

Rotating Packed Bed with Enzyme Coated Packing for CO₂ Capture and Conversion

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Highlights

- A rotating packed bed has been built using metal mesh and an enzyme coated cloth.
- The pressure drop, residence time and CO₂ capture rate were measured for the new packing design.
- Residence time measurements indicated that the liquid flow was predominantly in the cloth layer.
- The rate of CO₂ capture for the new packing design was comparable with the capture rate for mesh only packing using 30 mas% MEA.

1. Introduction

It has been shown previously that carbonic anhydrase can be used to enhance the rate of CO₂ capture in a rotating packed bed using the tertiary amine n-methyl diethanolamine¹, with the captured carbon dioxide being converted into bicarbonate ions. The capture rate was high making this an attractive option, but fresh enzyme would have to be continually added to the process because it would be denatured during thermal regeneration of the amine to release the captured CO₂. In a new capture process, which forms the basis of the REUSE project² immobilized carbonic anhydrase was used in a rotating packed bed to enhance the formation of bicarbonate ions in the feed amine. The amine will be regenerated in a three-chamber electrolytic cell to produce formic acid. This paper describes work that has been carried out to characterize the RPB containing the enzyme.

2. Methods

The rotating packed bed (RPB) used in this study had an inner diameter of 80mm, and outer diameter of 300mm and an axial height of 20mm. The rotating packed bed was assembled using layers of metal mesh and cloth coated with immobilised carbonic anhydrase. The hybrid packing was clamped between two discs of PEEK and attached to a drive shaft, see Figure 1(a) showing the general arrangement of the rotating packed bed. Rotational speeds for the RPB were in the range of 300 – 1200 rpm. The rotating packed bed was connected to a flow loop that supplied amine and a simulated flue gas to the RPB, see Figure 1(b).

(a) 300mm Diameter RPB

(b) RPB Flow Loop

Figure 1. Rotating packed bed test system

The pressure drop over the RPB was measured between the gas inlet and the gas outlet using a water manometer. Pressure drop data was used to determine the flooding limit of the rotating packed bed and the working flow range of the RPB. The residence time of the liquid in the packing of the RPB was measured by injecting 50ml of 1M NaCl solution at the inner edge of the RPB and recording the response using conductivity probes. The rate of CO₂ absorbance was measured in two ways; (1) Measuring the change of CO₂ concentration between the inlet and outlet gas using an infrared gas analyzer, (2) Measuring the change in CO₂ loading between the amine inlet and outlet by titration³.

3. Results and discussion

(a) RPB Pressure Drop, $G = 0.8 \text{ kg min}^{-1}$ (b) Liquid residence time, injection at time $t = 10 \text{ s}$

Figure 2. Pressure drop and liquid residence time in the new RPB design

Figure 3. Rate of CO₂ absorption as a function of rotational speed. Solid circles enzyme packing, crosses no enzyme

4. Conclusions

The pressure drop increases as the rotational speed decreases, reaching a maximum when flooding occurs. Gas pressure drop increases significantly with liquid flow. The CO₂ absorption rate is lower using enzyme loaded cloth+mesh packing compared to mesh only packing with no enzyme.

References

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Keywords

CCU; rotating packed beds; carbonate forming amines; pressure drop