



# Effects of Tween 80 concentration as a surfactant additive on morphology and permeability of flat sheet polyethersulfone (PES) membranes

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## ABSTRACT

In this study, effects of Tween 80 (polyoxyethylene sorbitan monooleate) as a variable hydrophilic surfactant additive on morphology and permeability of flat sheet polyethersulfone (PES) membranes prepared from PES/polyethylene glycol (PEG)/n-methyl-2-pyrrolidone (NMP) system via phase inversion induced by immersion precipitation in water coagulation bath were investigated. Cross-sectional morphology of the prepared membranes was studied by scanning electron microscopy (SEM). Permeation performance of the prepared membranes was evaluated in terms of pure water permeability ( $L_p$ ), water content, porosity, hydraulic permeability and thickness of the prepared membranes. It was found out that little addition of Tween 80 to the casting solution increases water content and porosity of the membrane support layer and enhances pure water permeability through the membranes.

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## 1. Introduction

Nowadays membrane processes are needed for a wide spectrum of separations including supply of high-quality water for communities and industries (to remove surfactants [1–3], microparticles and macromolecules, organic colloidal, dissolved organic matters (DOM) [4,5] etc.), food and pharmaceutical industries to obtain high-grade products, and removal or recovery of toxic or valuable components from various industrial effluents [6]. The phase inversion is the most extensively used technique for preparation of asymmetric membranes, in which cast solution film on a substrate is immersed in a coagulation bath for precipitation. During the process, solvent in the cast solution film is exchanged with non-solvent and phase separation occurs in the film [7]. It is well known that the formation of asymmetric membranes depends on kinetic parameters such as exchange rate between solvent and non-solvent and kinetics of phase separation, as well as thermodynamic parameters such as polymer–solvent interactions, solvent–non-solvent interactions and interfacial stability. Thus, selection of materials such as polymers, solvents and non-solvents is very important for fabrication of membranes, according to their applications [8]. Membrane formation via the phase inversion technique is often accompanied by occurrence of large elongated pores, namely, macrovoids [9,10]. 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/non-solvent pair [12], casted thickness [13], presence of certain additives [14], temperature of coagulation bath [15] and presence of some other solvents [16]. In order to prepare a membrane with good penetration properties, introduction of suitable additives to the casting

solution is a convenient and efficient method. The additives may be water, inorganic salts, low molecular weight organics, surfactants, polymers, mineral fillers or a mixture of them and there are several mechanisms through which such additives can affect the final membrane properties [17–21]. Some researchers studied effects of natural additives such as maleic acid and piperazine on performance of PES ultrafiltration (UF) membranes [22]. Hydrophilic structure of the membranes are obtained by addition of additives such as glycerol, polyethylene oxide, LiCl and ZnCl<sub>2</sub>. Non-solvent additives such as methanol, ethanol, n-propanol, diethylene glycol and deionized water were used to prepare PES hollow fiber membranes [23,24] and their effects on separation properties of the membranes were investigated. Rahman et al. [25] studied the effects of Tetronic 1307 as a surfactant additive on morphology and performance of PES porous hollow fiber membranes and found that increasing the Tetronic 1307 concentration increases hydrophilicity of the membranes. Yamasaki et al. [26] and Alsari et al. [27] used sodium dodecyl sulphate as a surfactant additive in polysulfone (psf) casting solution for gas separation and as a gelation media in formation of PES membranes. The main purpose of this work was to investigate the effect of Tween 80 as a hydrophilic surfactant additive on morphology and performance of asymmetric PES membranes prepared from PES/PEG/NMP system via immersion precipitation in water coagulation bath.

## 2. Experimental

### 2.1. Materials

Polyethersulfone (PES Ultrason E6020P with  $M_w = 58,000$  g/mol) supplied by BASF was used as polymer for preparation of the

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