REMOVAL OF DISSOLVED OXYGEN USING PVDF HOLLOW FIBER MEMBRANE CONTACTOR

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ABSTRACT

The removal of dissolved oxygen(DO) from water was studied using a poly(vinyliene fluoride)(PVDF) hollow fiber membrane contactor(HFMC) with the vacuum degassing process(VDP). Asymmetric porous PVDF hollow fiber membranes (HFM) for membrane contactor were prepared by a wet phase inversion method. In spinning of these PVDF hollow fibers, dimethy lacetamide (DMAc), LiCl and pure water were used as a solvent, a pore-forming additive and internal/external coagulant, respectively. The characteristics of the structure(pore size, porosity etc.) of the prepared PVDF HFMs as a function of concentration of pore-forming additive in polymer dope solution were studied. Also, the removal efficiency of DO from water according to flow rates of water, using PVDF HFMC with VDP, was studied. The performance of the asymmetric porous PVDF HFMC and a symmetric porous PP HFMC commercialized were compared. As a result, the asymmetric porous PVDF HFMC showed higher removal efficiency of DO than that of a symmetric porous PP HFMC.

INTRODUCTION

Recently, the removal of dissolved oxygen(DO) from water is needed to produce ultrapure water in many industry fields such as semiconductors, foods, pharmaceuticals and power industries. There have been conventional methods available to remove DO from water, such as physical methods(thermal, vacuum degassing and nitrogen bubble degassing) and chemical methods(addition of hydrazine or sodium sulphite etc.). However, since those techniques are complex and energy consuming, a hollow fiber membrane contactor(HFMC) process have been investigated as possible replacements lately. This process can offer significant opportunities of energy saving, as compared with conventional methods. Furthermore, this process can be integrated into other processes to enhance removal efficiencies. W.K.Teo et al. investigated removal of DO from water using membrane reactors, which had been fabricated by a microporous hollow fiber module packed with a catalyst in the void space[1]. A.Ito et al. reported the removal process of DO using a silicone rubber HFM module[2]. Others, researches on the removal of DO from water by using HFMC have been performed by many researchers[3-5]. In this study, we prepared an asymmetric porous PVDF HFM with various pore sizes by the phase inversion method. And we investigated the removal efficiencies of DO from water through HFMC according to structures of prepared PVDF HFM and flow rates of water using a vacuum degassing process. Further, we compared performances of the prepared PVDF HFMC and the symmetric porous PP HFMC commercialized.

RESULTS AND DISCUSSION

Preparation of PVDF HFM

Figure 1 shows the SEM photograph of the cross-section structure of the asymmetric porous PVDF hollow fiber membrane. It can be seen from Figure 1 that the long finger-like structures are formed near the inner skin layer and developed up to the center of the membrane wall. And the short finger-like structure formed near the outer skin layer of membrane slowly changed to a sponge-like structure at the center of membrane wall. Table 1 shows the characteristics of PVDF hollow fiber membranes. The average pore diameters decrease with increasing concentration of LiCl in the polymer dope solution. However, the effective surface porosities increase with increasing that.

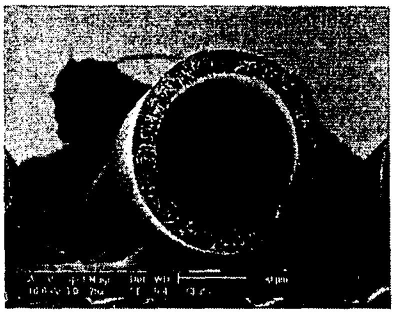


Figure 1. A SEM photograph of cross-section of the asymmetric porous PVDF hollow fiber membrane.

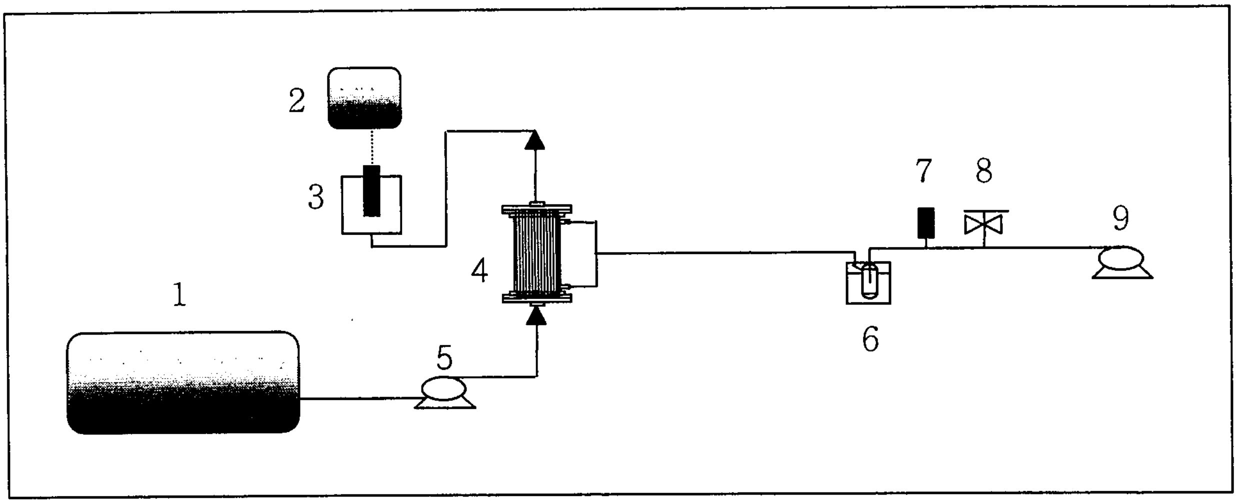
Table. 1 Dimensions of the PVDF hollow fiber membranes

additive	OD(μm)	r(m)[a]	ε/Lp(m^{-1})[b]
PVDF-1	660	2.70×10^{-8}	4.34×10^{3}
PVDF-2	613	4.21×10^{-8}	2.04×10^{3}
PVDF-3	590	9.27×10^{-8}	2.64×10^{2}

a : average pore size, b : effective surface porosity
* PVDF-1 : PVDF /LiCl / DMAc = 13/7/80wt.%
* PVDF-2 : PVDF /LiCl / DMAc = 15/5/80wt.%
* PVDF-3 : PVDF /LiCl / DMAc = 17/3/80wt.%

Removal of dissolved oxygen by PVDF HFMC

Figure 2 shows the apparatus used in this study. Figure 3 shows the removal efficiencies of DO according to the variation of the DO water flow rate. The removal efficiencies of DO from water decrease linearly with the increasing DO water flow rate. Figure 4 shows flux of oxygen through HFMC(Dimension; ID:20mm, Length:25cm, packing density:0.4) with the same surface area. The removal amount of DO from water increases with the increasing effective surface porosity of HFMC; or to say it in other words, with the increasing concentration of LiCl in the polymer dope solution. As compared to commercialized PP HFMC, PVDF-1 HFMC shows higher flux of oxygen per unit surface area of the membrane than that of PP HFMC



1. inner tank
2. dissolved oxygen meter
3. outer tank
4. membrane contactor
5. gear pump
6. cold trap
7. pressure transducer
8. vacuum regulator
9. vacuum pump

Figure 2. Schematic of experimental apparatus for oxygen removal from water using a hollow fiber membrane contactor.

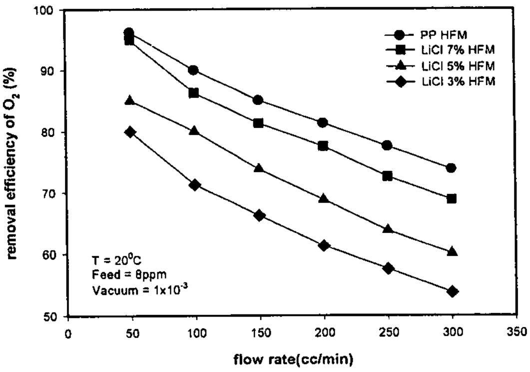


Figure 3. Removal efficiencies of O_2 as a function of various flow rates.

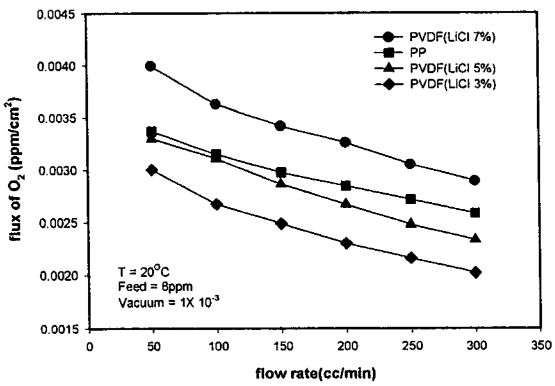


Figure 4. Flux of O_2 as a function of various flow rates.

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