Chemical Data Collections 2 (2016) 25–35

Contents lists available at ScienceDirect

Chemical Data Collections

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Data Article

Kinetic performance of ionic liquid – diethanolamine system for CO_2 absorption

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ARTICLE INFO

Article history:
Received 15 March 2016
Revised 18 May 2016
Accepted 19 May 2016
Available online 28 May 2016

Keywords:
Carbon dioxide capture
CO_2 absorption
Ionic liquid
DEA
Stopped-flow

ABSTRACT

Ionic liquid 1-Butyl-3-methylimidazolium bis(trifluoromethyl sulfonyl)imide ([bmim][Tf_2N]) and diethanolamine (DEA) blend in hexanol was examined experimentally to provide a dual solvent with high absorption capacity and low regeneration energy for post combustion CO_2 absorption. For this purpose, kinetic parameters of the system with respect to termolecular reaction mechanism were determined by stopped-flow experiments. Activation energy of the reaction between the solvent and CO_2 was found to be 58.89 kJ/mol. In addition, experiments were carried out in a gas-liquid reactor and the loading capacity and the initial absorption rate of 10 wt % [bmim][Tf_2N]-15 wt % DEA system were found to be 0.43:1 mol ratio of CO_2: DEA and 1.66×10^{-5} kmol/m^2s, respectively. Cyclic absorption-desorption behavior of the solvent and its desorption achievement were also investigated briefly.

Abbreviations: CO2, Carbon dioxide; DEA, Diethanolamine; FTIR, Fourier transform infrared spectroscopy; IL, Ionic liquid; MFC, mass flow controller; MFM, mass flow meter; N2, Nitrogen; TMG, 1,1,3,3- Tetramethyl guanidine; [bmim][Tf2N], 1-Butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide.

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http://dx.doi.org/10.1016/j.cdc.2016.05.001
2405-8300/

Specifications table

Subject area	*Chemical engineering*
Compounds	*Carbon dioxide, [bmim][Tf_2N], DEA, 1-Hexanol*
Data category	*Synthesized*
Data acquisition format	*Stopped Flow Outputs, CO_2 absorption/desorption data, FTIR spectrum*
Data type	*Analyzed*
Procedure	*Rate constants obtained from stopped flow equipment using conductivity detection. CO_2 absorption/desorption data from a gas-liquid reactor to evaluate loading for a hybrid solvent. Regenerability by FTIR analysis*
Data accessibility	*All data are with this article*

1. Rationale

Control of CO_2 amount in the atmosphere is an urgent issue due to its greenhouse gas effect on environment. Currently there are several on-going aqueous amine-based carbon dioxide capture projects and properties of these solvents have been widely studied and the detailed reviews are available [1–3]. Indeed, aqueous alkanolamine solutions are currently used for CO_2 capture in process and power industries [4]. However there are certain detriments of these aqueous solutions, such as their high energy requirements [5]. For instance, if 30 wt percent aqueous mono-ethanolamine is used, to remove 1 kg CO_2 approximately 3800–5400 kJ is needed. High corrosivity of aqueous alkanolamine solutions is another pitfall which limits the concentration of commonly known amines to a maximum of about 20–30 wt percent [6].

In order to overcome these existing problems of aqueous solutions, several novel solvents have been proposed. For instance, certain ionic liquids –mostly imidazolium based- have been suggested [7,8]. As a CO_2 capture solvent, they provide high CO_2 solubility, non-corrosiveness and high thermal stability which can be an advantage for the regeneration process [9–11]. However low CO_2 absorption rate of ordinary ionic liquids restricts their usage as a single solvent [12].

In order to increase both the capacity and the reaction rate, ionic liquids have been functionalised by certain amine groups [13]. Another approach is to use ionic liquids together with common alkanolamines [14]. Here, it is envisaged that such a blend may be non-corrosive and non-volative as well as a requiring low regeneration energy while possessing favorable absorption characteristics. For instance, Hasib-ur-Rahman et al. have found that corrosion rate of the DEA/[hmim][Tf_2N] system which is nearly 10^5 times lower than that of aqueous DEA [15]. Ahmady et al. have studied the kinetics of CO_2 absorption into aqueous MDEA/[bmim][BF_4] solutions and found that the addition of IL significantly decreases the activation energy [16]. Lu et al. have studied the CO_2 absorption performance of aqueous MEA/[bmim][BF_4] solutions where they observed that the hybrid system shows higher absorption capacity than the pure MEA solution. Also they investigated the cyclic regeneration behaviour of the hybrid system and found that the addition of IL resulted with high thermal stability [17]. Shan-Tung Tu et al. investigated the absorption performance of aqueous MEA/[bmim][BF_4] solution by using a membrane module as the absorber. They showed that the regeneration energy requirement is 37.2% lower than pure MEA solution. Further, MEA loss was found to be 75% less when compare with the amine solution alone [18].

Almost all of the previous studies involve aqueous solutions of an IL and an alkanolamine which still leads to detrimental re-boiler duty. As a new approach, this study proposes a non-aqueous hybrid system consisting of an IL and DEA in hexanol.

2. Procedure

Specifically, the aim of this work is to obtain intrinsic rate data of reaction between CO_2 and [bmim][Tf_2N]-DEA system in hexanol medium by a stopped flow technique. In addition, the cyclical behaviour of absorption-desorption of this system was studied by using a stirred gas-liquid contactor which resulted also absorption capacity and the initial absorption rate of this hydrid system. Hexanol was chosen because of its high boiling point so that the regeneration may be possible without neces-