Chemical Engineering Journal 214 (2013) 355–363

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Absorption of CO_2 by amino acid-functionalized and traditional dicationic ionic liquids: Properties, Henry's law constants and mechanisms

Yi Zhang, Ping Yu, Yunbai Luo *

College of Chemistry and Molecular Sciences, Wuhan University, Wuhan 430072, China

HIGHLIGHTS

- Six novel dicationic ionic liquids (DILs) were synthesized and characterized.
- Henry's law constants of CO_2 in DILs were calculated for the first time.
- Different absorption rate curves accounted for 1.0 and 2.0 molar ratio.
- High temperature dissatisfied chemical absorption in AA-DIL solution.
- Mechanism was verified by NMR and FT-IR.

ARTICLE INFO

Article history:
Received 8 August 2012
Received in revised form 9 October 2012
Accepted 9 October 2012
Available online 10 November 2012

Keywords:
Dicationic functionalized ILs
Henry's law constant
CO_2 absorption rate
Mechanism

ABSTRACT

Six dicationic ionic liquids (DILs) were synthesized, including four amino acid-functionalized DILs (AA-DILs) and two traditional DILs (T-DILs), and were found to be effective for CO_2 capture as reversible absorbents. Their physical properties were measured, containing density, conductivity, thermal decomposition temperature, glass transition temperature and viscosity. Their CO_2 absorption behaviors under different pressures and temperatures with various water contents were also investigated. The results showed that the CO_2 absorption capacities of pure AA-DILs were enhanced heavily compared to other monocationic ionic liquids. Mixing AA-DIL and water could be combined in a more rapid and efficient manner for CO_2 gas capture, superior to the use of pure DIL only, due to their visible decrease in viscosity. The effect of temperature on CO_2 absorption by aqueous AA-DIL mixtures at ambient pressure was extremely obvious: when temperature rose from 30 to 50 °C, the capacity of the 60 wt% $[Bis(mim)C_4][Pro]_2$ solution decreased from 1.52 to 0.78 mol/mol; as the pressure rose up to 10.0 bar, the total maximal capacity also dropped by more than a half. On the other hand, the two traditional DILs also exhibited an excellent physical absorption compared to varieties of monocationic ionic liquids.

1. Introduction

Carbon dioxide is the main greenhouse gas in the atmosphere, responsible for the global warming. The CO_2 emissions significantly from fossil fuels and petroleum industries can be substantially reduced by capturing and storing CO_2. Chemical absorption of CO_2 using aqueous alkanolamine solutions is considered as a proven technology for CO_2 capture due to the advantage of high reactivity and low solvent cost, especially the widely use of blend amine systems increasingly improves the absorption capacity and absorption rate [1]. However, the application of aqueous alkanolamines to the CO_2 absorption process faces some obstacles, such as loss of sorbents caused by volatilization, regeneration fee, corrosions of equipments and oxidative degradation [2–4].

Recently, ionic liquids, organic salts with a low melting point, high thermal stability, negligible vapor pressures, nonflammable, and nontoxic, have been emerging as reversible absorbents for CO_2 removal [5,6]. A diverse range of ionic liquids are formed with imidazolium, pyridinium, tetraalkylammonium, phosphonium as cations, and trifluoromethanesulfonate ($[TFO]^-$), tetrafluoroborate ($[BF_4]^-$), hexafluorophosphate ($[PF_6]^-$), bis(trifluoromethylsulfonyl)amide ($[Tf_2N]^-$) as anions. Bates et al. [7] synthesize task-specific functionalized ionic liquids by incorporating amine group into ionic liquids, the absorption mechanism between CO_2 and an ionic liquid containing amino functionalized group is also proposed. Zhang and co-workers [8] prepare several (3-aminopropyl)tributylphosphonium amino acid salts ($[aP_{4443}][amino\ acid]$), approaching 1.0 mol CO_2 per mol ionic liquid in chemical absorption after being

* Corresponding author. Tel./fax: +86 27 68752511.
E-mail address: ybai@whu.edu.cn (Y. Luo).

1385-8947/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.cej.2012.10.080