Effects of Coagulation Bath Temperature and Polyvinylpyrrolidone Content on Flat Sheet Asymmetric Polyethersulfone Membranes

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In this study, effects of coagulation bath temperature (CBT) and polyvinylpyrrolidone (PVP K15) concentration as a pore former hydrophilic additive on morphology and performance of asymmetric polyethersulfone (PES) membranes were investigated. The membranes were prepared from a PES/ethanol/NMP system via phase inversion induced by immersion precipitation in a water coagulation bath. The morphology of prepared membranes was studied by scanning electron microscopy (SEM), contact angle measurements, and mechanical property measurements. Permeation performance of the prepared membranes was studied by separation experiments using pure water and bovine serum albumin (BSA) solution as feed. The obtained results indicate that addition of PVP in the casting solution enhances pure water permeation flux and BSA solution permeation flux while reducing protein rejection. Increasing CBT results in macrovoid formation in the membrane structure and increases the membrane permeability and decreases the protein rejection. POLYM. ENG. SCI., 50:885–893, 2010.

INTRODUCTION

Since Loeb and Sourirajan first introduced the phase inversion method [1], much investigation has been made for understanding the mechanism of asymmetric membranes formation. Phase inversion is the most extensively used technique for preparation of asymmetric membranes. In this process, a casting solution is cast onto a suitable support by using a casting knife, and then immersed into a coagulation bath. Subsequently, phase inversion occurs by exchange of solvent and nonsolvent across the interface between casting solution and coagulation bath [2]. It is well known that the formation of asymmetric membranes depends on kinetic parameters such as exchange rate between solvent and nonsolvent and kinetics of phase separation, as well as thermodynamic parameters such as polymer-solvent interactions, solvent/nonsolvent interactions, and interfacial stability [3]. Thus, the materials selection such as polymers, solvents, and nonsolvents is very important for fabrication of membranes, according to their application [4]. Asymmetric membranes are characterized by a thin and dense skin layer on top of a porous substructure. The thin top layer plays a role of selective barrier, and the porous sublayer, which includes macrovoids, pores, and micropores, offers good mechanical strength [5]. Macrovoids are often observed in asymmetric microfiltration (MF) and ultrafiltration (UF) membranes made by the phase inversion process. However, their presence must be avoided for high-pressure operations such as gas separation and reverse osmosis because they can be weak points leading to membrane collapse of the membranes. Therefore, there were reported many studies for the macrovoid formation mechanism as well as the methods to depress macrovoids [6–10]. A wide range of parameters have been checked concerning the formation of macrovoids, such as polymer concentration in the casting solution [11], type of solvent/nonsolvent pair [12], presence of certain additives [13], coagulation bath temperature [14], and presence of some other solvents [15]. It is possible to avoid the formation of macrovoids in immersion precipitation membranes by addition of a specified quantity of nonsolvent additive (NSA) to the polymer solution. Various aspects of the choice of NSA and its effects on the polymer solution properties and structures of the resulting membranes were investigated so far [16–18]. In order to control the membranes structure in membranes fabrication by phase inversion process, it is common to add low molecular weight components. Also, a secondary polymer is frequently used as an additive in the membrane forming system because it offers a convenient and effective way to develop high performance membranes [19, 20]. Water soluble polymers such as polyvinylpyrrolidone (PVP) [9, 21] and polyethyleneglycol (PEG) [6] have been used frequently to study the effects of polymer additives. PVP, as a nontoxic material, has been used for biomedical applications. It is one of the good polymer additives because PVP is miscible with membrane materials and is quite well soluble in water as well as other solvents. During the phase inversion process, it is assumed that the hydrophilic additive, PVP, is dissolved out by water and the sites where PVP exists become micropores. Several researchers have reported that

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DOI 10.1002/pen.21603
Published online in Wiley InterScience (www.interscience.wiley.com).