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Effect of TiO_2 concentration in PVDF-TiO_2-PVP mixed matrix membrane performance using ultrafiltration process

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ABSTRACT

This study investigated how the addition of hydrophilic TiO_2 to a porous asymmetric polyvinylidene fluoride (PVDF) Ultrafiltration (UF) membrane altered its properties and performance. The hydrophilicity and flux of PVDF and polyvinylpyrrolidone (PVP) combinations will be lower, and TiO_2 will significantly impact raising those values. By mixing titanium dioxide (TiO_2) nanoparticles with a pore-forming agent in a dope solution, PVDF-TiO_2-PVP membranes were prepared via non-solvent-induced phase inversion method. Experiments using PVDF membranes with varying concentrations of TiO_2 (0, 0.25, 0.5, 1, 1.5, and 2% wt) were applied to evaluate pure water flux and Bovine Serum Albumin (BSA) flux. The functional group composition of membranes was investigated by Fourier transform infrared spectroscopy. The wettability of porous membranes was determined by measuring contact angles. Results demonstrated that membranes constructed from PVDF/PVP/TiO_2 with a lower loading of TiO_2 nanoparticles had a smaller mean pore size, more apertures inside the membrane, and better membrane hydrophilicity. The highest flux of pure water (121 L/m^2h) was achieved by the PVDF-TiO_2-PVP mixed-matrix membrane at a TiO_2 concentration of 2 wt%.

1. Introduction

Wastewater production has been cited as one of the major issues in the previous few decades due to global population expansion and industrial operations [1]. The treatment of municipal and industrial wastewater has made use of numerous technologies. One of the important technologies today is the membrane separation technique. Due to their potential for managing water scarcity, there has been a rise in the usage of membrane technology for wastewater treatment [2].

PVDF, a polymeric material composed of (CH_2-CF_2) with excellent thermal stability and chemical resistance to acids, bases, and organic solvents, making it one of the most popular materials for use in microfiltration (MF) and ultrafiltration (UF) processes [3]. Pure PVDF membranes are extremely susceptible to fouling by bacteria and other wastewater components because of PVDF's hydrophobic nature, which generally results in a considerable decline in water flux [4]. PVDF polymers are inherently less hydrophilic, and introducing TiO_2 nanomaterials has significantly improved membrane performance [5]. PVDF membranes' hydrophilicity is increased when TiO_2 nanoparticles are added, and the fouling issue is also reduced [6].

To enhance the hydrophilicity and performance of PVDF membranes, numerous high molecular weight organic additives, such as PVP or poly(ethylene glycol), and inorganic additives, such as nanoparticles, are commonly added to the casting solution [7,8,9]. PVP applications mostly refer to their exceptional pore-forming capacity and wide molecular weight range according to the preceding research.Creating finger-like or sponge-like structures in the membrane sublayer and employing them to increase water flux through the membrane is a common practice [10]. The impact of PVP on PVDF-based membrane production during the phase inversion process was also examined by Fontananova et al [11], they concluded that adding PVP to the casting solution would alter the permeability of the membrane. Surface-

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