treatment: Characterization and Performance of Fouling-Resistant Polymeric and Lyocell Cellulose Nanofiber Membranes

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Sustainable and hydrophilic cellulose nanofiber (CNF) coated membranes possess wastewater reclamation applications to meet increasing global water demands. In this investigation, CNF coated electrospun polyacrylonitrile (ePAN) and lyocell membranes' characterization and fouling-resistant behavior were compared to establish inexpensive and efficient membranes. Pre- and post-fouling characterizations were completed with SEM, zeta potential, Fourier transform infrared spectroscopy (FTIR), water contact angle, computational fouling mechanisms and turbidity. Dead-end filtration performance of CNF coated ePAN membranes demonstrated reduced fouling (98% flux recovery) at high area densities (AD; 0.40AD) and high degrees of oxidation (DO; 1.80DO). Reduced fouling due to high AD was supported by SEM and high DO was confirmed with zeta potential, FTIR, and water contact angle findings. Fouling-resistant CNF coated lyocell exhibited 100% flux recovery, and both ePAN and lyocell fluxes recovered better than polyvinylidene difluoride (40%). Computational derivation of fouling mechanisms highlights cake formation in ePAN (36%) and lyocell (31%). Turbidity determined superior permeate quality of lyocell (0.41 nephelometric turbidity units) compared to alternative membranes. Enhanced membrane efficiency was achieved with CNF ePAN membranes at high ADs and DOs under low pressures. The high flux, fouling resistance, and superior permeate quality of CNF lyocell membranes illuminate an avenue for cellulose-based membranes as a promising alternative to polymeric membranes for the progression towards wastewater reclamation for developing countries. Future investigations include determining fouling resistance in a cross-flow system and industrializing the lyocell synthesis process.

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