

## CHAPTER I

### INTRODUCTION

Membrane separation technology has shown a great application potential in gas separation field such as air separation, hydrogen and heavy hydrocarbon recovery, and CO<sub>2</sub> removal. Membrane technology has become a workhorse in gas purification as it requires less energy for the separation and has less environmental impacts since it needs no additional chemicals and produces no waste (Diestel *et al.*, 2014). Natural gas sweetening is one area of importance for CO<sub>2</sub>/CH<sub>4</sub> gas separation. Since CO<sub>2</sub> in natural gas has several destructive effects during gas transportation and increases pipeline corrosion, it must be separated from such indigenous gas (Zhang *et al.*, 2013). Moreover, natural gas sweetening reduces the volume of gas which would be transported and thus increases its heating value (Xiao *et al.*, 2009).

Efficient separation technologies are required for the removal of carbon dioxide from natural gas streams. Membrane-based natural gas separation has emerged as one of the fastest growing technologies, due to the compactness, higher energy efficiency and economic advantages. However, the inadequacy of the existing polymeric membrane materials inhibits the full exploitation of the application opportunities on the industrial scale. Polymeric membranes have lower separation performance than inorganic materials such as zeolites, carbon molecular sieves and cannot pass the upper bound of the Robeson curve (Chung *et al.*, 2007; Goh *et al.*, 2011). Although the inorganic materials have properties lying far beyond the upper-bound limit for the organic polymers, the immediate application of inorganic membranes is still seriously hindered by the lack of technology to form continuous and defect-free membranes, the extremely high cost for the membrane production, material fragility and low packing density (Chung *et al.*, 2007). Therefore, new methods have been investigated to improve the separation properties of polymeric membranes.

Mixed matrix membranes (MMMs), comprising rigid permeable or impermeable particles, such as zeolite, carbon molecular sieve and silica, dispersed in a continuous polymeric matrix present an interesting approach for improving the

separation properties of polymeric membranes. In this approach, by using properties of both organic and inorganic phases, a membrane with good permeability, selectivity, mechanical strength, thermal and chemical stability and processibility can be prepared (Aroon *et al.*, 2010). A MMM is an intimate and homogeneous dispersion of filler particles in a polymeric matrix. Both polymer and filler properties affect MMM morphology and separation performance. The successful implementation of MMM depends greatly on the polymer matrix selection, the inorganic filler as well as the interaction between the two phases (Goh *et al.*, 2011).

The purpose of this study was to investigate the formation and separation performance of solid-polymer mixed matrix membranes using three different inorganic fillers as the dispersed phase in Matrimid 5218 polymer matrices for CO<sub>2</sub>/CH<sub>4</sub> separation at elevated temperature and pressure. The selection of suitable types of inorganic fillers and Matrimid at a certain loading which affects the compatibility (a good dispersion with an excellent interfacial contact) between the two phases was determined through the permeability and selectivity of gases. Another purpose was to investigate the performance of  $\gamma$ -Al<sub>2</sub>O<sub>3</sub>-Matrimid MMMs prepared and tested at the Petroleum and Petrochemical College (PPC) by the alteration of fabrication method.