

CHAPTER I

INTRODUCTION

Carbon dioxide (CO₂) is a greenhouse gas found primarily as a main combustion product of fossil fuels as well as a component in natural gas, biogas, and landfill gas. The presence of CO₂ and other acid gases reduces the calorific value and makes the gas streams become acidic and corrosive, which in turn reduces the possibilities of gas compression and the transport within the transportation systems (Zhang *et al.*, 2013). The specifications for natural gas delivery to the U.S. national pipeline grid demand CO₂ contents of less than 2% (Othman, 2009). Therefore, the separation of CO₂ from CH₄ plays an important role in many industrial processes (Nik *et al.*, 2012). Conventional separation methods are based on reversible absorption, such as amine scrubbing, but these processes are energy intensive and pose environmental concerns. One type of technology which has experienced substantial growth, breakthroughs and advances during past decades is membrane-based technology.

Membrane technology is an attractive separation approach that has been studied extensively as a result of low investment and operating costs, simple process design and energy efficient process. Membrane-based separation involves the use of membrane as a thin barrier between miscible fluids to separate a mixture based on the size and shape of the molecules and on their interaction with the membrane material. Generally, the permeability and selectivity are the two common basic performance characteristics of a membrane. Polymeric membranes are inexpensive and facile to fabricate, but the productivity and selectivity trade-off suggested by Robeson (1991) are the main problems of polymer materials (Singha-in *et al.*, 2008). Moreover, most membranes do not have the flexibility in practically industrial conditions and quickly fail. Because of this limitation, to enhance membrane selectivity and permeability, mixed matrix membranes (MMMs) have been investigated for the past several years.

MMMs are hybrid membranes containing fillers such as carbon molecular sieves, zeolites, and silica nanoparticles dispersed in a polymer matrix. Traditionally, zeolite is one class of dispersed phase material which has attractive separation

properties for a desired gas separation. Nevertheless, zeolite-based MMMs have two major drawbacks which must be overcome. Firstly, the number of zeolite types identified to produce successful MMM is limited. Secondly, the inorganic surface chemistry of zeolites leads to additional membrane formation challenges when attempting to create a defect-free morphology (Dai *et al.*, 2012).

In the last decade, metal organic frameworks (MOFs) have gathered much interest. MOFs are a relatively new class of microporous materials containing a transition metal with various organic linkers to form a different type of dimensional structure such as one-, two-, and three-dimensional with surface area, porosity and tunable pore structure, which has attracted great attention for gas separation. However, the performance of membrane may be increased by choosing a suitable dispersed phase and polymeric phase which improves membrane performance to obtain a high permeability without reducing membrane selectivity.

The purpose of this study is to investigate the performance of solid-polymer mixed matrix membranes using several different MOFs as a dispersed phase for CO₂/CH₄ separation at room temperature. In this work, Ultem[®]1000 (Polyetherimide) was utilized as a continuous matrix because it has acceptable intrinsic separation properties and exhibits excellent mechanical and thermal properties. For all membranes, the single gas permeability measurements were performed at both low and high pressures with which separation behavior of the membranes were evaluated. The effects of MOFs and pressure were investigated on the permeability and selectivity of gases (i.e., CO₂ and CH₄).