High Temperature Carbon Dioxide Capture via Carbonate-Bicarbonate Cycling

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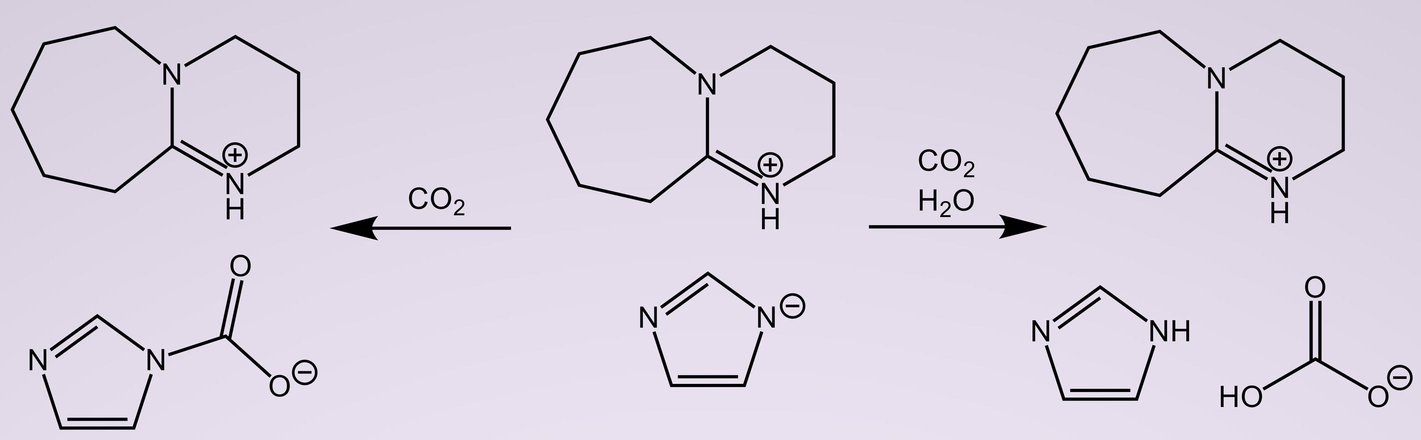
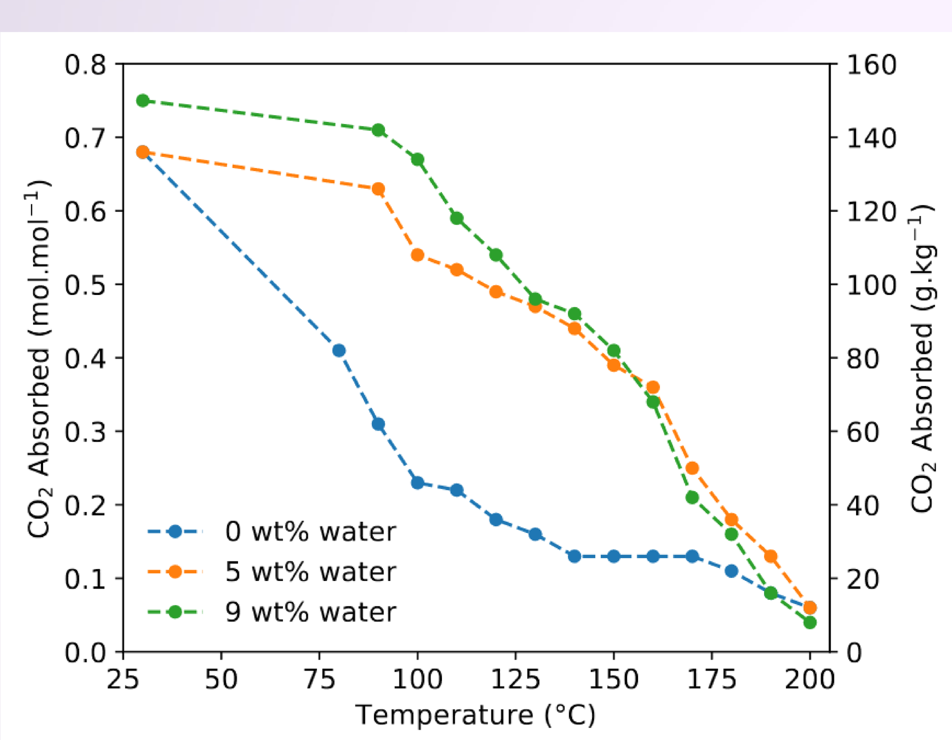
Background

Much of the current research into carbon capture by chemisorbant ionic liquids (ILs) focuses on maximising capacity while reducing the temperature needed for regeneration. Unfortunately, much of this work has been focused on dry gas streams, ignoring the effect of water which has been shown to change the capture mechanism. This work flips that approach, using the water in a flue gas stream to promote a bicarbonate pathway while using the heat to keep the absorbent above the melting point. [DBUH][Im] was used to demonstrate this approach however this IL is known to be sub-optimal.

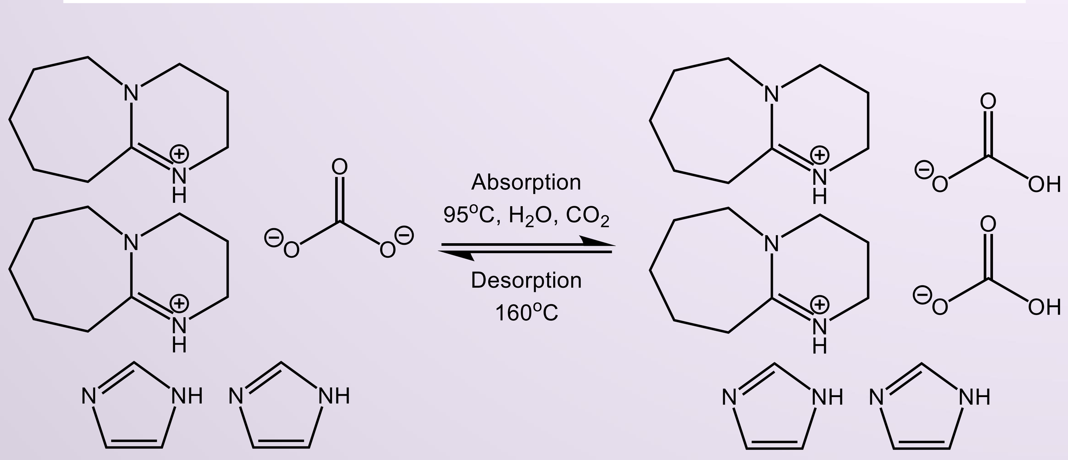
Practical results

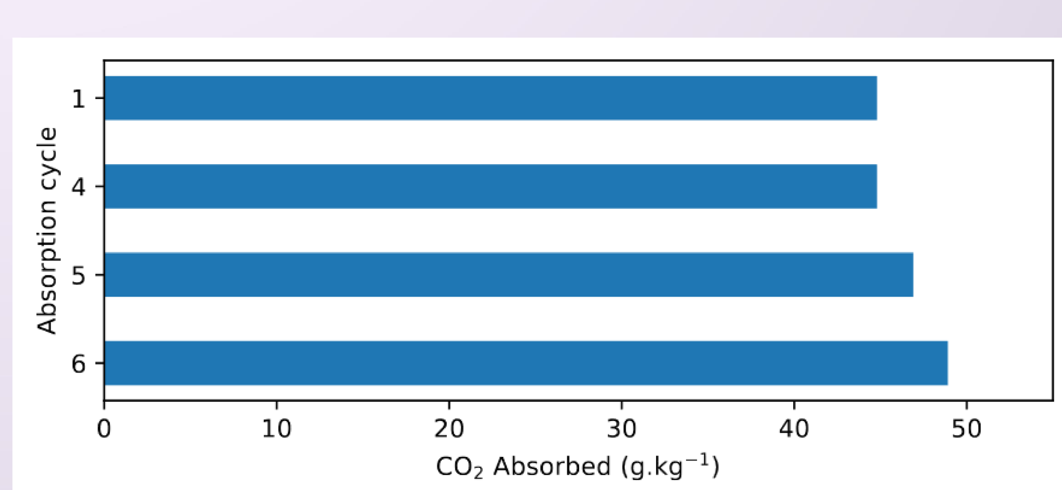


- Under dry, conditions at room temperature the IL forms a carbamate which dramatically increases the viscosity
- In the presence of water, bicarbonate is formed which precipitates as [DBUH][HCO_3] (see right)
- At 95°C and in the presence of water, the precipitate melts and the mixture stays a low viscosity liquid that can absorb ca. 100 g.kg^{-1} of CO_2.



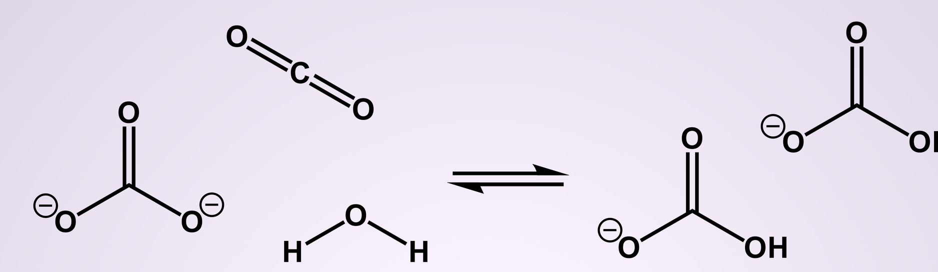
- ~10 wt% water was added to the IL to where it was then heated to 95°C and CO_2 bubbled through the mixture
- Further heating to 160°C then induces thermal decomposition of bicarbonate, releasing half of the CO_2 and forming divalent carbonate (see below)
- Six absorption-desorption cycles were performed under these conditions with a working capacity of ca. 45 g.kg^{-1}, comparable to that of aqueous amines





So… why bother with the imidazole? And anyway, DBU is expensive and not thermally stable to 160°C…

Theory



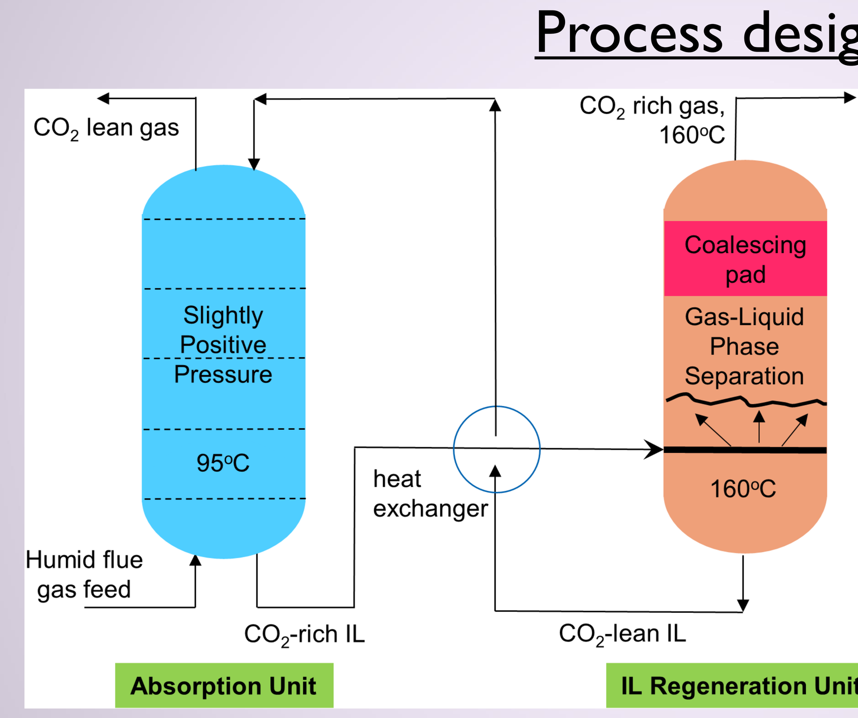
The practical results show that carbonates can absorb CO_2 at relatively high temperatures in the presence of water to form two equivalents of bicarbonate and can be regenerated by further heating

The system needs a cation that:

1. Supresses the melting point
2. Thermally stable to 200°C
3. Low molecular weight

So… What's that cation???

Process design



Based on this work, a process was designed that avoids the need to cool or dry the flue gas stream prior to absorption, significantly saving on OPEX expenditure

Conclusions

1. [DBUH][Im] showed that a high temperature carbonate-bicarbonate capture system is possible but this IL was not optimal
2. The working capacity of this system is comparable to aqueous amines however the specific heat capacity is much lower and the absorbent is less volatile
3. This process negates the need to cool and dry the flue gas stream prior to scrubbing, significantly reducing OPEX

This work has been patented by Chevron and the Work is being continued by Michael Sweeney

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