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PE12) Coating Optimization of a Silicone Based Hollow Fiber Membranes for VOC - Air Separation

Erli Eros Lee · Viava Jane Africa · Juhyeon Ahn · Dong Min Shim
Andrew Premacio · Seoung - Hyun Kim · Wook - Jin Chung
Department of Environmental Engineering and Biotechnology, Myongji University

1. INTRODUCTION

Volatile organic compounds (VOC) when carelessly released to the atmosphere are known to cause serious health and environmental problems. Most VOCs are known carcinogens and one of the major contributors to air pollution and some are even considered as green house gases [1 - 5]. Thereby recovering it from waste air vent has been mainly motivated by this issue. In the same way VOCs, which is mostly used as solvents, are often a valuable and expensive compounds and recovering it is desirable so it can be recycled [2, 3]. Of the technologies used on recovering VOCs, membrane separation technology is a suitable recycling means because during the process of recovering, VOCs are not subjected to high temperatures or changed in their chemical structure [2]. In terms of operation, membrane processes in VOC application is advantageous for smaller feed gas flowrates and not too low VOC concentrations in air [3, 4].

Permeation of gases through non porous or dense polymer membranes is generally described by solution - diffusion model [5]. Usually in silicone based membranes, overall selectivity is primarily governed by difference in penetrant solubility [6]. Vapor of higher solubility is therefore has higher permeability. Furthermore, it is known that permeance of VOCs in a silicone based membranes are highly concentration dependent [7].

It is well known that non - porous silicone based membranes are highly selective to VOCs over inert gases. Permeability of organic vapors in this sense is far higher as compare to O_2 and N_2 permeability. Thereby, as far as organic vapor recovery is concerned, silicone based membranes are the most ideal membrane to be used in this application [4].

This study aims to attain the optimum coating condition especially on coating solution concentration on two support membranes and be furtherly utilized for a larger scale membrane module production. Also to explore on the feasibility of using commercially available silicon sealant as the primary coating layer component. And be able to use the module for VOC - air separation application.

2. MATERIALS AND METHODS

Commercial silicone sealant dissolved in hexane at varying concentration (10 - 60 wt %) is used to coat hydrophobic porous PE and PVDF hollow fiber membrane. Coating rate is maintained at approximately 2 cm/sec. Composite membranes are then made to module using epoxy for potting. Consequently, modules are tested for leaks by passing nitrogen gas while it is immersed in water. Leak free modules are then subjected to oxygen and nitrogen single gas permeation at 40°C and 20 psi. In addition, membranes performance to toluene vapor and nitrogen gas mixture was evaluated. Feed flowrate was kept constant at 13 L/min using a mass flow controller. In the same way permeation temperature and pressure is maintained at 30°C and 30 psi respectively. Toluene concentration is determined using GC - FID (Hewlett Packard, HP 6890 Series).

3. RESULTS AND DISCUSSION

Increasing silicone coating solution concentration results to increasing coating layer thickness. The occurrence of which can be attributed to increase in viscosity of the coating solution as its concentration is increased. A silicone concentration of 10 - 60 wt % is used to coat the support membranes. Concentration of more than 60 wt % is very viscous already making it impossible to coat. From the leak test done, membranes are found to have leaks at concentration below 40%. In a single gas permeation done, permeance obtained tends to decrease with increasing silicone concentration shown in Fig. 1. This is due to increase resistance brought by the coating layer for it becomes thicker as its concentration is increased. Permselectivity on the other hand is not significantly different from each other. For PE support, values are around 1.6 to 1.8 and for PVDF support, it ranges from 1.5 to 1.7. Mixed gas performance of the membrane is already efficient enough. High percent toluene recovery to as high as 97% and to most membranes from 92 - 93% is attained (Fig. 2). To all membranes coated with 50 and 60% silicon shows same performance. Both its selectivity as well recovery of toluene is almost the same. No big advantage is offered by increasing the silicone concentration to more than 50%.

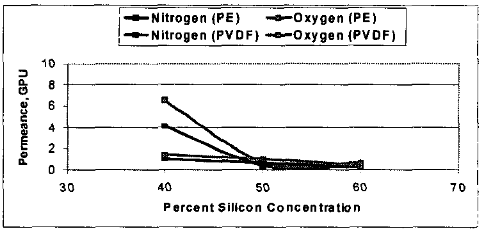

Fig. 1. Single gas permeance of O_2 and N_2 for varying silicone concentration.

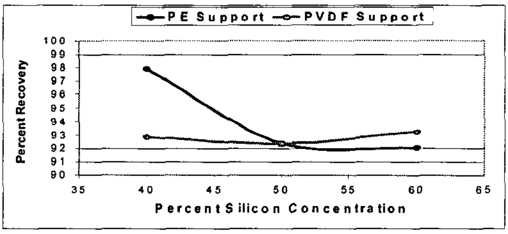

Fig. 2. Toluene recovery of membranes at varying silicone concentration.

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