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Effect of Flue Gas Impurities on the CO₂ Uptake of Superbase Ionic Liquids

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The absorption of CO₂ in a variety of ionic liquids (ILs) has been widely reported in the literature and it is well known that their tunability allows them to reversibly absorb over equimolar amounts of CO₂ in comparison to other solvents.[1] This high CO₂ capacity, paired with a low vapor pressure and increased thermal stability, means that they have been proposed as a suitable alternative to the aqueous amine solvents (*e.g.* monoethanolamine) currently used in industrial CO₂ capture plants. ILs have the potential to overcome the disadvantages of volatility, corrosion, and the high energy penalty associated with synthesizing and regenerating MEA. For a sorbent to be used in a separation process it must also be able to withstand poisoning from impurities within the feed stream such as SO₂, NO_x and water. Currently, literature focuses on the capture of a single gas by ILs, and very little is known about the competitive absorption of CO₂, SO₂, and NO_x. In this work, an experimental set up employing mass spectrometry was designed to study the competitive absorption of CO₂ with the impurities SO₂, NO₂, or NO, using superbase ILs with a trihexyltetradecylphosphonium cation, and 1,2,4-triazolide or benzimidazolide anion ([P₆₆₆₁₄][124Triz]/[P₆₆₆₁₄][Benzim]).

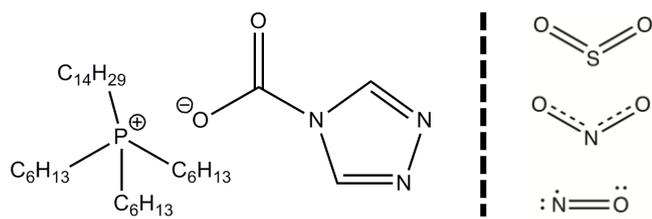


Figure 1. Chemical absorption of CO₂ to the [124Triz]⁻ anion.

Repeated absorption cycles of industrially relevant gas concentrations (14 % CO₂ and 0.2 % impurity) are studied, showing how the CO₂ uptake of the IL is affected by repeated exposure to SO₂, NO₂ and NO. *In situ* infrared (IR) spectroscopy has been carried out to aid understanding of the competitive absorption and desorption mechanism, alongside DFT calculations. Furthermore, the change in physical properties of the ILs has been studied post absorption.

This work has also shown that when a superbase IL absorbs CO₂, it does so both physically and chemically (Figure 1). The change in geometry of the CO₂ molecule after chemical absorption lowers the activation energy required to electrochemically reduce CO₂, producing 0.05 mmol of formate at an applied potential of 0.17 V and 95 % FE with a silver working electrode.[2] Further results will be presented on the effect of these impurities on the reduction products.

Results show that in the superbase ILs studied, CO₂ can compete with low concentrations of gaseous impurities, depending on the type of impurity and the IL used, evidenced using IR. This work provides a crucial understanding of how these types of ILs would behave in a realistic, industrial CO₂ capture setting. A subsequent process will then be proposed, whereby the captured CO₂ can be transformed into value-added chemicals and feedstocks.

Acknowledgments

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References

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