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TiO_2 Nanofiltration Membranes Prepared by Molecular Layer Deposition for Water Purification

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ABSTRACT

In this study, molecular layer deposition (MLD) was used as a novel and highly controllable method to prepare TiO_2 nanofiltration membranes with approximately 1 nm pores for water purification. Number of deposition cycles and precursors ($TiCl_4$ and ethylene glycol) were used to control membrane quality and final pore sizes, respectively. Optimized TiO_2 nanofiltration membranes had a pure water permeability as high as ~48 L/(m^2·h·bar). Salt and dye rejection measurements showed moderate rejection of Na_2SO_4 (43%) and $MgSO_4$ (35%) and high rejection of methylene blue (~96%). In addition, natural organic matter (NOM) removal testing showed high rejection (~99%) as well as significantly improved antifouling performance and recovery capability. MLD, as a new TiO_2 nanofiltration membrane preparation technique, has great potential to realize excellent control of membrane composition, thickness, and potentially pore sizes in a scalable way.

Keywords: Membranes; Nanofiltration; TiO_2; Molecular layer deposition

1. Introduction

Water scarcity is one of the most serious global issues because of the growing freshwater use and depletion of usable fresh water resources.[1] It is, therefore, in a great need to develop various energy-efficient water treatment technologies to realize water purification for different water sources and at different levels. Nanofiltration membranes are now widely used in drinking water and wastewater treatment, as well as pretreatment for desalination because of their ability to remove viruses, hardness, dissolved organic matter, and salts, especially multivalent ions.[2-5] Currently, polymers, such as cellulose acetate, polyamide, polyimide, and poly(ether)sulfone, are dominant materials in nanofiltration.[4, 6] Most of the polymeric nanofiltration membranes have advantages of flexibility, simple preparation process, and relatively low cost.[2] Compared with