Mixed Nanostructures / PES / RO Membrane for Water Desalination

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Abstract
Different nanomaterials graphene, zinc nanorode and zinc nanosephere were used in membrane preparation. Polyethersulphone as a main polymer was blended with nano-soultions of these nanomaterials. This Support layer was coated by a composite coating layer formed of polyvinylacohol and titanium dioxide nanotubes to provide strength and enhance hydrophilicity of such membranes. M2 (using graphene) provides highest permeate flux 30.6 L/m2.h due to its highest hydrophilicity, but it was lowest salt rejection 48.9% at feed concentration of 5000 ppm. M3 and M4 provide high salt rejection 99% for M4 and 89% for M3. The highest mechanical strength was found clear with M3 formulation, which gives about 8.8 N/cm2 tensile strength and elongation of 20 mm.
Keywords: RO membrane, membrane desalination, Zinc nanospheres, Zn nanorods, Polyvinyl alcohol coatings

1. Introduction

In the past, membranes were frequently used in water desalination; large scale desalination plants were then under construction, or was realized to be developed in the coming years, making pressure-driven membrane systems the leading technology in this strategic area in the previous two decades [Porter1990, Semiat 2000, Ahmed et al.2002]. However; Nowadays, around the world, there are more than 12,500 sea and/or brackish water desalination plants; installations based on Reverse Osmosis (RO) technology account for around 50% of the total desalination capacity. Separation by membranes is the result of differences in the transport rate of various species through the membrane [El Kady et al.2001]. The transport rate is mainly determined by the nature of forces acting on each individual component (usually called “driving force”), and by its mobility through the membrane [Wiesner et al.1999, Verliefde et al. 2008]. According to these basic concepts, membranes are usually classified on the basis of the applied driving force(s). Focusing only on membrane operations used in desalination [Nghiem et al.2004, Shi et al.2014].

Over the years, various modification methods such as blending, coating and grafting have been devoted to improve hydrophilicity of PES-based UF membranes in order to enhance its anti-fouling properties [Tamin et al. 2005]. Among these available methods, blending with hydrophilic nanoparticles has been well documented in the literature owing to its easiness and simplicity. Nanoparticles have attracted attention mainly due to their unique effect on different properties chemical, mechanical, electrical, etc. and blend membranes enhanced behavior.

2. Experimental work & Results

2.1. Experimental work

Polyethersulfone (PES) membranes prepared using immersion precipitation process. The polymer PES was dissolved in a solvent N-Methyl Pyrrolidone (NMP) with 6% of nano-solution. Three kinds of nano-solutions were prepared by dissolving selected nanoparticles in certain solvent in presence of sodium dodecyl sulfate as a powerful surfactant under mixture sonication; first one was ethanol with graphene nanoparticles. The second was using NaOH and zinc oxide nano-rode. . Finally the third one was NaOH and zinc oxide nano-sphere in water. The stirring process for a polymeric solution was operated for 18 h. After membrane formation, membranes were coated using composite polyvinyl alcohol (PVA) with titanium dioxide nanotubes as crosslinking assistance layer. Cross linking solution was prepared by dissolving 15% gluataraldehyde with 85% acetone and poured on the surface of dried membranes for 1.5h.

2.2. Results & Membrane performance

The performance of prepared membranes using various salty solution concentration was studied and illustrated as salt rejection and permeate flux in fig 1 and 2. Fig.1 shows that M1 is the highest permeate flux because the membrane is free of nanomaterials and will be porous membrane. However; for M2, which is the membrane with graphene nanosolution, it gives higher flux when compared with M3 and M4. This can be attributed to its enhanced hydrophilicity by action of graphene and coating crosslinked layer of PVA/TiNt. However; for M3 (Zn nanorode) and M4 (Zn nanosphere), they provide highest salt rejection % for different feed water salt concentrations. And this could be due to the formation of high dense top layer of membranes.

3. Conclusions

Polymeric PES blended membranes with nanomaterial solutions of graphene, zinc nanorod and zinc nanosephere were used in membrane preparation. Coating crosslinking layer by composite layer of polyvinylacohol and titanium dioxide nanotubes were applied to each membrane formulation to provide enhanced mechanical strength and hydrophilicity of produced ones. Membranes morphology indicate the formation of highly dense layer on membrane top surface due to blending with nano materials and presence of coating crosslinking layer. M2 (using graphene) provides highest permeate flux 30.6 L/m2.h due to its highest hydrophilicity, but it shows a lowest salt rejection 48.9% at feed concentration of only 5000 ppm. M3 and M4 provide high salt rejection 99% for M4 and 89% for M3 for feed concentration 5000 ppm. The highest mechanical strength was for M3 which was 8.8 N/cm2 tensile strength and elongation 20 mm.

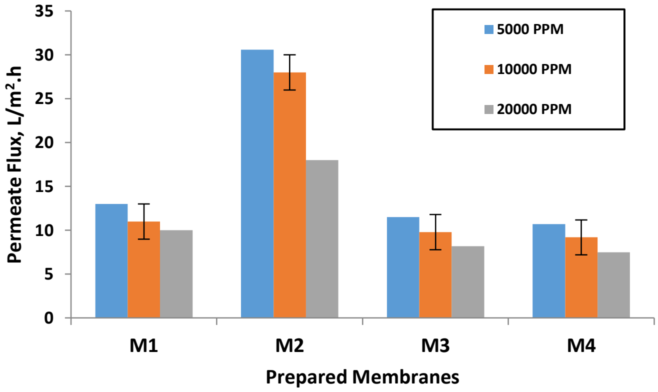

Figure1. Permeate flux of prepared membranes

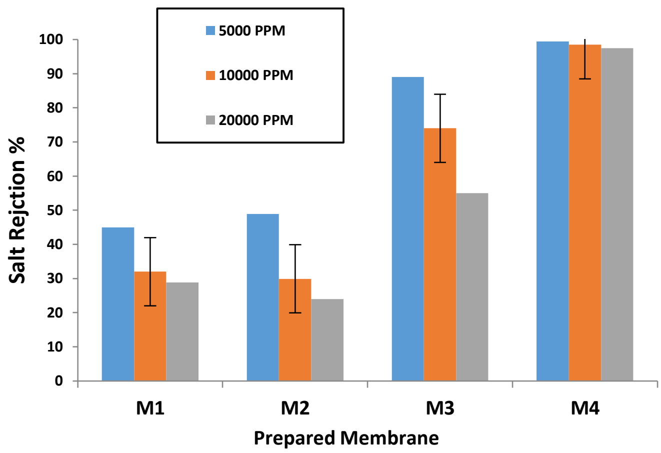

Figure 2. Salt rejection of prepared membranes

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