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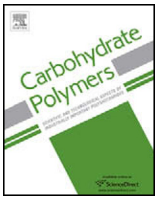

Review

Recent advances in cellulose and chitosan based membranes for water purification: A concise review

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ABSTRACT

Recently membrane technology has emerged as a new promising and pervasive technology due to its innate advantages over traditional technologies such as adsorption, distillation and extraction. In this article, some of the recent advances in developing polymeric composite membrane materials for water purification from natural polysaccharide based polymers namely cellulose derivatives and chitosan are concisely reviewed. The impact of human social, demographic and industrial evolution along with expansion through environment has significantly affected the quality of water by pollution with large quantities of pesticides, minerals, drugs or other residues. At the forefront of decontamination and purification techniques, we found the membrane materials from polymers as a potential alternative. In an attempt to reduce the number of technical polymers widely used in the preparation of membranes, many researchers have reported new solutions for desalination or retention of organic yeasts, based on bio renewable polymers like cellulose derivatives and chitosan. These realizations are presented and discussed in terms of the most important parameters of membrane separation especially water flux and retention in this article.

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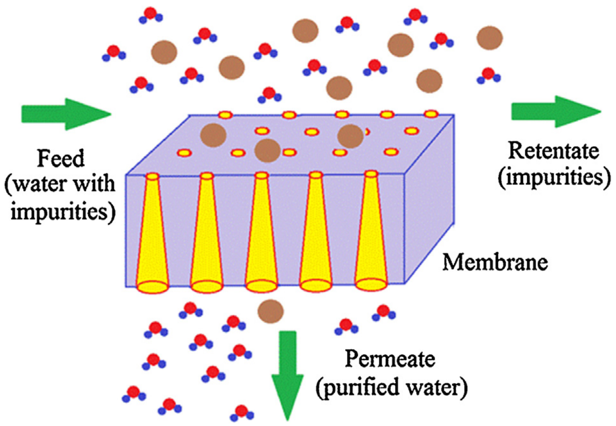

Fig. 1. Schematic representation of an asymmetric polymeric membrane and principle for separation.

1. Introduction

1.1. Membrane technology

Membrane technology has emerged as a new promising and pervasive technology for water purification due to its innate advantages over traditional technologies such as adsorption, distillation and extraction (Eminoglu, Beypinar, Kahraman, & Durmus, 2015; Mondal & De, 2015; Said et al., 2015). Indeed due to the human social, demographic and industrial evolution and expansion, the need for drinkable and pure water sources has become a major challenge (Pappu et al., 2015; Thakur & Thakur, 2014c, 2015). In the last few years, the impact of human activities to environment has affected the quality of water by polluting with large quantities of pesticides, minerals, drugs or other residues (Mondal & De, 2015; Zhao, Cheng et al., 2015; Zhao, Liu et al., 2015; Thakur, Vennerberg, & Kessler, 2014; Thakur & Kessler, 2015). So new technologies and materials are being researched for water purification. Different kinds of membranes from polymers are such potential materials and the membrane technology is one such technology at the first line of decontamination and purification techniques. (Khalil, Sheha, Hanafy, & Al-Hartomy, 2014; Ferreira et al., 2014Ferreira, Caridade, Mano, & Alves, 2014; He et al., 2015). A membrane, by definition is a selective barrier for a certain species of particles, molecules, ions from a complex mixture (or solution) (Zhao, Cheng et al., 2015; Zhao, Liu et al., 2015; Rahimnejad, Bakeri, Ghasemi, & Zirepour, 2014). A schematic representation of a polymeric membrane and principle of use is represented in Fig. 1(a). The feed solution (which contains the species to be removed) passes through the membrane and the impurities are retained at the surface of the material. The separation occurs due to the average diameter of pores which do not allow the species over a certain dimension to pass (Li et al., 2014). As a function of species dimensions, there are several known membrane processes that include conventional filtration, microfiltration, ultrafiltration, nanofiltration and reverse osmosis. In terms of water purification, the main role of each process can be summarized as following:

- Conventional filtration membranes separate eye-visible particles, like sand particles;
- Microfiltration membranes separate particles with dimensions between 0.1 and 10 μm, like microorganisms;
- Ultrafiltration separate membranes particles with dimensions between 10 and 1000 Å, like macromolecules or colloids;
- Nanofiltration and reverse osmosis membranes separate salts and ions.

Due to their unique property of selective separation, the membranes have found their use in various domains like biomedicine, food industry, electronics, and sensors (Jiang, 2014; Sivakumar et al., 2014; Stamatialis et al., 2008). In biomedicine, they are used as controlled drug delivery systems (Stamatialis et al., 2008)—osmotic systems (Wright et al., 2001), transdermal patches (Guy, 1996) or ocular patches(Jain, Carvalho, & Banerjee, 2010) or artificial organs as replacements for kidney (Sasaki, 2006) in the case of patients with chronic kidney disease, artificial liver or lung(Kobayashi, Okitsu, Nakaji, & Tanaka, 2003). The use of technical polymers in the preparation of membranes is preferred due to the versatility in the properties of these polymers. Intensively studied polymers for the membrane preparation includepolysulfone, polyether sulfone, polyethylene, polyimide, poyetherketone, polyphenylene oxide and polyphenylene sulphate (Akther et al., 2015; Choudalakis & Gotsis, 2009; Ravanchi, Kaghazchi, & Kargari, 2009; Pendergast & Hoek, 2011).

1.2. Synthesis of polymeric membranes

There are several methods that can be effectively used for the synthesis of polymeric membranes, the most important being the precipitation of the polymer from a polymeric solution film in the presence of a non-solvent for the polymer totally miscible with the polymer solvent (Voicu et al., 2007). This process is called phase inversion technique and has a significant importance because of the type of membranes that are obtained during this technique. Depending on the geometry of pores, the membranes can be classified in symmetric and asymmetric (Voicu et al., 2009). The symmetric membranes have cylindrical pores with a poor value in separation techniques. The asymmetric ones have pores with conic geometry and are the most suitable for separation processes. At asymmetric membranes, during the formation of porous polymeric film, large quantities of polymers are concentrated at the top surface of the membrane, with very small pores. This layer being the active layer of the membrane play a crucial role in the separation process. The active layer is very resistant at pressure and is sustained by large porous support layer. The geometry in section of an asymmetric and a symmetric membrane is presented in Fig. 2 (Baicea et al., 2011; Voicu, Aldea, & Nechifor 2010).

1.3. Composite membranes

For improving the separation performances, one of the foremost possibilities refers to the synthesis of composite membranes (Luntraru et al., 2011. The fillers(graphene, carbon nanotubes, magnetic particles, fullerenes, TiO_2, zeolites, etc.) which are added to the polymer play an active role in the separation process (Cho et al., 2014; Jafarzadeh, Yegani, & Tantekin-Ersolmaz, 2015;Chen, Hong, & Gao, 2015). In this case, the membrane act more as a support, membrane pores facilitating the access of solute to active separation centres of filler. Another types of composite membranes can be obtained by coating a membrane support with a very thick film which acts as an active layer. The advantage of this method is given by the fact that the coating can be usually crosslinked, so the resulting material can also be used for the filtration of solutions made in organic solvents (solvent resistant nanofiltration membranes) (Corobea et al., 2015; Rusen et al., 2014; Ionita, Vaslie, et al., 2015; Voicu et al., 2013). The parameters which give the efficiency of membrane associated to a separation membrane process are water (solvent) flux and retention. The water flux is the quantity of water that can pass through the membrane in time. It is usually expressed in L/m^2h and indicates for which membrane processes, the porous obtained material is more suitable (microfiltration, ultrafiltration, nanofiltration or reverse osmosis). Retention expresses the capacity of membrane to retain on its active layer and the solute represents