Fabrication new PES-based mixed matrix nanocomposite membranes using polycaprolactone modified carbon nanotubes as the additive: Property changes and morphological studies

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ABSTRACT
In this study, the effects of different concentrations (0.5, 1.5 and 3% w/v) of polycaprolactone modified multiwall carbon nanotubes (PCL-MWCNTs) as the additive in the casting solution were investigated. PCL-MWCNTs are nanocomposite materials containing –OH end groups and other functional groups (e.g., carbonyl (C=O) groups) that can affect the membrane properties. Some membrane characteristics such as surface hydrophilicity, surface chemistry, thermal resistance, and surface and cross-section morphology were investigated by water contact angle, ATR-IR, TGA, AFM, and SEM tests, respectively. These tests represent some outstanding changes in the membrane properties due to the presence of PCL-MWCNTs. The membrane antifouling properties were examined by using the bovine serum albumin solution as the model system. The pure water flux enhanced from 28 L/m² h (the unmodified membrane) to 61 L/m² h (the modified membrane including 3 w/v% PCL-MWCNTs), SEM and AFM images show an even, porous and smooth surface along with the finger-like macrovoids in the sub-layer of membranes composed of PCL-MWCNTs.

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1. Introduction

The membrane process is an attractive separation technology due to the fast and energy efficient process without any phase change [1]. The application of membranes is growing in pharmaceutical, chemical, paper, semiconductor, textile, water and wastewater processes. The main goal in preparation of membranes is to control the membrane structure, which affects the membrane performance. Mixed-matrix membranes (MMMs) are a well-known way to enhance the properties of polymeric membranes [2]. Their structure consists of an inorganic material incorporated into a polymeric matrix. In principle, the incorporation of the inorganic component can be seen as a relatively easy modification of existing methods for fabricating large-surface area polymeric membranes; therefore, MMMs possess an economic advantage over inorganic membranes. In addition, they may offer enhanced physical, thermal, and mechanical properties for aggressive environments and could be a way to stabilize the polymer membrane against change in permselectivity with temperature [3]. These membranes offer very interesting properties. The successful development of MMMs depends on several factors such as the proper selection of a polymeric matrix and inorganic filler and the elimination of interfacial defects between the two phases. Most commercial membranes are fabricated from organic polymers. However, the membranes composed of inorganic materials are developing due to higher durability and performance in many separation applications [4–6].

Polyethersulfone (PES) is the material of choice for numerous membrane applications due to its outstanding mechanical strength, thermal stability, and formability. However, the important disadvantages of PES for membrane preparation are low permeability and high fouling tendency which are due to the inadequate hydrophilic property of PES compared to that of other polymers such as polyacrylonitrile, cellulose acetate, polyamide, and polysulfone. Many approaches were applied to impart higher hydrophilicity to PES membranes. One of these techniques includes addition of hydrophilic additives to the membrane casting solution, leading to decreasing membrane fouling.

Carbon nanotubes (CNTs) with unique properties such as physical, chemical, mechanical, and electrical properties are interesting both in academic and industrial aspects [7–9]. The outside wall modification of CNTs is a well-known way to improve the CNTs properties and obtain new materials with new and interesting properties. A well-known procedure to increase the processability of CNTs is chemical modification [10,11]. After modification, they are not only soluble in...