CHAPTER 2

CHOLINE-BASED DEEP EUTECTIC SOLVENTS FOR CARBON CAPTURE APPLICATIONS

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2.1 INTRODUCTION

Carbon dioxide is a one-carbon molecule that has the formula CO_2 and is characterized by the presence of double bonds between carbon atom and oxygen atoms. CO_2 is a prevalent by-product of natural gas production. At the wellhead, naturally occurring CO_2 concentrations in natural gas can reach up to 35 vol%. Thus, CO_2 is typically removed from natural gas streams that are rich in hydrocarbons in gas processing plants. The CO_2 content was reduced until it follows the maximum allowable CO_2 level before it was distributed for commercial use. The presence of CO_2 in natural gas causes more harm than good as it can cause malfunction towards pipeline as CO_2 is considered as one of the acid gases. The reaction of CO_2 with the contaminant such as water will ultimately cause corrosion to the pipeline causing a lot of loss to the natural gas industry. Hence, it is mandatory to reduce the amount of CO_2 in natural gas through CO_2 removal process.

It is widely agreed that CO_2 is a major contributor to the acceleration of global warming and the ensuing climate change even decades ago. CO_2 is the primary greenhouse gas component. As a direct result of increased industrial activity, the concentration of CO_2 in the atmosphere reached 400 parts per million in 2019 which result in the temperature of the earth increased by 0.8°C. By 2050, it is predicted that the level of carbon emissions would have increased to 900 ppm (Pishro et al., 2021). One of the effects of global warming to the mother nature is the rising of the ocean level as the heat from the global warming melts the ice thus, raises the level of the sea, putting at risk communities located on coasts and islands.

Carbon dioxide (CO_2) capturing methods have evolved and become more advance throughout this year such as postcombustion, precombustion, and oxycombustion. These methods are both fundamental for natural gas industry and carbon capture and storage (CCS). For postcombustion method of capturing CO_2 which has been commercially used, numerous alkanolamine has been used as absorbents in the past seven decades such as monoethanolamine (MEA), diethanolamine (DEA), and N-methyldiethanolamine (MDEA). As it promises high reactivity with CO_2 in addition to its economic cost, strong affinity for CO_2 and low viscosity it is foreseeable as why it has been favours in the past few years. However, the drawbacks that comes with it such as corrosiveness, the need for more energy for solvent regeneration and poor capacity to load CO_2 are the very reasons for the urge of potential new materials to be discovered by scientist. Besides, alcohol ammonia solution is also known to decompose at high temperature.

In quest of seeking for the best absorbent material, the exploration on deep eutectic solvent (DESs) has recently emerged. DESs are eutectic mixes of Lewis or Brønsted acids and bases, which are consists of hydrogen bond acceptor and hydrogen bond donors. Since the component of DES is controllable and may be engineered to act as the absorbent of certain gases, such as CO_2, sulfur dioxide (SO_2), and hydrogen sulfide (H_2S), it can be utilized in the process of gas separation. Their benefits include their ease of synthesis process and does not need for any purification processes or disposal issues due to the fact that they are biodegradable, non-flammable, and nontoxic. However, there are limited studies done related to the use of deep eutectic solvent for capturing CO_2. The objectives of this studies are to synthesis and characterize two deep eutectic solvents (DES) in addition to evaluate the performance of deep eutectic solvent in capturing CO_2.

The scope of this study covers the use of choline chloride (ChCl) as hydrogen bond acceptor (HBA) to be pair with two different hydrogen bond donor (HBD) which includes tetraethylenepentamine (TEPA), and ethylene glycol (EG). The characterization that will be executed were thermogravimetry analysis, differential scanning calorimetry (DSC), and fourier transform infrared (FTIR) spectroscopy before and after CO_2 capture process. CO_2 capture process with DESs were operated at 1 bar. The amount of CO_2 absorbed will be determined by using gas chromatography (GC) data. 500 rpm speed were employed for the rotating disc contactor (RDC).

2.2 SYNTHESIS OF DEEP EUTECTIC SOLVENTS

The steps involved in the preparation of DES are illustrated in Figure 2.1. The mixture of ChCl and TEPA at a 1:9 molar ratio was selected, as this ratio has been clarified by Pishro and members to exhibit highest CO_2 uptake value (Wang et al., 2021). It was prepared in round bottom flask with reflux on a magnetic hotplate. All of the combination of ChCl and TEPA is mixed with constant speed and temperature at 800 rpm and 353.15K respectively for at least 3 hours. The stirring remained until a homogenous fluid free of precipitate was created. The produced ChCl:TEPA DESs were stored in airtight bottles at ambient temperature (Pishro et al., 2021). Next, ChCl and EG were mixed at a mole ratio of 1:2 and stirred continuously at 353.15K until a homogeneous, colourless liquid was formed (Cheng et al., 2022). The structure of both DESs is shown in Table 2.1. The structure was confirmed via FTIR. The DESs were scanned for wavelength from 4000–5000 cm^{-1} to examine the sample's structural and functional group (Wang et al., 2021). Moreover, DESs were also characterized through FTIR analysis to study its functional group before and after CO_2 absorption process.