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Preparation and characterization of C-SiO_2 membranes modified by oxidation and their gas separation properties

Sang Hoon Han, Youn Kook Kim, Ho Bum Park, Young Moo Lee

National Research Laboratory for Membranes, School of Chemical Engineering, College of Engineering, Hanyang University, Seoul 133-791, Korea

1. Introduction

Gas separation membranes are now used in a wide variety of application areas as oxygen enrichment, hydrogen recovery, acid gas treatment, and natural gas dehydration etc [1]. Since polymeric membranes offer attractive properties for gas separation application, they have been variously studied [2-4]. However, current polymeric membrane materials have seemingly shown a limit in the productivity-selectivity trade-off. To solve this limitation, much research is focused on nanoporous molecular sieving materials such as carbon molecular sieve (CMS), carbon-silica, silica and zeolites. One of the carbon materials, carbon-silica membranes are revealed they offer excellent permeabilities and selectivities [5]. In this study, we prepared silica containing carbon (C-SiO_2) membranes derived from poly(imide siloxane) modified by partial oxidation and studied the structural characteristics of C-SiO_2 membranes and their gas permeation properties using small gas molecules [He (2.6 Å), CO_2 (3.3 Å), O_2 (3.46 Å) and N_2 (3.64 Å)]

2. Experimental

Poly(imide siloxane) (PIS) precursors were synthesized by a two-step polymerization using pyromellitic dianhydride (PMDA), 4,4'-oxydianiline

(ODA), and α,ω-animopropyl poly(dimethyl siloxane) (PDMS). The PIS films were pyrolyzed under an Ar flow in a quartz tube furnace. During the pyrolysis, the PIS films were modified by partial oxidation using pure air flow at 400 ℃.

3. Results and Discussion

The thermal decomposition behavior of poly(imide siloxane)was investigated using the thermogravimetric analyzer under Ar and air flow conditions. As shown in Fig. 1, the thermal decomposition curves exhibited two major weight-loss events at temperatures of about 400 and 550 ℃. The PIS precursor was decomposed at 400 ℃ and then began to rapid lose weight due to the decomposition of the main chains. As a result, the PIS precursors showed the different decomposition rate under the Ar and air flow conditions

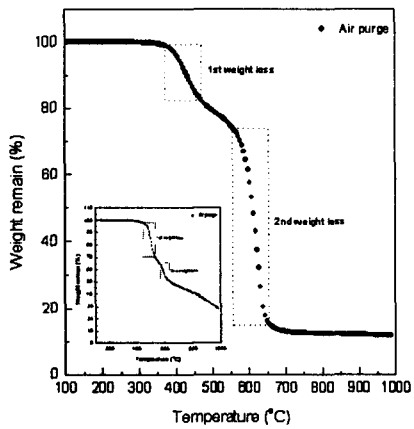

Fig. 1. TGA curves of PIS films under Ar and air conditions

Fig. 2 shows the gas permeabilities and selectivities of C-SiO_2 membranes modified by partial oxidation. As a result, the permeabilities of C-SiO_2 membranes decreased with the oxidation time. In general, the permeabilities of carbon membranes increased with the oxidation time

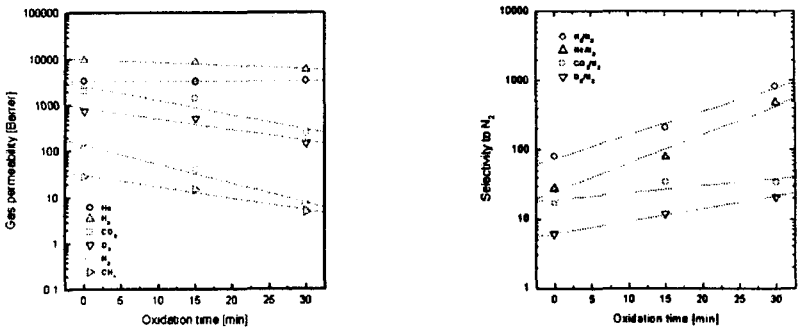

Fig. 2. Gas permeabilities and selectivities of C-SiO2 membranes modified by partial oxidation

during the pyrolysis. On the other hand, the modified C-SiO_2 showed the reverse results on the permeabilties and selectivies as compared with the carbon membranes modified by oxidation. That is, the permeable siloxane domains in the C-SiO_2 membranes were converted into the dense silica phase by the oxidation. Therefore, the C-SiO_2 membranes showed the lower permeabilities and the higher selectivities.

4. Conclusion

In this study, we have prepared the C-SiO_2 membranes modified by partial oxidation using poly(imide siloxane) precursor and have investigated the effect of oxidation on their structural characteristics and gas permeation properties. The C-SiO_2 membranes modified by oxidation showed the decreased permeabilities due to the conversion of siloxane domain into silica, which acted as a barrier to gas transport.

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