

A comparison of different amino acid solutions for CO₂ capture using a membrane contactor

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Highlights

- Comparison of performance of five different amino acids with membrane contactor.
- Similar performance between arginine and NaOH solvents.
- Better performance of amino acid salts than amino acids alone.

1. Introduction

The growing concern about the global warming has triggered the public attention to the main greenhouse gas contributor namely carbon dioxide (CO₂) [1]. The most extended post combustion CO₂ capture technologies rely on absorption columns. Alkanolamines are typical solvents due to low cost and high absorption rates [2]. However, amine-based systems have high energy requirements for solvent regeneration and large solvent losses due to amine vaporization [3]. Lower energy consumption would be achievable using a different kind of technology: membrane contactors, which also allow an ease control of operating conditions, large contact area and scale-up flexibility [4]. In addition, the use of novel absorption solvents have been proposed in membrane contactors. For example, solvents with similar functionality as amines, such as amino acid salts (AAS) [5,6]. AAS are positively characterized by their high surface tension, non-volatility, etc., and their kinetics is defined by zwitterion reaction [7]. While an amino acid is initially inactive in the solution, it can be activated by addition of sodium hydroxide (NaOH), potassium hydroxide (KOH) and sodium carbonate (Na₂CO₃) [8,9].

In this work, five different amino acids have been studied for CO₂ capture. The CO₂ capture feasibility is studied in the membrane contactor using the amino acid salts solutions as the solvent, activated with NaOH. The process performance using the amino acids was compared to that using only NaOH in solution.

2. Methods

Serine (Alfa Aesar, >95%), methionine (Sigma Aldrich, >98%), Arginine (Sigma Aldrich, 99%), 6-aminohexanoic acid (Alfa Aesar, 99%) and Valine (Acros Organics, 99%) and sodium hydroxide (VWR, >98 %) were acquired and used without further purification. All amino acids were neutralized with an equilibrium molar amount of sodium hydroxide.

A hollow fiber membrane contactor (MiniModule 1x5.5 G543, liquid-Cel, Membrane GmbH, Germany) was used for the chemical absorption process. The inlet and outlet volume percentage



of CO₂ was measured via the CO₂ gas analyzer (Rosemount™ X-stream enhanced XEGK continuous gas analyzer, Emerson, Germany).

3. Results and discussion

The overall mass transfer coefficient (K_{ov}) and process performance using amino acids and amino acid salts were studied. All amino acids saturated shortly after the start of experiments except arginine. The results could be explained since acid dissociation constant (pKa) for some amino acids is low. However, similar performance of arginine to NaOH is related to their comparable high pKa values.

The amino acid absorption improves after the activation with a base. As all amino acid have a primary amine group for the CO₂ capture, it is expected to observe a similar performance when they are activated. However, not all amino acids show same absorption rate for CO₂ capture, which is related to the difference in structure of amino acids. In addition, the absorption rate is higher when an amino acid is activated with a base that has higher pKa. A stronger base has higher capability of activation of amino acids.

4. Conclusions

This work uses a membrane contactor with amino acid salts for chemical absorption. The performance of different amino acids was compared to NaOH solution based on the mass transfer coefficient. Arginine performed similar to NaOH in the non-active form suggesting its direct application for CO₂ capture.

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