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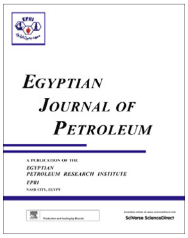

FULL LENGTH ARTICLE

Development of polyamide-6/chitosan membranes for desalination

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Abstract This article deals with "developing novel polyamide-6/chitosan membranes for water desalting using wet phase inversion technique", in which novel polyamide-6/chitosan membranes were prepared using an appropriate polymer concerning the national circumferences, along with the definition of different controlling parameters of the preparing processes and their effects on the characteristics of the produced membranes. Further, evaluation process of the fabricated sheets was undertaken. Preparation process was followed by assessment of the membrane structural characteristics; then the desalting performance of each prepared membrane was evaluated under different operating conditions in order to find the structure–property relationship. The results show that the membrane flux increases with the increase of operating pressure. The salt rejection and permeation flux have been enhanced this indicates that the chitosan (CS) addition to the polyamide-6 (PA-6) membrane increases the membrane hydrophilic property. Hydraulic permeability coefficient is not stable and varies considerably with the operating pressure.

1. Introduction

The need for fresh clean water is growing rapidly due to the world population growth, industrial expansion and deterioration of fresh water supplies. Needs for drinking water with appropriate qualities are continuously increasing around the world. At the same time, the available drinking water quantities are going down. The development of commercial reverse osmosis seawater desalination membranes has been of great influence on the development of flat sheet membranes [1–4]. Asymmetric membranes are the most interesting for industrial applications such as in reverse osmosis membrane, nanofiltration, ultrafiltration and microfiltration. As they consist of a thin dense layer in the top region in addition to porous supporting layer.

In the field of water treatment, reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF) and microfiltration (MF) membranes have been increasingly used. The evolution of membrane technology can be categorized into two specific avenues; the first is reverse osmosis and nanofiltration technologies and the second ultrafiltration and microfiltration technologies. The membrane research and development efforts

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have paved the way to a new family of future products and applications [5–8].

Generally, the asymmetric membrane structure can be obtained using different materials by phase inversion or in composite systems by forming a thin dense layer. Many commercial polymeric membrane materials such as polyimide-6 (PA-6), polyimide-66 (PA-66), polysulfone (PS), polyethersulfone (PES), polyvinylidene difloride (PVDF) and polypropylene (PP) have good chemical, thermal and mechanical stabilities [9,10]. However, they usually lack reactive functional groups on the polymer backbones. Hence, membranes prepared from their materials have to be modified to eliminate the non-specific type of absorption and to enhance efficiencies through improved adsorptive surfaces. Tsai et al. and Ghosh et al. [11,12] reported that, good separation of membranes need many polymer modification technologies which have been applied to improve it. In order to control the membrane structure, low molecular weight component (as inorganic) or the secondary polymer is frequently used as the additive in the membrane forming system because it offers a convenient and effective way to develop high performance membranes [13]. More recently, some of researches are concerning that issue with investigation number of methods such as blending, coating, grafting, and surface treatment. These processes involve obtaining new structural materials that are extremely attractive and inexpensive. Polymer blending process has been found to be an effective way to overcome the shortcomings of the polymeric membrane, because blending at the microscopic level due to the chemical interactions may form additional chemical bonds [9]. Also, membrane preparations with surface functional groups that may be applied as adsorptive sites for the separation are of great interest in industrial and environmental applications.

Chitosan is one of the promising membrane materials and has been widely studied due to its hydrophilicity [14]. Recently, blending chitosan with other polymers has been found to be an effective way to overcome the shortcomings of chitosan [15–18]. Most commercially available membranes are synthesized using surface modification to get affinity or adsorptive properties [7,19,20]. Adsorptive membranes have reactive functional groups on the surfaces, including –COOH, –SO3H, and –NH2 groups, that can bond the targeted substances through specific interactions such as surface complexation or ion exchange. The adsorptive membranes have many unique advantages, including fast separation rates, high efficiencies, good selectivities, low energy requirements and, possibly, large permeate flux [21,22]. These materials provide excellent binding capacities because chitosan molecules have both amino and hydroxyl groups that can be used to couple with ligands under mild conditions. Juang et al. [23] reported the preparation of chitosan membranes blended with poly(vinyl alcohol) (PVA) and their good mechanical properties by virtue of their specific intermolecular interactions between PVA and chitosan in the blends. Also, they showed that blending chitosan with other high strength polymers, for example PVA or its derivatives, is an attractive way to prepare adsorptive membranes for practical applications.

So, in our research PA-6 has been used as the polymer matrix and CS as the functional polymer to provide hydroxyl gropes and additional amine groups for the flat sheet PA-6 membrane in order to make it adsorptive. The choice of PA-6 as the polymer matrix is due to its long-known good chemical and thermal stability also, it has mechanical strength in fabricating flat sheets. Formic acid has been used as the solvent for PA-6 and CS to prepare the casting solution and water has been used as coagulant.

This study deals with preparing polyamide-6/chitosan (PA/CS) membranes for water desalting via casting technology. Evaluation process of the casted sheets was undertaken. Preparation process was followed by assessment of the membrane structural and morphological characteristics; then the desalting performance of the prepared membranes were evaluated under different operating conditions in order to find the structure–property relationships.

2. Experimental

2.1. Material

The following Chemicals have been used: polyamide-6 (PA-6) with bulk density 0.25 gm/ml and particle size 50–160 μm (Fulka Company Switherland, the molecular weight of PA-6 is not given); Formic acid (FA) with MW: 46.03 g/mol, density: 1.198 gm/cm^3 at 20 and 100.7 °C boiling point (El-Naser pharmaceutical Chemicals Company, Egypt).

2.2. Membrane preparation

Membrane preparation steps as presented in Fig. 1 include the preparation of casting solutions using PA-6 (16 wt.%), chitosan (1–2) wt.% as additive and formic acid (82–84) wt.%.

The casting solutions are then casted into glass plates by using doctor blade with drawdown thickness up to 200 μm for 1 min. The casted films are immersed into a coagulating bath containing pure water at temperature 18 °C for 60 min. The glass plates are then immersed into washing bath containing pure water at temperature 25 °C. The flat sheets membranes formed are stripped from the carrier, and then the

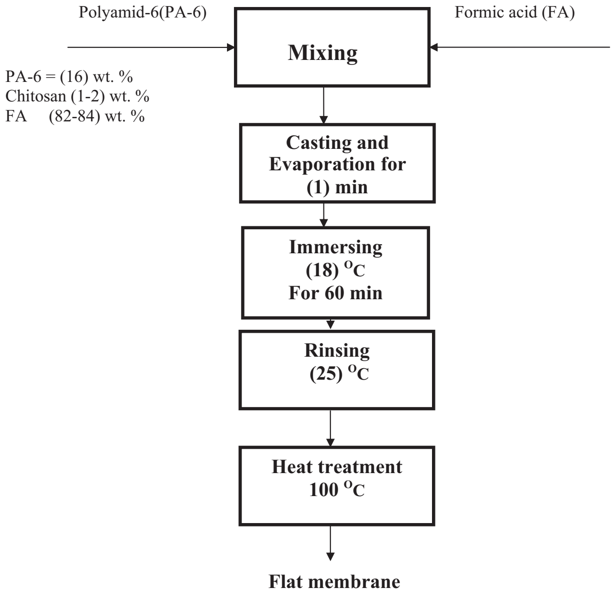

Figure 1 Process Flow Diagram for the Preparation of PA-6/chitosan membranes.