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REVIEW

Alteration of polyethersulphone membranes through UV-induced modification using various materials: A brief review

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Abstract Polyethersulphone (PES) membranes have been widely applied in various separation applications such as microfiltration, ultrafiltration and nanofiltration. This has occurred as these membranes are easy to form, have good mechanical strength and good chemical stability (resistant to acidic or alkaline conditions) due to the presence of aromatic hydrocarbon groups in the structure. PES membranes are commonly fabricated through the phase inversion method due to the simplicity of the process. However, PES membranes are generally hydrophobic, which usually requires them to be modified before application. In most cases, these methods can reduce the hydrophobicity of the membrane surface and thus reduce membrane fouling during application. This review will further discuss the recently developed UV-induced modifications of PES membranes. The UV-induced grafting method is easy to apply to existing PES membranes, with or without the need for a photo-initiator. Additionally, nanoparticles entrapped in PES membranes subsequently exposed to UV-irradiation have been reported to possess photo-catalytic activity. However, UV-irradiation methods still require special care in order to produce membranes with the best performance.

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Contents

1. Introduction

In the last few decades, with increasing population and urbanisation, the huge amount of wastewater produced has become a great concern for many countries. These concerns need a more efficient and high quality technique for the treatment of wastewater. Polymeric membranes are the most recognised materials used in various separation processes (Robeson, 2012) due to their effective separation performance and lower production or maintenance costs in comparison with inorganic materials such as ceramic and metallic-based membranes. Types of well-known polymeric membrane materials used and investigated in depth include polysulphone (Abu-Thabit et al., 2010; Homayoonfal et al., 2010; Li et al., 2012; Namvar et al., 2013; Prakash et al., 2008; Shah and Murthy, 2013; Sueyoshi et al., 2012; Yoo et al., 2003), cellulose nitrate (Shieh and Chung, 2000; Soylak and Cay, 2007; Sun et al., 2007), polyvinyl chloride (Hu et al., 2011; Wenjuan et al., 2011; Xia et al., 2010, 2011; Zhang et al., 2009), polyvinylidene fluoride (De Gusseme et al., 2011; Feng et al., 2008; Puspitasari et al., 2010; Souzy et al., 2012; Venault et al., 2012b), polyvinyl alcohol (Han et al., 2008; Liu et al., 2013b; Singha et al., 2009; Wu et al., 2006; Zhang et al., 2006), cellulose acetate (Lv et al., 2007; Sossna et al., 2007; Zavastin et al., 2010), polyethersulphone (Cao et al., 2010; Fang et al., 2009; Qian et al., 2009; Rahimpour and Madaeni, 2010; Susanto et al., 2009; Zhao et al., 2011), and so forth. Most of the time, these polymeric materials are suitable to be applied in pressure-driven applications, for instance reverse osmosis, nanofiltration, ultrafiltration, microfiltration, dialysis and in some circumstances pervaporation.

To be used for long-term pressure-driven liquid-based separation processes, polymeric membrane materials should possess properties such as excellent mechanical or tensile strength, good anti-fouling resistance, high selectivity, high permeability and good control of the pore size distribution over the entire membrane surface area (Akar et al., 2013). This reduces the production and maintenance costs over the long term (Strathmann, 2001) and ensures sustainability. Thus, researchers have been working on modifying and improving various polymeric membranes for better tensile strength(Lin et al., 2009; Seol et al., 2007), better fouling resistance (Li et al., 2009; Liu et al., 2009; Mansourpanah et al., 2009; Peeva et al., 2010), higher rejection or selectivity (Ben-David et al., 2010; Cano-Odena et al., 2011; Li et al., 2007; Malaisamy et al., 2011) and higher flux or permeability (Shen et al., 2011a; Susanto et al., 2009; Yu et al., 2010; Zou et al., 2011). Polymeric membranes have some physical and chemical disadvantages in comparison to inorganic materials such as low resistance towards oxidising agents and pH-dependent performance (Van Wagner et al., 2009; Wang et al., 2011; Zhai et al., 2003), and they usually cannot withstand long-term exposure to a high temperature which causes deterioration of the polymeric structures. Polymeric membranes which are resistant to acids (Tanninen et al., 2004), bases, solvents (Vandezande et al., 2008), oxidising agents (such as hydrogen peroxide, chlorine (Glater et al., 1994), fluorine, and so on), pressure-induced compaction, and extreme temperature (Deligöz and Yilmazoglu, 2011; Jun et al., 2011) could be an added benefit and advantage for polymeric membranes to be well-commercialised and applied in various fields.

Polyethersulphone (PES) membranes have been focused on in this review due to their recently increased popularity in the polymeric membrane research field. PES membranes have been fabricated, applied and modified for microfiltration, ultrafiltration and nanofiltration purposes.

In microfiltration (MF) application, researchers employed gamma-ray irradiation during the grafting of PES powder with acrylic acid (Deng et al., 2008). They prepared the membranes using the modified PES powder with different degrees of grafting (DG) through phase inversion method. They confirmed that the water permeability and porosity of the produced MF membranes increased with an increase in DG. Besides, they also reported that the properties of produced MF membranes (using modified PES powder) were highly dependent on the pH value of the aqueous solution. The increased degrees of swelling and decreased flux were reasoned with enhanced ionisation of grafted polyacrylic acid side chains in elevated pH value of aqueous solution. PES MF membranes were also produced using N-methyl-2-pyrrolidone (NMP) and 2-methoxy ethanol (2-ME) non-solvent as an additive in the casting solution (Shin et al., 2005). In this specific work, vapour-induced phase inversion and non-solvent induced phase inversion were employed during the membrane preparation. The non-solvent additive and the exposure time at the relative humidity of 74% were found to have significant effects towards the membrane porosity. High performance PES MF membranes with a high flux and stable hydrophilic property were also produced using induced phase separation coupled with non-solvent induced phase separation method (Susanto et al., 2009). It was observed that the non-solvent content (tri-ethylene glycol) and the exposure time were important to obtain high-flux membranes, whereas the Pluronic was important in improving the membrane surface hydrophilicity.