CHAPTER IV
RESULTS AND DISCUSSION

4.1 Dispersed Butanediols-Silicone Rubber on Porous Polysulfone

Permeabilities of propylene, propane, and nitrogen were determined from steady-state permeation rates of each gas through mixed matrix membrane at room temperature. The experimental results are demonstrated in Table 4.1.

Table 4.1 Permeabilities of gases through mixed matrix membrane prepared from silicone rubber and added glycols on polysulfone.

Membrane	Permeability (cm^3/cm^2-sec-cmHg)		
	N_2	C_3H_6	C_3H_8
SR/PS	$1.8717*10^{-6}$	$7.1896*10^{-5}$	$7.6629*10^{-5}$
SR+PEG/PS	$5.1208*10^{-8}$	$2.2249*10^{-7}$	$1.1580*10^{-7}$
SR+12BD/PS	$1.1671*10^{-6}$	$3.8357*10^{-5}$	$3.1055*10^{-5}$
SR+14BD/PS	$6.9324*10^{-7}$	$1.2012*10^{-5}$	$1.3887*10^{-5}$
SR+23BD/PS	$2.1481*10^{-6}$	$4.1126*10^{-5}$	$3.6091*10^{-5}$
SR+13BD/PS	$3.8466*10^{-7}$	$6.2984*10^{-7}$	$8.4618*10^{-7}$

Silicone rubber is rubbery polymer, of which the segments of backbones can rotate freely around their axis; this makes the polymer soft and rubbery. Transport of gas through rubbery polymer is postulated to occur when there is a transient gap of sufficient size to accommodate the penetrant. These transient gaps form and fade throughout the polymer matrix due to thermally induced motion of the polymer segments.

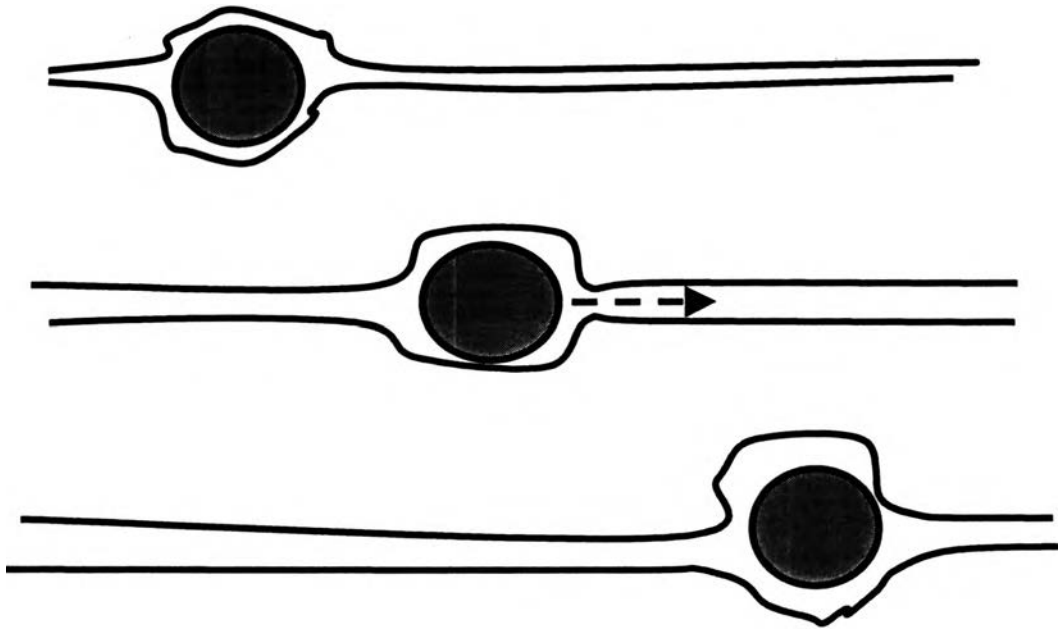

Figure 4.1 Gas diffusion through transient gap formed between polymer chain.

In addition, silicone rubber, rubbery polymer, preferentially permeates the larger more condensable gases, propylene and propane, over the smaller noncondensable gases, nitrogen and methane (Yang and Hsuie, 1998). As it is seen in the Table 4.1 that the permeabilities of propylene and propane are higher than permeability of nitrogen in membrane prepared from silicone rubber.

The obtained results show the highest permeabilities of all three gases through membrane prepared from silicone rubber in absence of added glycol. These results are found consistent with previous literature studies (Yang and Hsuie, 1998). Permeabilities of all three gases decreased when polyethylene glycol (PEG) and butanediols were added. The added glycols filled up the

transient gap between polymer chain and hindered the diffusion path of gas molecules. In this regard, gas molecule permeates slower.

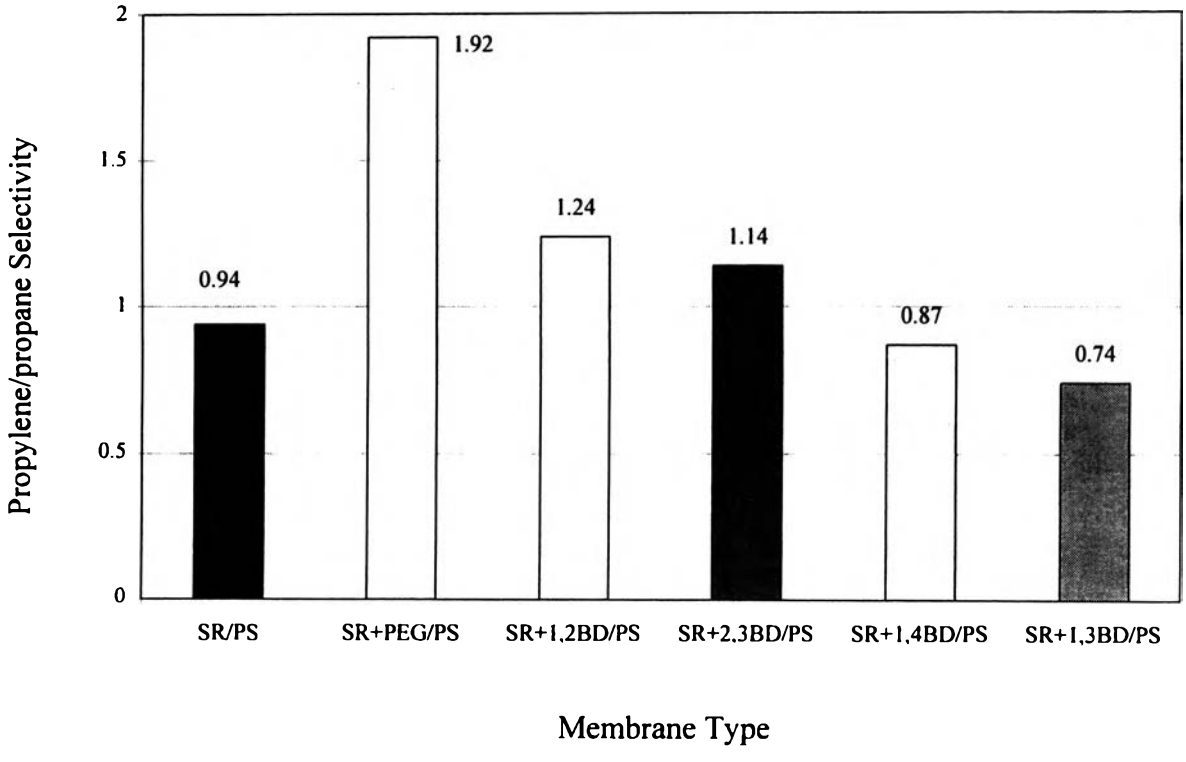

Figure 4.2 Propylene to propane selectivity of mixed matrix membranes prepared from silicone rubber incorporated with PEG and butanediols on polysulfone.

Figure 4.2 shows the effect of added four isomers of butanediol on propylene to propane selectivities of mixed matrix membranes. Silicone rubber, with high permeation to all gases, exhibits low propylene selectivity. PEG, which is consistent with the previous work (Sukapintha, 2000), alter the selectivity of silicone rubber. Because propylene and propane are similar in their size, the diffusion through polymer matrix is not different. Thus, the propylene separation should not caused by diffusion mechanism. The separation should be attributed to the higher solubility of propylene in PEG.

The propylene selectivity is found to be highest in SR+PEG/PS compared to the membranes prepared from four isomers of butanediol. 1,2-butanediol and 2,3-butanediol can improve propylene selectivity as well although the propylene selectivity is not as high as the value obtained in SR+PEG/PS. However, the propylene selectivity is not improved when 1,3-butanediol and 1,4-butanediol were added.

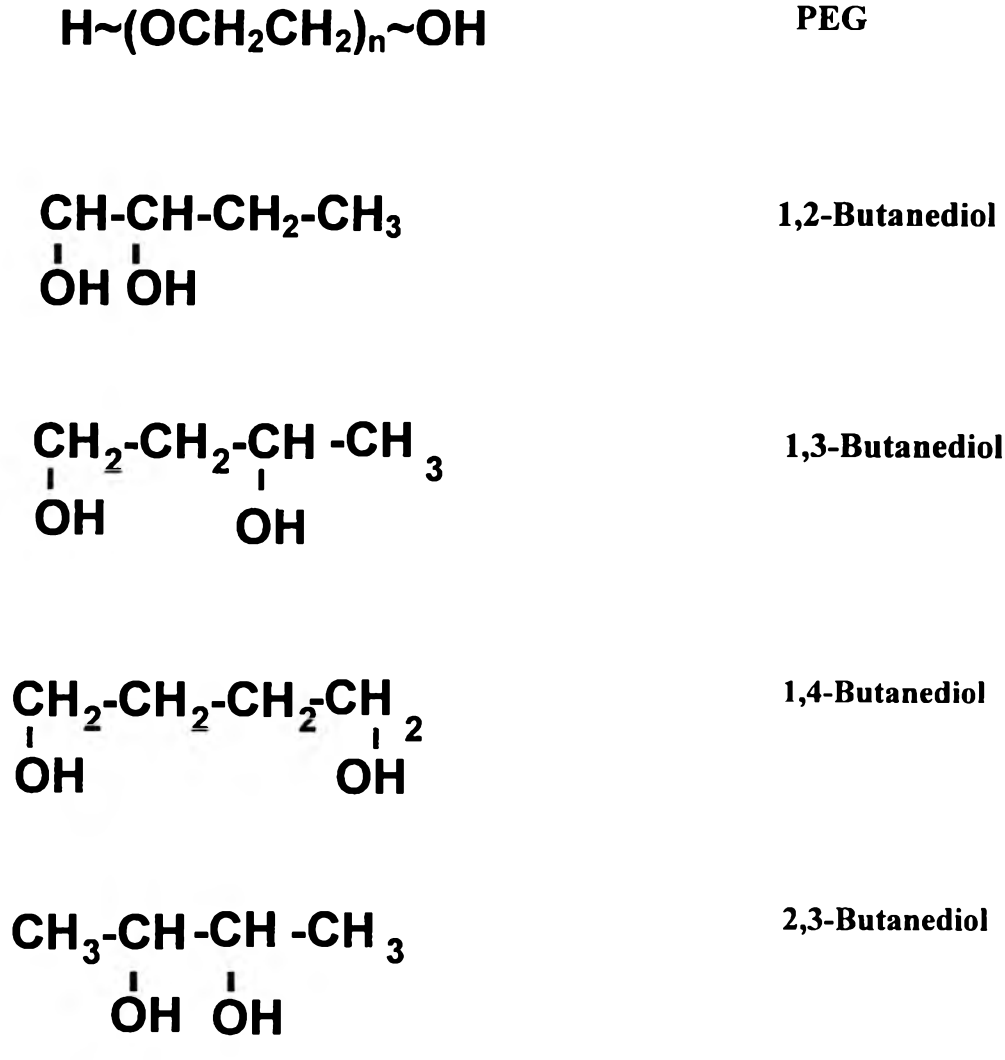

Figure 4.3 Diagram molecular structure of PEG and four isomers of butanediol.

In PEG, the hydroxyl group is attached to each carbon atom on carbon backbones. A portion of 1,2-butanediol and 2,3-butanediol molecules are similar to PEG in which the hydroxyl group is attached to the adjacent carbon atoms. In contrast, the hydroxyl group in 1,3-butanediol and 1,4-butanediol is not attached to the adjacent carbon atoms. Therefore, the position of hydroxyl group on the carbon backbones is postulated to be a control factor for propylene separation.

4.2 PEG Adsorbed NaX and Silicone Rubber on Porous Polysulfone

It was found from the previous work that PEG emulsified silicone rubber mixed matrix membrane, though it has capability of altering selectivity of silicone rubber, lost their stability due to PEG leakage. In this study, NaX adsorbent was used to prevent the leak out of PEG by adsorbing it into NaX pores before incorporated in silicone rubber. Table 4.2 shows the permeabilities of propylene, propane, and nitrogen through mixed matrix membranes prepared from NaX and PEG-adsorbed NaX.

Table 4.2 Permeabilities of gases through mixed matrix membrane prepared from silicone rubber and NaX and PEG-adsorbed NaX on polysulfone.

Membrane	Permeability (cm^3/cm^2-sec-cmHg)		
	N_2	C_3H_6	C_3H_8
SR/PS	$1.8717*10^{-6}$	$7.1896*10^{-5}$	$7.6629*10^{-5}$
SR+PEG/PS	$5.1208*10^{-8}$	$2.2249*10^{-7}$	$1.1580*10^{-7}$
SR+[PEG-NaX]/PS	$5.0458*10^{-7}$	$3.5604*10^{-6}$	$2.3243*10^{-6}$
SR+NaX/PS	$5.6036*10^{-7}$	$7.0953*10^{-6}$	$7.1794*10^{-6}$

NaX incorporated silicone rubber membrane exhibits lower permeabilities for all three gases, compared to silicone rubber. Kulpratipanja and Kulkarni,1988 believed that gases were adsorbed into the pores of NaX zeolite and led to the saturation of pore. Consequently, a time lag for reaching steady-state permeation occurred.

Permeabilities of solid NaX incorporated silicone rubber membrane are found to be higher than the values obtained from liquid PEG emulsified silicone rubber membrane since gas diffuse harder through viscous PEG which filled up the gap between polymer chains. Likewise, this reason is contributed to the higher permeabilities of mixed matrix membrane prepared from PEG-adsorbed NaX, compared to PEG emulsified silicone rubber membrane.

In comparison of NaX incorporated silicone rubber membrane with mixed matrix membrane prepared from PEG-adsorbed NaX, the latter is less permeable to all three gases due to the presence of PEG in NaX pores which hindered the path of gas diffusion.

The comparison of propylene to propane selectivities of mixed matrix membrane prepared from PEG-adsorbed NaX and NaX are illustrated in Fig 4.4.

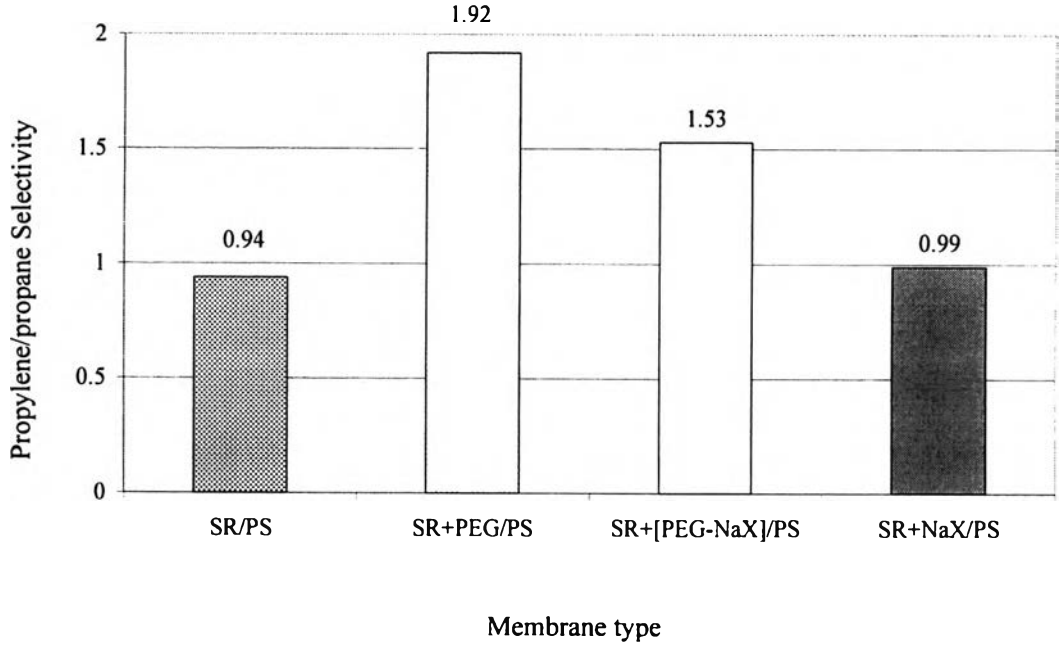

Figure 4.4 Propylene to propane selectivities of mixed matrix membrane prepared from silicone rubber and NaX and PEG-adsorbed NaX on polysulfone.

It can be seen that mixed matrix membrane prepared from PEG-adsorbed NaX has the capability of altering selectivity of silicone rubber although the propylene selecitivity is not as high as the value obtained from PEG emusified silicone rubber membrane. The controlling mechanism which is involved in the selecitivity enhancement comprises the presence of PEG in NaX pores. Propylene passes through mixed matrix membrane prepared from PEG-adsorbed NaX at a more rapid rate due to the higher solubility of propylene in PEG compared with propane. Mixed matrix membrane prepared from NaX is not selective to either propylene or propane. Thereby, the selectivity enhancement is attributed to PEG in the pore of NaX.