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Evaluating molecular weight of PVP on characteristics of CTA membrane dialysis

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ABSTRACT

The polymer inclusion membranes used for the selective transport and separation of metal species have emerged in recent years. Their development depends on the method of preparation and the study of their intimate structure.

In this work, we have developed a novel class of cellulose triacetate (CTA) membranes modified by poly-electrolytes incorporation that are selectively permeable to metallic ions.

The effect of molecular weight of Polyvinylpyrrolidone (PVP) as additive on morphology and transport performance of (CTA) membrane was studied in this work. Diverse CTA membranes have been developed. PVP at different molecular weight (10,000, 24,000 and 40,000) was noted, respectively, (PVPk10, PVPk25 and PVPk30) and Polyethylene glycol (PEG (2000)) were used to modify the morphology and performance of membranes based CTA. The membranes have been prepared by dissolving amounts of CTA, PVP and PEG in Chloroform. The films obtained after solvent evaporation were characterized by thermogravimetric analysis (TGA), Fourier Transform infrared spectroscopy (FTIR) and scanning electron microscopy (SEM). It was found that the degradation of the membranes is done in two steps. The first one starts at 250 °C due to thermal degradation of the polymeric chains. The SEM image shows that the porosity decreases with increasing of molecular weight of PVP. The influence of the molecular weight of PVP in performance of membranes was examined by application of dialysis process using cations solution containing Cd^{2+}, Cu^{2+}, Ni^{2+} and Zn^{2+}. The membrane containing PVPk10 showed better efficiency compared to the other ones.

1. Introduction

The risks caused by heavy metals pollution due to their toxic nature, their no-biodegradability and their accumulation in food are very important [1,2]. Conventional techniques such as sorption and chemical precipitation were used for the removal of these metal ions from aqueous effluents [3–5], however, these techniques are unable to reduce the concentration to the level required or have a high cost. The use of membrane processes in water treatment containing toxic metal ions are attractive and suitable techniques, since they propose separating metals without state change or the use of chemical or thermal energy [6,7]. Cadmium, copper, lead, mercury, nickel and zinc are considered as the most dangerous heavy metals [8].

Dialysis was applied since 1861 and was used as a laboratory technique for the purification of small amounts of solutes [9]. In recent years, research on dialysis membranes were focused primarily on the characteristics and various properties of these membranes such as sieving properties, permeability, the distribution and size of pores [10–13]. Membranes based polymer were used for dialysis process in several cases, cellulose acetate and cellulose triacetate were used as basis material to dialysis membranes for their efficiency [14–18], their permselectivity and physical properties such as resistance, flexibility [19,20], biocompatibility [21] and a low cost [22]. Several parameters were verified on the membranes forming mechanism including the polymer concentration in the initial solution and the presence of some additives on the morphology and permeability of these membranes [23–25].

Modification of surface state and separation properties was used to improve the membrane performances based on polymers by introducing new modifiers such as polyethylene glycol (PEG) and polyvinylpyrrolidone (PVP). Additives are the main factors and have a great role in the formation of the membrane, by enlarging or

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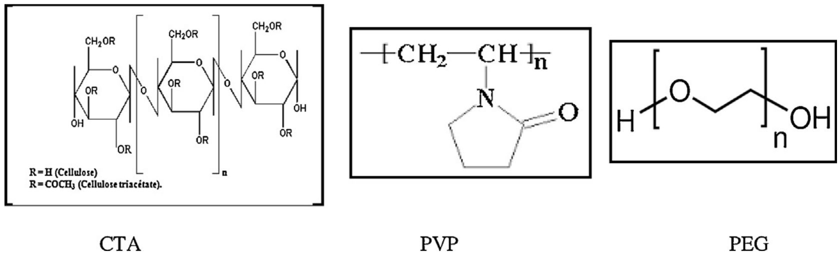

Fig. 1. Chemical formula of CTA, PVP and PEG polymers.

removing the formation of pores, improving the interconnection of pores and permeation properties and/or introducing hydrophilice [26–31]. Studies of improvement of performance of CTA and CA membranes were made in our previous works by adding plasticizers or other additives such as PEG, PEI and PVP [32–35].

Membrane based Cellulose acetate (CA) polymer was prepared by Saljoughi et al. [36,37]. PEG was used as plasticizer as well as pore-forming agent to control thermodynamics and kinetics in the casting system. The effect of CA and PEG on morphology and performance of the membrane forming was studied. Various combinations of CA and polyethylene glycol (PEG) concentrations and distilled water bath temperature were chosen and their effects on the membrane morphology in terms of membrane thickness and cross section structure, and also pure water permeation flux of the membranes were discussed. The effects of PVP and PEG additives in cellulose acetate membrane performance were studied by Wen Jen Lin and G. Shiue [38]. Different composition of CA/PVP and CA/PEG were used for membranes preparation. The same membranes were used by Arthanareeswaran et al. [39] to the removal of heavy metals such as Cu(II), Zn(II), Co(II) and Cd(II). They found that heavy metals can be separated and concentrated after ultrafiltration.

Polymeric membrane system with complexing properties has been examined in our previous works for the separation and concentration of (Ag^{+}, Cu^{2+}, Pb^{2+} and Ni^{2+}) [40], poly-4-vinyl-pyridine has been incorporated in CTA-TEHP membrane giving rise to the separation of ions according their hydrophilic and hydrophobic balance and protonation ratio of nitrogen group of polymer. This concept has been extensively developed by our group when polyethyleneimine was used as chelating agent at the interface of membrane/aqueous solution [34]. This polymer has been chosen since it exhibits an interesting change in the conformation according to pH and concentration in solutions, this change is strongly dependent of pH medium and concentration which cause interaction between amine and ammonium groups of partially protonated sites.

They observed that the membrane is selective for Cu^{2+} and this selectivity decreases in the quaternary system. Yamazaki et al. [41] studied the internal structure of CTA dialysis membranes. They found that the pore diameters on the inner surface of the CTA membranes were much greater than those on the outer surface. Yahia Cherif et al. [42] have developed membranes based on cellulose triacetate modified by polyelectrolytes such as (poly-phosphoric acid, polyacrylic acid, polyvinyl alcohol and poly-anetholsulfonic acid) and plasticizers for the cations separation. Transfer of nitrate ions using a polymeric-surfactant membrane was recently studied in our previous works [43]. CTA was used as basic polymer, PVP as additive and polysorbate as plasticizer. It has been found that the presence of HCl in feed compartment permitted the transference of nitrate ions.

Physicals and chemicals characteristics of polymer membranes were studied by several methods such as Fourier Transformer Infra Red spectroscopy (FTIR), Scanning Electron Microscopy (SEM), Thermo Gravimetric Analysis (TGA) and contact angle [44–46].

In this work, three membranes were prepared by dissolving CTA in chloroform. PVP with different molecular weight and PEG2000 were used as additives in the CTA-chloroform solutions. The films obtained after solvent evaporation were characterized by Fourier Transform infrared spectroscopy, thermo-gravimetric analysis, and scanning electron microscopy. The performance of these membranes was elucidated by application of dialysis process for solution containing a mixture of metallic ions.

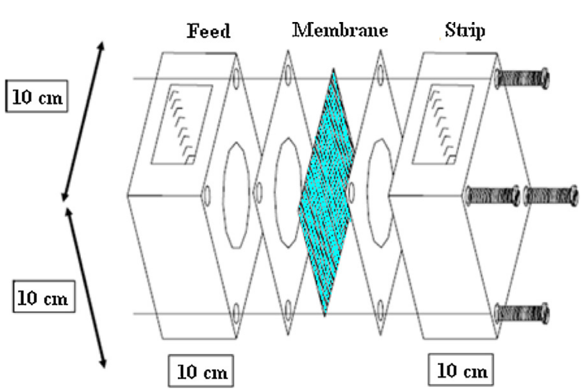

Fig. 2. Dialysis cell scheme.

2. Experimental part

2.1. Chemicals

Cellulose triacetate (CTA 72000–74000 g/mol), polyvinylpyrrolidone (PVP (K10; K25 and K30)) and polyethylenglycol (PEG2000) (Fig. 1) with analytical grade reagents obtained from Fluka

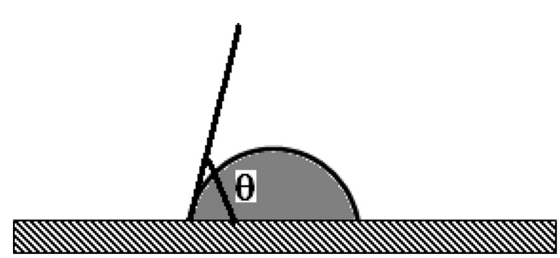

Fig. 3. Describing contact angle procedure. The angle can vary from 0° to 180°.