

A kinetic study of CO₂ sorption improvement in the CA-CNTs mixed matrix membrane

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Abstract. Greenhouse emission notably carbon dioxide (CO₂) in the atmosphere have been increasing significantly over the last century. Hence, there is a need to address this issue to minimize the adverse environmental effects. Membrane separation is one solution that could potentially help in this endeavour. Among the many types of membranes available, mixed matrix membrane (MMM) is the most promising with the potential to surpass the many deficiencies present in both inorganic and polymeric membranes. In this study, results confirmed that incorporation of functionalized CNTs increases CO₂ permeance. Hence, the different loadings of MWCNTs-F were investigated to find the optimum gas separation performance. From this optimization study, excellent MMM performances in terms of CO₂ permeance were shown in 0.1wt% loading of MWCNTs-F. This superior performance was attributed to a good homogeneous dispersion of MWCNTs-F in the CA matrix which consequently enlarged the free volumes between the polymer chains and improved the polymer nano particulate interface. Apart from this, a kinetic sorption study showed improvements in the CO₂ solubility coefficient over previous related work at $14.9601 \times 10^{13} \text{ cm}^3(\text{STP})/\text{cm}^4 \cdot \text{cmHg}$. Hence, the usage of lower acetyl content is proven to be capable of increasing the CO₂ solubility coefficient.

1. Introduction

Over the years, greenhouse gasses (GHGs) such as carbon dioxide (CO₂) have been increasing significantly in the earth's atmosphere [1]. This has serious implications to the Earth from global warming to weather changes [2]. CO₂ gas is the main subject matter among these GHGs as it is released in large quantities compared to rest [2]. Hence, a few incentives have been taken to reduce the release of CO₂ into the environment [3].

The usage of membranes in separation is one that could possibly help in this endeavour as it addresses the many issues plaguing commercial CO₂ capture [4]. Some of the polymeric materials available are cellulose acetate (CA), polyimide (PI), polysulfone (PSF), polyethersulfone (PES), and polycarbonates (PC). Commercially, only PI and CA have been mainly used for CO₂/CH₄ and CO₂/N₂ separations [5]. This is due to the excellent gas separation performance of these 2 polymers [6]. Mixed matrix membrane (MMM) which is made up of a polymer matrix and an inorganic filler is currently the most promising way forward. [7]. Carbon nanotubes (CNTs) were proved to be able to transport light gases many times faster than any other known microporous material [8]. However, the poor distribution and weak interfacial interaction of the inorganic fillers within the polymer matrix leads to the formation of unselective channels within the membranes [9]. Thus, there is need to enhance the compatibility between the inorganic fillers and the polymer matrix within the MMMs.

