



## CHAPTER V

### CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Conclusions

In this work, the effects of various liquid additives incorporated into activated carbon and polyimide polymer matrix on  $H_2/N_2$ ,  $CO_2/CH_4$ ,  $CO_2/N_2$  and  $N_2/CH_4$  separation performance were investigated. All membranes and mixed matrix membranes (MMMs) were prepared by solution-casting method. The results clearly show that incorporating liquid additives (1,2-, 1,3-, 1,4- and 2,3-butanediol) into activated carbon and polyimide polymer MMMs has effectively improved the  $CO_2/CH_4$  separation performance as compared to neat Ultem membrane and activated carbon MMMs. The reason is that hydroxyl group attached to the carbon atom in glycol isomers increases the solubility of polar gas ( $CO_2$ ) resulting in the higher permeance and selectivity of  $CO_2$ . Whereas the other gases ( $H_2$ ,  $N_2$  and  $CH_4$ ) take less effect from glycol isomers or liquid additives.. Pressure effect were studied and clearly seen that the increase in operating pressure hardly affects the glycol isomers-MMM performances. However, further studies about improving the selectivity at elevated pressure in order to enhance the separation efficiency should be investigated and compared with other types of MMMs. Effective factor can be used to characterize the performance of membranes by relating two parameters, permeance and selectivity. The highest effective factors are 1,2- and 2,3-butanediol MMMs.

#### 5.2 Recommendations

Polyimide membranes and mixed matrix membranes (MMMs) used in this work normally have high potential in gas separation with and without activated carbon and liquid additives or glycol isomers. However, no attempt from any researcher to develop MMMs that consist of polyimide, zeolites and liquid additives. From this work, it was found that liquid additives or glycol isomers incorporated into activated carbon and polyimide polymer successfully enhance the solubility and permeance of polar gas. The MMM that is composed of various types of zeolites and liquid addi-

tives into polyimide polymer should be investigated. The effects of both physical properties of adsorbent and liquid additives, and interfacial properties between adsorbent and liquid additives should be focused in the future work.