포스터 발표 P-14

Recovery of Toluene in gas by Polydimethylsiloxane/silica hybrid membrane permeation

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1.Introduction

Volatile organic compounds (VOCs) are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects. Current technologies for the treatment of VOC contaminated off-gasses are expensive to operate and more cost effective technologies are needed.

The membrane processes enjoy certain advantages, viz., compactness and light in weight, low labor intensity, modular design permitting easy expansion or operation at partial capacity, low maintenance (no moving parts), low energy requirements and low cost especially so for small sizes. PDMS flat and hollow membrane is widely use for VOC recovery for its perfect separation performance.

Now, the focus of research and development has shifted to the modification of the surface of the membrane. The effect of introduction of fumed-silica particles into organic polymeric membranes for gas separation processes have attracted a great deal of interest, because the addition of inorganic particles can enhance mechanical toughness, and separation performance of the membrane.

The separation performance of VOCs/N_2 by PDMS/silica hybrid membrane was noted in this study.

2. Materials and Methods

Dense and composite PDMS/silica hybrid membranes were prepared for this study. The PDMS polymer is generously supplied by Dow Corning Company. It's composed of two parts: part A and part B. Main component of part A is dimethylvinyl-terminated polydimethylsilane, part B is the crosslink agent which is formed by pt-based catalyst.

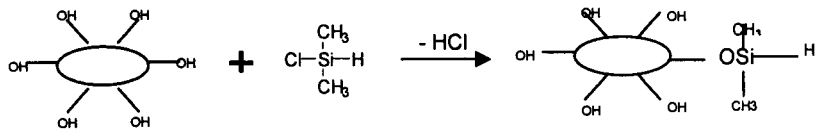
Information of fumed-silica

Fumed-silica type	Silica content	Surface groups	Surface area	Particle size
M-5	99.8%	-OH	200(m^2/g)	14nm

(supplied by Sigma company)

In our experiment, we successfully prepared the uniformed hybrid polydimethylsiloxane(PDMS)/fumed-silica membrane system by the process of surface modification to the fumed silica. This was achieved

by the reaction between the hydroxy group on the silica surface and chlorodimethylsilane(CDS) reagent.



The IR spectra results (Figure 1), shows that the original hydrophilic nano-scale silica (A) were changed into the hydrophobic one(B). Conversion of surface Si-OH to Si-$OSiH(CH_3)_2$ was observed by the completely disappear-ance of absorptionpeaks at 3433, assigned to Si-OH bond vibrations, and by the appearance of the absorption peaks at 2973, 2149, 914, assigned to C-H, Si-H, O-Si(CH_3) bond stretching vibrations respectively.

Figure 1. IR spectra result

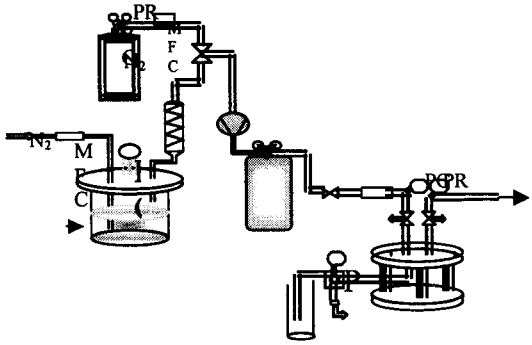


Figure 2. Schematic diagram of separation apparatus

Homogeneous dense PDMS/silica hybrid membranes were prepared by radical crosslinking between PDMS oligomer (part A) terminated with vinyl groups and a mixture of Pt catalyst(partB), then hybrid it together with the modified silica. Dissolving modified silica in toluene, after sonification, adding PDMS part A and part B as a ratio of 10:1, prepared a casting solution. The casting solution was poured into a Teflon Petri dish and then allowed to dry in a fume hood for several hours, and then, place it in the vacuum oven for one day for complete curing.

The total membrane separation apparatus is composed of three parts: feeding system, membrane cell, and data acquisition system, shown in Figure 2.

3. Results

Generally, the permeation of permeants through the rubbery membrane is characterized as a sorption controlled process, so the sorption behavior of a permeant could determine significantly

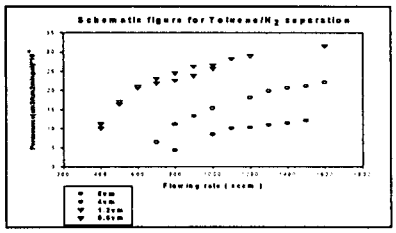


Figure 3. Toluene/N2 separation performance

permeation and separation performance the greater the affinity of a permeant towards a membrane is, the higher the solubility of the permeant in the membrane is. VOC/N_2 separation experiment was done by employing PDMS/PS composite membranes in various coating thickness. With the increasing of the inlet flowing rate, the permeance and permeability can be increased apparently. In the case of permeance, the value is related with the thickness of the membrane.

The pure and mixed-gas permeation properties of the PDMS/silica hybrid membrane were studied. The gas permeability (Fig. 4) and selectivity (Fig. 5) increased simultaneously as the filler content increased.

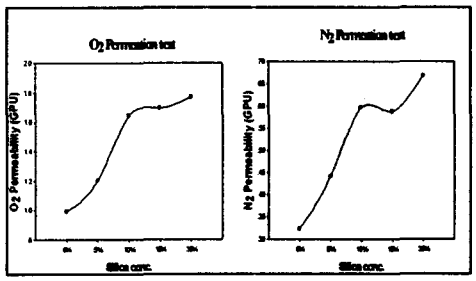


Figure 4. Pure gas permeability of silica hybrid membrane

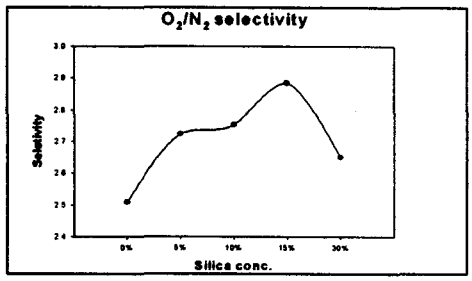


Figure 5. Gas selectivity of silica hybrid membrane

From figure 6, we can see, permeance of PDMS membrane for toluene/N2 separation increased with the increasing of inlet flowing rate; when the the higher the feed concentration, the bigger the permeance is.

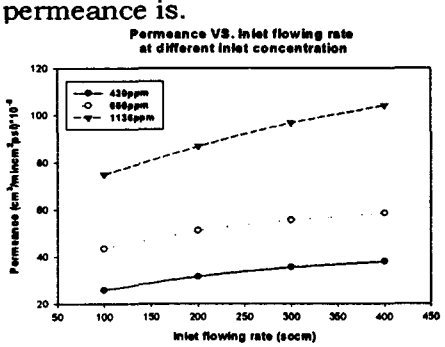


Figure 6 Toluene/N_2 permeation with PDMS membrane

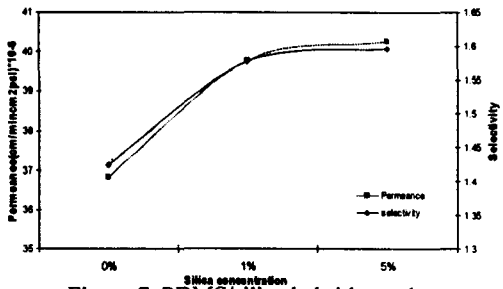


Figure 7. PDMS/silica hybrid membrane separation performance

The separation performance of silica hybrid PDMS membrane was shown in Figure 7. The permeance and selectivity increased simultaneously as the concentration of the incorporated silica increased.

4.Discussion

The oxygen and nitrogen permeability were increased 2-3 folds when the silica content increased by 30% compared with the pure sylgard 184 PDMS dense membrane. In addition, the selectivity of O_2/N_2 also increased apparently. From the AFM, X-ray and Tg test results, it can be noted that, the modified silicas can exist homogeneously with PDMS polymer, by adding the Inorganic silica particles, the glass transition temperature increased. the improvement of gas permeability and selectivity is because of the enhancement of free volume among the polymer chain packing. Just because of the enlarged free volume among polymer chains, the separation performance for VOC/N2 test was improved apparently.

5 Reference:

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