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# Cellulose acetate (CA)/polyvinylpyrrolidone (PVP) blend asymmetric membranes: Preparation, morphology and performance

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ABSTRACT

Cellulose acetate (CA) membranes are widely used for reverse osmosis (RO) and ultrafiltration (UF) applications. In this study, asymmetric CA membranes were synthesized using phase inversion method. CA with molecular weight of 52,000, polyvinylpyrrolidone (PVP) with molecular weight of 15,000 and 1-methyl-2-pyrrolidone (NMP) were used as polymer, additive and solvent, respectively. The effects of PVP concentration (at 0, 3 and 6 wt.%) and coagulation bath temperature (CBT at 0, 25 and 50 °C) on morphology, contact angle and permeability of the prepared membranes were studied and discussed. It was found out that the effects of PVP concentration and CBT depend on their values.



## 1. Introduction

Nowadays membrane processes are needed for the wide spectrum of separations including supply of high-quality water for domestic and industrial demands to obtain high-grade products and removal or recovery of toxic or valuable components from various industrial effluents [1–4].

The phase inversion process induced by immersion precipitation is a well-known technique to prepare asymmetric polymeric membranes [5–10]. In this technique, a cast film containing a polymer and its suitable solvent is immersed into a coagulation bath containing a non-solvent (material with high and low affinity to the solvent and the polymer, respectively). Then precipitation starts due to the low miscibility between the polymer and the non-solvent. Simultaneously, the high miscibility between the solvent and the non-solvent causes their diffusional flow (the exchange of solvent and non-solvent) in several points of the film top layer and the film sub layer which subsequently leads to formation of nucleuses of polymer-poor phase. In fact, the low affinity between CA chains and water molecules, at points that water molecules diffuse, results in repelling of the polymer chains and consequently formation of nucleuses of polymer-poor phase. Due to continuation of the diffusional flow of solvent and non-solvent, the mentioned nucleuses continue to grow until the polymer concentration at their boundaries becomes too high so that solidification occurs (demixing process completes) [2,5].

Rate of the demixing process affects morphology of the CA membranes. Instantaneous demixing often leads to macrovoids formation in the membrane structure, while slow demixing results in denser structure. In the case of slow demixing, nucleation occurs after a certain period of time and polymer concentration increases in the film top layer. Then nucleation starts in the inferior layer at short time intervals, successively. Hence, size and composition of the nucleuses in the former layer are such that new nucleuses are gradually formed in their neighborhood [5]. In other words, in slow demixing, free growth of limited nucleuses (in the film top layer) is prevented and a large number of small nucleuses are created and distributed throughout the polymer film. Consequently, contrary to instantaneous demixing, macrovoids formation is suppressed and denser membranes are synthesized [2].

A wide range of parameters have been checked concerning the membrane formation mechanism and consequently the membrane morphology and permeability such as polymer concentration in casting solution [11], type of solvent/non-solvent pair [12], cast film thickness [13], presence of certain additives [14], CBT [15] and presence of some other solvents [16]. It seems that the above parameters have significant effects on the instantaneous/delayed demixing process that takes place in the coagulation bath during the membrane formation process.

It is evident that advances in membrane technology, particularly for waste water purification, can be obtained by better understanding of the effects of the above mentioned parameters on the membrane morphology and permeability. Two major parameters seem to be the presence of additive and CBT. There are not many published literature regarding investigation of their effects, particularly effect of CBT, on membrane formation mechanism and consequently membrane

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