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ABSORPTION OF CARBON DIOXIDE USING GLYCEROL BASED DEEP EUTECTIC SOLVENT

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Nowadays, the rise of CO_2 emissions in the air plays an important role in global warming. Therefore, it is important to control the concentration of carbon dioxide. The binary system was prepared to absorb carbon dioxide gases. This system consists of a deep eutectic solvent and morpholine. A deep eutectic mixture was synthesized with ammonium chloride as a hydrogen bond acceptor and glycerol as a hydrogen bond donor. The HBA/HBD were mixed at room temperature, and the molar ratios of 1:6. The volume ratios of Morpholine/DES were taken as 1:1. The absorption capacity of DES/morpholine was evaluated in 1 hour. The results showed that this type of binary system has selective capture of the carbon dioxide.

Keywords: Deep eutectic solvents, CO_2, absorption, NMR

INTRODUCTION

As we know, more than 80% of energy is produced by the combustion of fossil fuels. Burning motor fuels, coal tar and natural gas especially increases hazardous pollutants such as SO_2, NOx, and CO_2. Many of the scientists claim that greenhouse gases cause global warming. The most important among them is carbon dioxide. The increase in CO_2 emissions can cause climate change. The concentration of CO_2 in the atmosphere has been limited to 350 ppm. Despite this, the Intergovernmental Panel on Climate Change (IPCC) predicts that it will rise to 570 ppm by 2100 [1-5].

For future environmental protection, more attention should be paid to the capture and storage of CO_2. Therefore, new technologies are being investigated for the capture of carbon dioxide. The solvent absorption method is widely used to reduce CO_2 emissions by different absorbents. One of them is called Deep eutectic solvents. DESs can be prepared easily by mixing at room or no higher temperatures. The components of DESs (HBD and HBA) are cheap and non-toxic materials. They are considered a new class of “green” solvents of the 21st century [6-10]. Depending on their structure, Deep eutectic mixtures can absorb or separate hazardous gases by physical and chemical absorption [11-17].

In this study, we prepared a new type of glycerol-based deep eutectic solvent. Glycerol is hydrogen bond donor and ammonium chloride is hydrogen bond acceptor of DES. The ability of CO_2 absorption was studied at room temperature by using of DES : morpholine = 1:1 mixture. The process continued for 1 hour. The removal efficiencies were confirmed by NMR analysis.

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EXPERIMENTAL

Chemicals

Ammonium chloride, glycerol, morpholine, natrium sulfate and hydrogen chloride (37%) were supplied by Sigma-Aldrich (Germany).

Preparation of DES

Ammonium chloride/glycerol were chosen as the hydrogen bond acceptor and hydrogen bond donor of eutectic mixtures. HBA and HBD were mixed at the molar ratio of 1:6. The preparation process was carried out at room temperature. The mixing process finished till a homogeneous liquid appeared.

Experimental procedure

CO_2 absorption experiments by the NH_4Cl/6Glycerol were studied in presence of morpholine. Carbon dioxide was obtained by the reaction of sodium sulfate and hydrogen chloride. DES and morpholine were mixed at the volume ratios of 1:1. After intensive absorption of carbon dioxide, the sorbent was investigated by NMR.

NMR analysis

NMR experiments have been performed on a BRUKER FT NMR spectrometer (UltraShieldTM Magnet) AVANCE 300 (300.130 MHz for ^1H) with a BVT 3200 variable temperature unit in 5 mm sample tubes using Bruker Standard software (TopSpin 3.1). The ^1H chemical shifts were referenced to internal tetramethylsilane (TMS); the experimental parameters for ^1H: digital resolution = 0.23 Hz, SWH = 7530 Hz, TD = 32 K, SI = 16 K, 900 pulse-length = 10 μs, PL1 = 3 dB, ns-= 1, ds= 0, d1 =1 s. NMR-grade D_2O was used for the analysis of sorbent.

RESULTS AND DISCUSSION

A new type of eutectic mixture based on glycerol and ammonium chloride was prepared and studied as an absorbent of carbon dioxide. DES (NH4Cl/6Glycerol) and morpholine were mixed at a volume ratio of 1:1. The absorption efficiency of the DES and morpholine mixture was investigated at room temperature.

First, from the reaction of sodium sulfate and hydrogen chloride, CO2 was obtained. The formed H2O is absorbed by the presence of dried natrium sulfate. On the other side, carbon dioxide is captured by DES/morpholine. NMR (Figure 1) and gravimetric analysis results showed that the absorption efficiency of CO2 was 17%. A schematic illustration of the process is described in Figure 2.

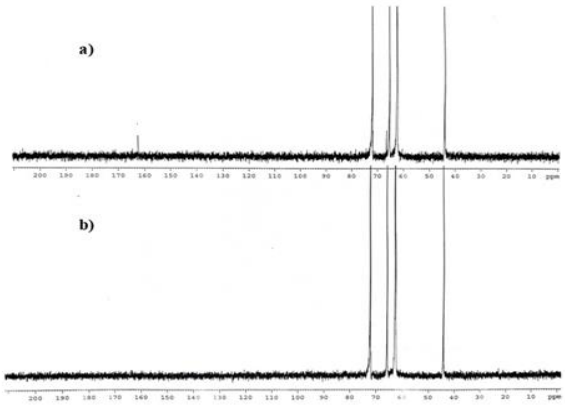

Figure 1. ^{13}C NMR analysis for CO_2 absorption of (a) before and after (b).

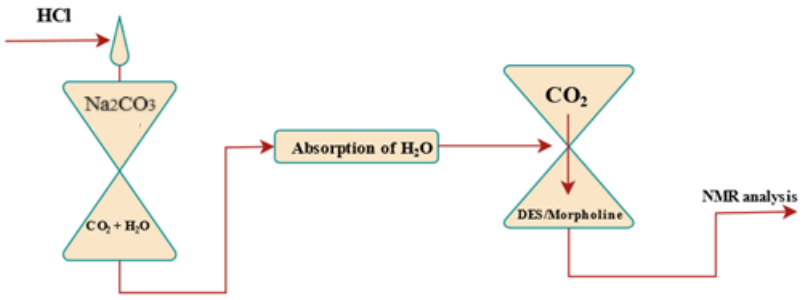

Figure 2. Schematic illustration of CO_2 removal by DES.

Morpholine is recognized as a medium-light solvent. İn this system, morpholine is utilized to augment the absorption capacity and important roles have deep eutectic solvent (DES), which enhances the stability and selectivity of the absorber. This process operates through both physical and chemical absorption mechanisms. The DES facilitates physical absorption, while morpholine contributes to the chemical absorption within the capturing system.

CONCLUSION

In this work, ammonium chloride as HBA and glycerol as HBD were used to prepare a new deep eutectic mixture. The molar ratios of NH_4Cl and Glycerol were taken as 1:6. The morpholine was mixed with DES to improve the performance of carbon dioxide absorption. The volume ratios of DES and morpholine were chosen as 1:1. The absorption process was continued for 1 hour.

The capturing result of this binary system showed a high absorption capacity for carbon dioxide. The absorption efficiency of CO_2 was 17 %. According to NMR analysis, we can say that, DES and morpholine mixture has a good potential ability for CO_2 absorption.

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