Propylene-nitrogen separation using PDMS/fumed silica thin film composite membranes

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1.INTRODUCTION

Polypropylene is one of the most common home plastic used today. It is made by the polymerization of propylene. Monomers unreacted are purged by nitrogen streams. Recovering these monomers presents a promising market. PDMS thin film composite membranes is widely used to recover hydrocarbons form air or nitrogen even at dilute concentrations. It has high permeability and selectivity towards hydrocarbons due to their high solubility in PDMS. Nowadays inorganic adsorptive fillers such as fumed silica and zeolites are being added into PDMS polymer matrix to enhance its permeation properties. It has been demonstrated that fillers act as barriers that produce longer diffusion paths and free volume in the membrane thus enhances sorption of the hydrocarbons over low sorbing gases such as oxygen and nitrogen.

2.EXPERIMENTAL

Fumed silica TS-720 from Cab-O-Sil was incorporated into PDMS in solution. Two concentrations of fumed silica were tested, 10% and 20% (based on polymer weight) as well as a were prepared. Fumed silica was first dried at 100?C for 1 hour. A PDMS coating solution was made by dissolving 10 g of PDMS with 1g platinum curing agent in toluene then sonicated for 1 hour. Then two 10g portions of the solution were put in vials and in one vial 11 mg of fumed silica was added while 25 mg in the other to make 10% and 20% concentration of silica in the solutions. A 10g solution with no silica was also taken.

Polyethylene ((PE) microfiltration flat sheet membranes with a porosity of 85% and average pore size of 0.15 ㎛ were used as support for PDMS. The sheet was first immersed in deionized water to prevent intrusion of the coating solution into the pores. After immersion the sheets were wiped of excess water. Prior to coating, the coating solutions were heated at 80? C until near gelling point. The solutions were coated unto the PE sheets using doctor blade. Then the membranes were air dried and cured at 80? C.

Pure gas and mixed gas permeation tests were done on the membranes. The pure gas permeabilities of oxygen, nitrogen and propylene were obtained at feed pressures 3,4,5,6 bars and at temperatures 25, 35, 45? C. The mixed gas tests were done on 15mol% propylene in nitrogen at same parameters as with the pure gases.

3.RESULTSANDDISCUSSION

The filled and unfilled PDMS were successfully coated unto the PE support with the thickness of the PDMS coating ranging from 11 to 30 ㎛. It was found that multiple coatings were necessary to produce a defect free layer.

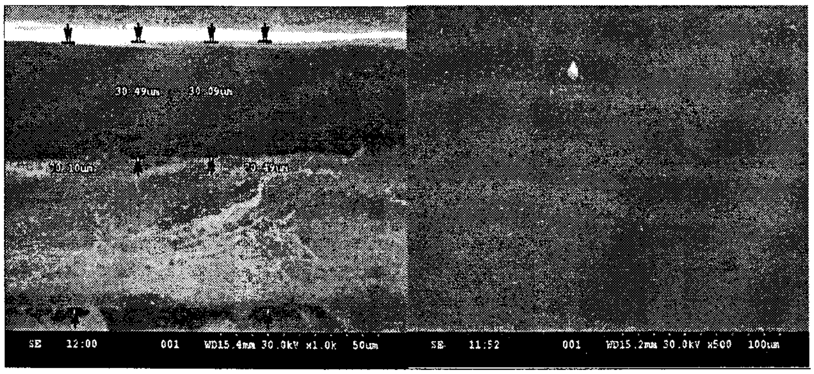

Figure 1. SEM micrograph of 10% PDMS in toluene coated unto PE support membrane

The pure gas permeancesand selectivities obtained for filled and unfilled PDMS was similar to that of any condensable hydrocarbon. The propylene permeance increases with pressure but decreases with temperature. For nitrogen however, the permeance increases with temperature and decreases slightly with pressure.

The mixed gas test showed that propylene/nitrogen permeances selectivities were lower as compared to puregases. Also in a mixture, the plasticization effect of propylene which is responsible for its high permeability is lessened when in mixture.The fumed silica was able to increase the permeance of propylene at 20% loading and a small an increase in selectivity was observed. The increase in permeance and selectivity is more pronounced at a lower temperature than at a higher temperature. This is due to the fact that propylene permeability increases at lower temperatures.

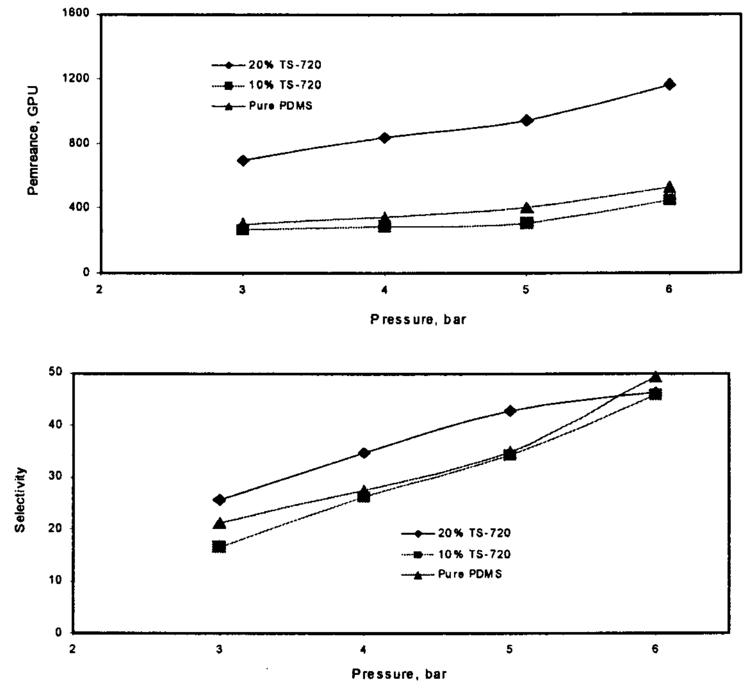

Figure 2. Propylene permeance and selectivity at 25℃ of pure PDMS and PDMS filled with fumed silica TS-720

4.CONCLUSION

Fumed silica TS-720 at 20% loading was able to increase propylene permeance and propylene/nitrogen selectivity. The improvement in permeation properties was evident even at temperatures as high as 45 C.

5.ACKNOWLEDGEMENT

This study has been supported by a grant (#032-071-016) from Eco-Technopia 21 Project (Korea Institute of Environmental Science and Technology), Republic of Korea

6.REFERENCES

1. Robeson L.M *"Correlation of separation factor versus permeability for polymeric membranes"* Journal of Membrane Science 1991 Vol. 62 pp.165-185.
2. Liu L. Chakma A. Feng X *"Propylene separation from nitrogen by poly (ether block amide) composite membranes"* Journal of Membrane Science 2006 Vol. 279 pp. 645-654.
3. Shi Y. C.Burns, .Feng X *"Thin film composite Membranes for propylene separation from nitrogen"* Journal of Membrane Science 2006 Vol. 282 pp.115-123
4. He Z. Pinnau I. *"Pure and mixed gas permeation properties of polydimethylsiloxane for hydrocarbon/methane and hydrocarbon/hydrogen separation"* Journal of Membrane Science 2004 Vol. 244 pp.227-233.