

Poly(vinylidene fluoride-co-hexafluoropropylene) (PVDF-co-HFP) Hollow Fiber Membranes Prepared from PVDF-co-HFP/PEG-600Mw/DMAC Solution for Membrane Distillation

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ABSTRACT: Poly(vinylidene fluoride-co-hexafluoropropylene) (PVDF-co-HFP) hollow fiber membranes were prepared by using the phase inversion method. The effect of polyethylene glycol (PEG-600Mw) with different concentrations (i.e., 0, 5, 7, 10, 12, 15, 18, and 20 wt %) as a pore former on the preparation and characterization of PVDF-co-HFP hollow fibers was investigated. The hollow fiber membranes were characterized using scanning electron microscopy, atomic force microscopy, and porosity measurement. It was found that there is no significant effect of the PEG concentration on the dimensions of the hollow fibers, whereas the porosity of the hollow fibers increases with increase of PEG concentration. The cross-sectional structure changed from a sponge-like structure of the hollow fiber prepared from pure PVDF-co-HFP to a finger-like structure with small sponge-like layer in the middle of the cross section with increase of PEG concentration. A remarkable undescribed shape of the nodules with different sizes in the outer surfaces, which are denoted as "twisted rope nodules," was observed. The mean surface roughness of the hollow fiber membranes decreased with an increase of PEG concentration in the polymer solution. The mean pore size of the hollow fibers gradually increased from 99.12 to 368.91 nm with increase of PEG concentration in polymer solution. © 2013 Wiley Periodicals, Inc. *J. Appl. Polym. Sci.* 129: 3304–3313, 2013

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INTRODUCTION

During the last decade, poly(vinylidene fluoride-co-hexafluoropropylene) (PVDF-co-HFP) has been recognized as an excellent material for preparation of membrane distillation (MD) membranes: it has an excellent thermal stability and chemical and abrasion resistance, and it is self-extinguishing and retains properties on aging.^{1–6} The most important characteristics of membranes desired for MD are pore size, pore size distribution, porosity, and membrane thickness. The permeation flux increases with increasing membrane pore size and porosity and decrease of the membrane thickness. Moreover, a narrow pore size distribution of the membrane avoids wetting of the large pore sizes, which leads to a decrease of the retention.⁷ Therefore, several researchers focused their work on improving the membrane specifications in order to enhance the MD performance by drastically altering the membrane morphology. For example, Feng et al.,^{1,2} studied the effects of LiCl and LiClO₄·3H₂O/tri-methyl phosphate as a pore-forming additive on the permeabil-

ity of PVDF-co-HFP membranes. They found that the additives increased the average pore size and porosity of the membrane, and thus, a higher permeate flux is attained. PVDF-co-HFP porous membranes were prepared from polyethylene glycol (PEG) serial additives by Feng et al.³ PVDF-co-HFP membranes exhibited high water permeability, but the dry membrane shows a low rejection in direct contact membrane distillation (DCMD) due to the existence of residual additives in the membrane matrix. Khayet et al.⁶ prepared PVDF-co-HFP membranes using different polymer concentrations, PEG-10kDa as additives, a range of coagulation temperatures, and solvent evaporation times for application in DCMD. They found that the fluxes increased with increase of the PEG concentration and decrease of the PVDF-co-HFP concentration, the coagulation temperature, and the solvent evaporation time. This result is attributed to large pore size, high porosity, low thickness, and high mean roughness.

Most researchers cited above have used different additives for the preparation of PVDF-co-HFP membranes such as poly(vinyl