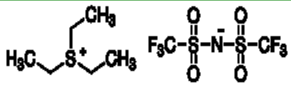
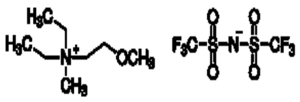
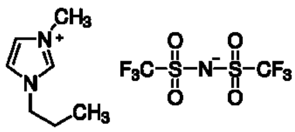
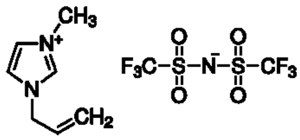
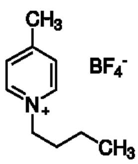
thermal stability, and structural tuneability make ionic liquids environmentally benign and appropriate for gas separation without solvent loss or contamination of vapour phase as well as being able to be tailored for specific applications. Nonetheless, for some, the high viscosity of ionic liquids is regarded as a very important drawback especially during CO_2 absorption, leading to a reduction of overall mass transfer rate and an increment in power requirement for pumping and mixing (Carvajal et al., 2012). Accordingly, the understanding of the solubility of gases in the ionic liquid phase and the selection of low-viscosity ionic liquids are prerequisites to their selection as potential solvents for CO_2 capture. In this research, the solubilities of CO_2 in five novel ionic liquids: triethylsulfonium bis(trifluoromethylsulfonyl)imide ([S_{222}][Tf_2N]), diethylmethyl(2-methoxyethyl)ammonium bis(trifluoromethyl sulfonyl)imide ([deme][Tf_2N]), 1-propyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide ([pmim][Tf_2N]), 1-allyl-3-methylimidazolium bis(trifluoromethylsulfonyl) imide ([amim][Tf_2N]), and 1-butyl-4-methylpyridinium tetrafluoroborate ([4mbp][BF_4]) were measured using a gravimetric microbalance (IGA-003). Our experimental CO_2 solubility data in the investigated ionic liquids were compared to data published in the literature for other ionic liquids. Henry's law constants for the ionic liquid + CO_2 systems studied were also reported.

2. Materials and methods

2.1 Materials

Ionic liquid samples were ordered from Sigma-Aldrich Ltd. Table 1 lists their names, abbreviations, chemical structures, purities, and CAS numbers. Carbon dioxide (CO_2) as research grade was purchased from Praxair Products Inc. with a purity of 99.99 %.

Table 1: Ionic liquids investigated in this work

Ionic liquids	Abbreviation	Chemical structure	Purity	CAS Number
Triethylsulfonium bis(trifluoromethylsulfonyl) imide	[S_{222}][Tf_2N]		≥99.0 % (NMR)	321746-49-0
Diethylmethyl(2-methoxyethyl)ammonium bis(trifluoromethylsulfonyl) imide	[deme][Tf_2N]		≥98.5 % (T)	464927-84-2
1-Propyl-3-methylimidazolium bis(trifluoromethylsulfonyl) imide	[pmim][Tf_2N]		≥98.0 % (H-NMR)	216299-72-8
1-Allyl-3-methylimidazolium bis(trifluoromethylsulfonyl) Imide	[amim][Tf_2N]		≥98.5 % (HPLC)	655249-87-9
1-Butyl-4-methylpyridinium tetrafluoroborate	[4mbp][BF_4]		≥97.0 % (T)	343952-33-0

2.2 Experimental set-up and procedures

Gas solubility measurements were performed using a gravimetric microbalance (Hiden Isochema Ltd, IGA-003). The microbalance is composed of a sample bucket containing the liquid and counter weight components inside a stainless steel pressure-vessel. The stainless steel (SS316N) reactor is able to operate up to 20 bar and 500 °C. In the experiment, approximately (65 to 75) mg of ionic liquid sample were loaded to the sample container and the reactor was installed. After waiting for stability, the thermostat was then attached to the reactor and the external water jacket was connected. The sample was dried and degassed by fully evacuating the reactor to 10 - 8 bar. While performing ultra-high vacuum, the sample was heated to approximately 70 - 75 °C for at least 10 h by the water jacket connected to a constant-temperature bath. The sample weight slowly decreased since trace amounts of water and other volatile solvents were removed. Once the sample weight had stabilized for at least 60 min, the sample dry weight

4. Results and discussion

Experimental solubility isotherms of five ionic liquids including [S_{222}][Tf_2N], [deme][Tf_2N], [pmim][Tf_2N], [amim][Tf_2N], and [4mbp][BF_4] were measured at 313.15, 323.15 and 333.15 K at different pressures up to 20 bar using an Intelligent Gravimetric Analyzer (IGA-003) manufactured by Hiden Isochema. A graphical representation of our solubility data in Figure 1 is presented, where solubility data is shown as a function of pressure at different temperatures for all of the studied ionic liquids. Solubilities of CO_2 in the ionic liquids are dramatically affected by temperature and pressure. The solubility decreases as temperature increases and pressure decreases.

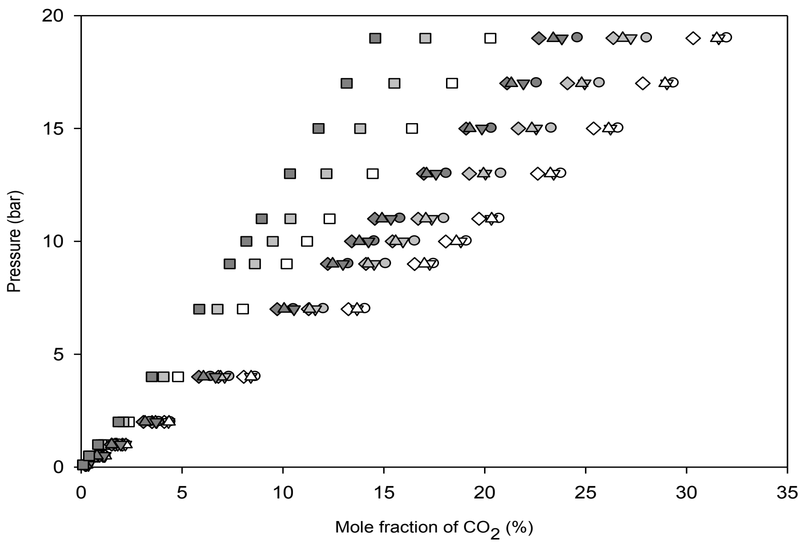


Figure 1: Comparison of measured isothermal solubility data of CO_2 in different ionic liquids: ■, [4mbp][BF_4]; ♦, [S_{222}][Tf_2N]; ▲, [amim][Tf_2N]; ▼, [pmim][Tf_2N]; ●, [deme][Tf_2N]; white, at 313.15 K; gray, at 323.15 K; dark gray, at 333.15 K

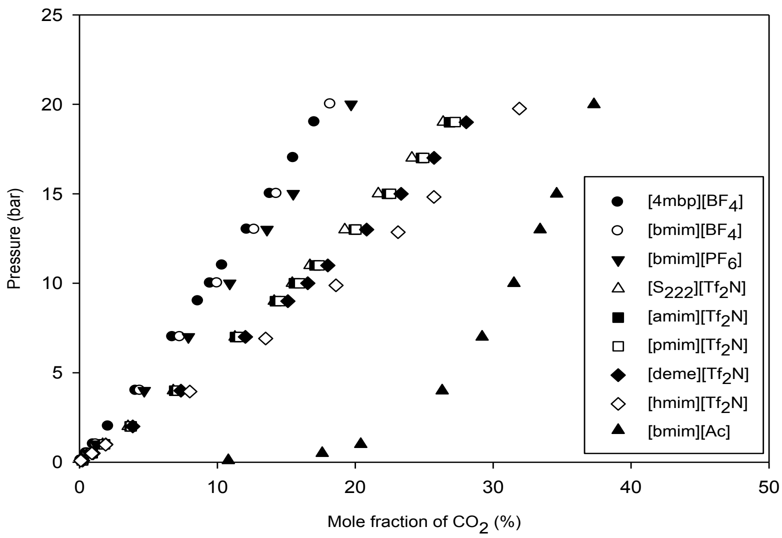


Figure 2: Comparison between the solubility of CO_2 in the studied ionic liquids and the published ones in the literature at 323.15 K: ●, [4mbp][BF_4] (This work); ○, [bmim][BF_4] (Shiflett and Yokozeki, 2005); ▼, [bmim][PF_6] (Shiflett and Yokozeki, 2005); ∆, [S_{222}][Tf_2N] (This work), ■, [amim][Tf_2N] (This work); □, [pmim][Tf_2N] (This work); ♦, [deme][Tf_2N] (This work); ◊, [hmim][Tf_2N] (Shiflett and Yokozeki, 2007); ▲,[bmim][Ac] (Shiflett et al., 2008)

Table 2: Henry's law constants for CO_2 in the studied ionic liquids

Ionic liquids	$H_{2,1}$ (bar)		
	313.15 K	323.15 K	333.15 K
$[S_{222}][Tf_2N]$	44.6	54.7	62.4
$[deme][Tf_2N]$	41.8	49.8	56.9
$[pmim][Tf_2N]$	43.3	52.5	55.1
$[amim][Tf_2N]$	43.8	54.3	60.8
$[4mbp][BF_4]$	82.7	97.1	111.5

5. Conclusion

Measurements of CO_2 solubility in five ionic liquids, triethylsulfonium bis(trifluoromethylsulfonyl)imide ($[S_{222}][Tf_2N]$), diethylmethyl(2-methoxyethyl)ammonium bis(trifluoromethylsulfonyl)imide ($[deme][Tf_2N]$), 1-propyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide ($[pmim][Tf_2N]$), 1-allyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide ($[amim][Tf_2N]$), and 1-butyl-4-methylpyridinium tetrafluoroborate ($[4mbp][BF_4]$) were reported at three temperatures (313.15, 323.15 and 333.15 K) and at pressures up to 20 bar using a gravimetric microbalance. For all ionic liquids studied, the solubility decreased as temperature increased and pressure decreased. The trend of the investigated ionic liquids in terms of solubility of CO_2 was reported as: $[deme][Tf_2N]$ > $[pmim][Tf_2N]$ > $[amim][Tf_2N]$ > $[S_{222}][Tf_2N]$ > $[4mbp][BF_4]$. The four ionic liquids ($[deme][Tf_2N]$, $[pmim][Tf_2N]$, $[amim][Tf_2N]$ and $[S_{222}][Tf_2N]$) can be considered promising solvent alternatives for CO_2 capture because of their high physical capacity in absorbing CO_2.

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