CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Matrimid dense membrane and mixed matrix membranes (MMMs) containing three different inorganic fillers (activated carbon, gamma-alumina and 4A zeolite) for gas separation were successfully fabricated at 0 wt.% (pure Matrimid), 15 wt.% and 25 wt.% via the solution-casting method. Single gas permeation measurements showed that the selectivity of CO_2 to CH_4 for MMMs decreased with corresponding increase in its permeability over CH_4 as the loading of inorganic fillers was increased. This may be because of poor contact between inorganic fillers and polymer matrix forming interfacial voids. Furthermore, the selectivity of CO_2 was considerably decreased for a 25 wt.% 4A-Matrimid MMM as a result of more non-selective interfacial voids formed at a higher zeolite loading. However, both CO_2 permeability and CO_2/CH_4 selectivity increased at a certain amount of activated carbons loaded in Matrimid polymer as compared to those of pure Matrimid membrane.

On the other hand, γ-Al_2O_3-Matrimid MMMs were effectively fabricated in PPC lab, resulting in increasing permeance of the tested gases combined with increasing CO_2/CH_4 and CO_2/N_2 selectivity at a higher gamma-alumina loading. γ-Al_2O_3-Matrimid MMMs improved the gas separation properties and it is possible that γ-Al_2O_3-Matrimid MMMs might be an interesting solid-polymer mixed matrix membrane to enhance the performance of gas separation.

5.2 Recommendations

From this work, activated carbon-Matrimid MMMs enhanced the CO_2/CH_4 gas separation performance comparing with pure Matrimid membrane and other MMMs. Consequently, the CO_2 permeability and CO_2/CH_4 selectivity increased with 73 % and 14 % over the pure Matrimid polymer. On the other hand, γ-Al_2O_3-

Matrimid and, 4A zeolite-Matrimid MMMs suffered from defects, interfacial void formation at the interface of inorganic fillers and organic polymer in UOP lab. The effect of interfacial void formation plays a significant role in the improvement of the gas separation performance to develop the membrane technology. There are certain approaches such as modifying zeolite surface with silane coupling agents, introducing low molecular weight materials, annealing the membrane above the Tg of the polymer to eliminate the voids, and priming the surface of zeolites by polymer especially for glassy polymers. Therefore future work should explore an appropriate approach to improve gas separation properties not only by eliminating non-selective interfacial void formation but also by choosing proper inorganic materials and polymeric matrix to be good adhesion.

The possible presence of non-selective interfacial voids in γ-Al_2O_3-Matrimid MMMs was partially overcome by an alternative fabrication method in PPC lab: priming a small amount of polymer and using a low boiling point solvent. Accordingly, γ-Al_2O_3-Matrimid MMMs increased both permeance of the tested gases and selectivity of the pairs of the gases (CO_2/CH_4 and CO_2/N_2) with increasing gamma-alumina loading. Although the study found the enhancement of MMM performance by using single gas permeation by a bubble flow meter, it was not exactly possible to determine the reasons. Further studies are therefore necessary to determine the more reasonable causes such as possible separation mechanisms and interaction between gamma-alumina and Matrimid polymer to clarify the improvement of γ-Al_2O_3-Matrimid MMM performance. Moreover, more effective technique should be explored to disperse inorganic particles homogeneously in polymer matrix since an agglomeration of inorganic particles has occurred in γ-Al_2O_3-Matrimid MMMs. To compare MMM performance with Maxwell model, the gas permeance of CO_2 and CH_4 for pure inorganic particles i.e., γ-Al_2O_3, activated carbon and 4A zeolite should be studied. Furthermore, future work should investigate the effect of high annealing temperature on the gas separation performance of γ-Al_2O_3-Matrimid MMMs.