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Investigation of raw and oxidized multiwalled carbon nanotubes in fabrication of reverse osmosis polyamide membranes for improvement in desalination and antifouling properties

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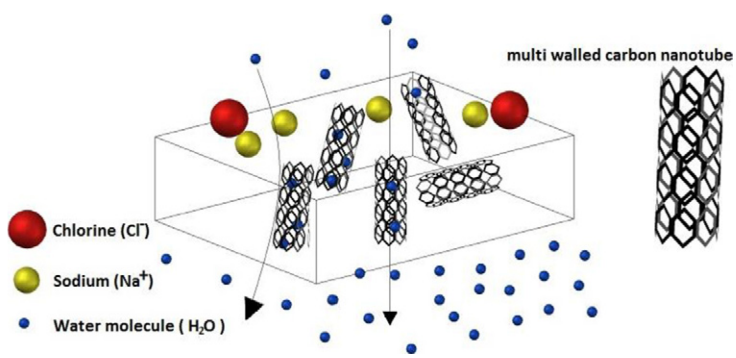
HIGHLIGHTS

- Fabrication of raw and oxidized MWCNTs blended polyamide reverse osmosis membranes
- MWCNTs were mixed in diamine aqueous solution i.e. polyamide layer.
- Permeate flux was improved by increasing amount of MWCNTs upto 0.005 wt%.
- By increasing amounts of MWCNTs, membrane surface become smoother.
- Membranes by all raw or oxidized CNTs contents had well antifouling than bare one.

GRAPHICAL ABSTRACT



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ABSTRACT

Multiwalled carbon nanotubes (MWCNTs) embedded polyamide reverse osmosis membranes were synthesized by incorporating two kinds of raw and oxidized MWCNTs with different concentrations in diamine aqueous solution of interfacial polymerization method. The oxidized MWCNTs were functionalized with hydrophilic groups in order to increase membrane performances. Surface contact angle, SEM images, FTIR, salt rejection, water flux and BSA/salt fouling tests of the nanocomposite membranes were investigated to reach an acceptable performance. Results exhibited that the amount of water flux and hydrophilicity were improved by increasing the concentration of the MWCNTs up to 0.005 wt%. In high concentrations of both MWCNTs, the flux was decreased. For raw MWCNTs, despite less hydrophilicity, the experiments showed a considerable growth in water flux and salt rejections due to well disperse with polyamide membrane materials. The saline solution fluxes were reached from 20.3 to 25.9 in the raw and 28.9 L/m^2 h in the oxidized MWCNTs embedded membranes. The evaluations of fouling behavior in 24 h test with BSA/salt solution were shown that the membranes with all concentrations of raw or oxidized MWCNTs had better antifouling performance rather than the unfilled membrane.

1. Introduction

Generally, water is imperative for survival, which is more considerable than other necessary demands including industrial and economic

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developments. Among water treatment processes, the membrane is one of the most important technologies in terms of high performance and increased efficiency [1,2]. The filtration membranes are divided into four sections consisting of microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO), which RO exhibited best rejection especial for brackish water. The productive RO membrane should suggest simultaneously high solute rejection, water permeability, chemical stability, good chlorine and fouling resistance.

Over past two decays, the reverse osmosis became a great process for desalination. After developing asymmetric membranes especial cellulose acetate (CA) asymmetric membranes, thin film composite membranes (TFC) appeared and showed significant improvement in permeability and rejection [3]. Thin film composite membranes, which are commercially produced, contained three layers including; a base layer (often with a non-woven fabric) and a second layer is an anisotropic micro-porous polymer, the top layer is coated with an ultrathin cover of polymer composition (polyamide layer) [4]. Recently, novel desalination RO membranes particular containing nanomaterials have been developed as nanostructured materials in preparation of RO membranes [3].

There are two types of nanotechnology enhanced membrane materials: the mixed matrix membrane (MMM), a mixture of nanomaterials (i.e. filler) in a polymeric material (i.e. matrix) and a thin film nanocomposite (TFN), the formation of a thin-film layer with nanofillers on a porous support [5]. The mixed matrix/nanocomposite membranes may exhibit improved mechanical, chemical, and thermal stability, as well as separation, reaction and sorption capacity [2,6]. The thin film nanocomposite membranes are a combination between TFC membranes and nanomaterials that made a new structure for assess improving results [7].

Carbon nanotubes (CNTs) are a kind of graphene sheets, however, there are two differences: mechanical and antibacterial properties [8]. It seems that the carbon nanotube is regarded as desirable and helpful to increasing hydrophilicity on the surface of membranes, although, research in CNTs performance has not been considered enough since previous decades [9]. In addition, many scientists are interested in extending research with the assistance of further investigation.

It can be seen that the advantage of studying nanotechnology, the TFN membrane with CNTs embedded within the support layer has important advantages when compared to the previously studied TFN membranes (mainly CNTs applied in the active layer). In the past few years, researchers have discussed diverse subjects regarding CNTs developments. For example, in mixture of nanosilvers and MWCNTs, water flux of TFN membranes improved by blending MWCNTs at 5 wt% and nAg particles at 10 wt% to 23% and 20%, respectively [5]. Grafting procedure by poly(methyl methacrylate) for carbon nanotube was made to go hydrophobicity up as high as 62% compared to the thin-film composite membranes when using 2 g/L piperazine in aqueous phases [7]. Further, the use of carbon nanotube based nanocomposite reverse osmosis noticeably enhanced chlorine resistance, compared to conventional polyamide membranes when 0.1–1 wt% of CNTs were applied [10]. Also, interfacial polymerization of single walled carbon nanotube (SWCNTs) with polyamide-aluminosilicate has been investigated in order to find an optimum condition for considerable improve

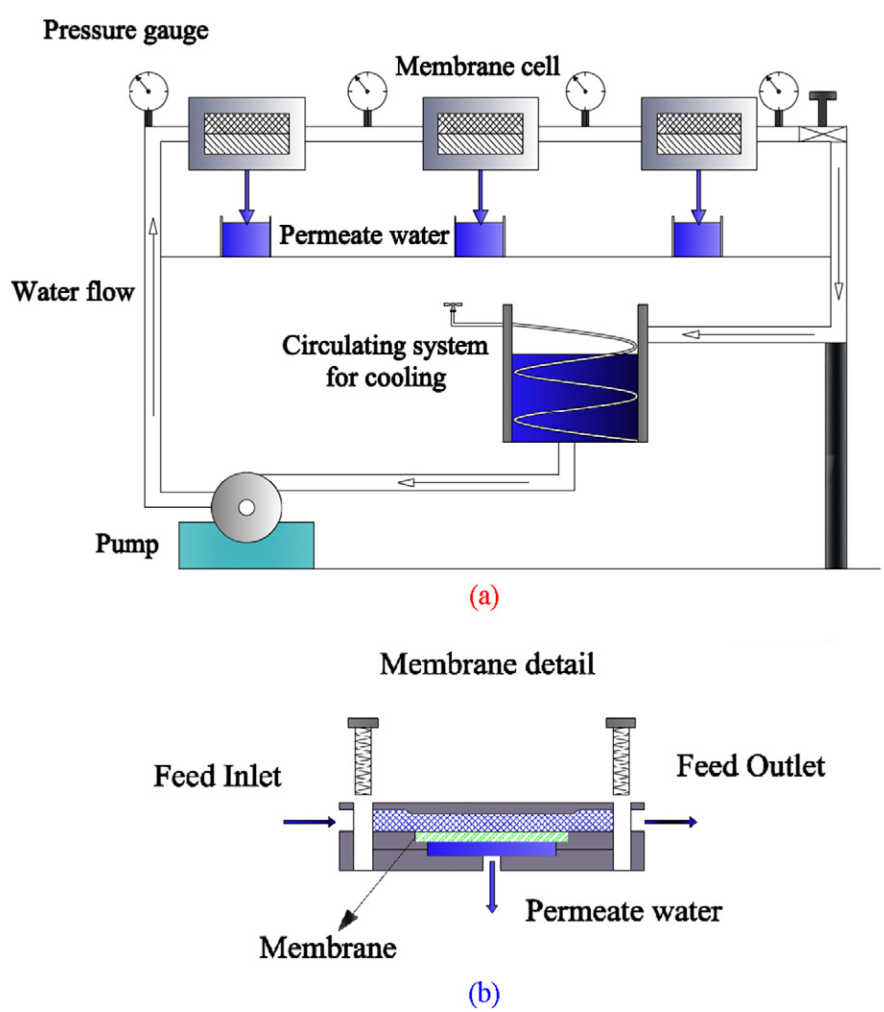

Fig. 1. (a) Schematic view of cross-flow setup with three series cells (b) and schematic of used membrane cell.