Gas Separation Performance of Polyvinyl Chloride Membrane

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***Abstract*— The gas permeation properties of Polyvinyl Chloride (PVC) membrane was investigated for N_2, O_2, CH_4 and CO_2 gases. At 10 bar feed pressure and 25 °C the CO_2/CH_4 and CO_2/N_2 ideal selectivity of 40.36 and 20.18 was observed respectively. The effects of feed pressure and temperature on the permeation properties of polymer were studied. The permeability of gases was increased with increasing temperature and decreasing feed pressure. By using time lag method the diffusivity of gases through polymer has been calculated. Base on the solution diffusion mechanism the sorption constant of gases in polymer has been evaluated at different temperature and pressures.**

I. INTRODUCTION

Membranes have been successfully developed for gas separation. Separation of hydrocarbons from natural gas, nitrogen purification and the foremost CO_2 removal from natural gas are recognized as major established and high value industrial application of membrane. Recently polymeric membranes have attracted more attentions because of the low production cost and ease of processing, especially for hollow fiber preparation [1]. Glassy polymeric membranes are used for natural gas purification (CO_2, H_2O, H_2S removal). The most common material used for such membranes is cellulose acetate. These materials only have CO_2/CH_4 selectivities of 12–15 under typical operating conditions in the field [2], which is well below the low-pressure mixed gas selectivity of ~30 for cellulose acetate dense membranes with zero permeate pressure [3].The decline in selectivity is primarily due to swelling-induced plasticization of the membrane by CO_2 and heavy hydrocarbons. The development of stable membrane materials with CO_2/CH_4 selectivities of 40 would significantly enhance the competitive position of membranes relative to alternate technologies such as amine scrubbing [2]. PVC is a glassy polymer with high mechanical strength, high thermal stability. This polymer is available with low cost. In this paper the Gas Separation Performance of Polyvinyl Chloride Membrane was studied.

II. EXPERIMENTAL

A. Materials

PVC powder was procured from Vinythai Co, Thailand. (K-Value = 65-67, Specific Viscosity = 0.36-0.38) Dimethylformamide (DMF) solvent was purchased from Merck. The CO_2 , O_2 and N_2 gases (purity 99.99) were purchased from Ardestan Gas Co., Iran and also CH_4 (purity 99.95) was purchased from Technical gas service.

B. Dense Membrane Formation

A solution casting method was used to prepare the dense film[4]. The average thickness of the films was 35 microns.

C. Gas Permeation Tests

The gas permeation properties of membranes were specified by a variable pressure/constant volume method [5]. The gas permeability was determine at 6, 8, 10 bar pressure and at 25ºC and 35 ºC. The test cell area was 13.2 cm^2 and the leak rate was 10^{-5} mbar/s, indicated a negligible effect on permeability data. The rate of pressure increase (dp/dt) (mbar/s) at steady state was used for the calculation of gas permeability with the following equation:

$$P = \frac{273.15\times10^{10} Vl}{76AT(p_2 - p_1)}\left(\frac{dp}{dt}\right)$$

where P is the gas permeability of a membrane in Barrer (1 Barrer = 1×10^{10} cm^3 (STP).cm/cm^2 s cmHg), V is the volume of the down-stream (cm3), A refers to effective area of the membrane (cm^2), l is the membrane thickness (cm), T is the operating temperature (K) and finally p_2 and p_1 (mbar)are pressure of the feed gas in up-stream and down stream respectively.

III. RESULTS AND DISCUSSION

A. Pure Gas permeation

The pure gas N_2, O_2, CH_4 & CO_2 permeabilities (P) and diffusion coefficients(D) were determined simultaneously by recording the increase of downstream pressure with time and solubility coefficients(S) were estimated as S = P/D. Tables 1 & 2 shows the Permeability, diffusivity and solubility coefficient of PVC membrane at 10 bar at 25ºC and 35 ºC respectively. In Tables 3&4 same properties were reported at 8 bar and 6 bar feed pressure respectively.