Surfactant addition to alkali solutions for increased carbon dioxide absorption rates

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Abstract

To meet the growing need for CO₂ capture and storage technology, Michigan Technological University is studying CO₂ capture using alkali-based solvents. The objective of the present study was to find a way to increase the absorption rate of CO₂ into an alkali solution without reducing the absorption capacity of the solution. One approach to increasing absorption rate is to use a surfactant to chemically alter the gas bubble size. The surfactant chosen for the study was a neutral-charge polypropylene glycol methyl ether (PPGME) with a molecular weight of 200. Experiments were conducted to study the absorption rate of CO₂ at varying surfactant concentrations. Results showed that as the concentration of PPGME increased in solution, the absorption rate also increased. The CO₂ absorption rate increased from 3.45×10^{-3} mol/min CO₂ at 0 g/L PPGME to 3.92×10^{-3} mol/min CO₂ at 0.48 g/L PPGME. This amounted to a 14% increase in the CO₂ absorption rate with no decrease in the absorption capacity of the solution.

Key words: Carbon dioxide, Capture, Absorption, Surfactant

Introduction

Chemical absorption using an amine solvent is currently the most mature carbon capture and storage technology available. Amines are advantageous in that they have a fast CO₂ absorption rate, which leads to a high CO₂ removal efficiency. However, amine absorption has some considerable drawbacks, such as high energy requirements, high equipment corrosion rates, amine degradation in the presence of oxygen, high waste generation and a large increase in plant footprint if new equipment is constructed (Herzog and Golomb, 2004; D'Alessandro et al., 2010). Due to these drawbacks, Michigan Technological University (MTU) is studying CO₂ absorption using alkali-based solvents, which address the above disadvantages of amine solvents.

However, the CO₂ absorption rate in alkali solvents (e.g., a potassium carbonate solution) is perceived to be slow in comparison to amine solvents. It is believed that rate-increasing additives will need to be identified for CO₂ capture with alkali solvents to be feasible. The focus of this study is to identify a surfactant that can increase the CO₂ absorption rate into an alkali solution without adversely impacting the absorption capacity of the solution. For the present study, CO₂ was bubbled through an alkali solution with varying concentrations of a polypropylene glycol methyl ether (PPGME). By knowing the inlet and outlet volumetric flowrates of CO₂, the moles of CO₂ absorbed was calculated as the difference between moles of CO₂ in the exhaust stream and the moles of CO₂ in the feed stream. The PPGME surfactant was chosen because it reduces the gas bubble size distribution and average bubble diameter. This would thereby increase the gas-liquid interfacial area, in theory increasing the CO₂ absorption rate. Thus, objectives of the study include the following: 1) examine the effect of PPGME on the CO₂ absorption rate and 2) examine the effect of PPGME on the CO₂ absorption capacity of the solution.

Results and discussion

Experiments were conducted to study the absorption rate of CO₂ in the alkali solvent at varying surfactant concentrations of 0, 0.12, 0.24, 0.36 and 0.48 g/L. Results show that the addition of

PPGME to the alkali solution increased the absorption rate of CO₂. Initially, at 0.12 g/L PPGME, a significant increase in absorption rate was seen. However, above 0.12 g/L PPGME, diminishing returns were seen with respect to increasing the absorption rate. This shows that a substantial increase in absorption rate can be achieved at a relatively low surfactant concentration. Results also show a negligible decrease in the CO₂ absorption capacity of each solution. The absorption capacity of each solution can be seen in Fig. 1 as the last data point on each curve.

References

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Figure 1 — CO₂ absorption in a 2% (w/w) alkali solution with varying concentrations of PPGME in solution. As the concentration of PPGME increased, the absorption rate of CO₂ also increased, and the CO₂ absorption capacity of the solution remained constant. Trials were repeated in triplicate. The error bars represent one standard deviation from the average.

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