New carbon capture materials: Novel approaches to post-combustion CO₂ capture

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New carbon capture materials: Novel Approaches to Post-Combustion CO₂ Capture


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Introduction

The most commercially viable capture method in carbon capture and storage (CCS) has been attributed to post-combustion carbon capture using chemical solvents. Although the conventional chemical solvents such as MEA solutions have high selectivity and capture capacity, they are highly corrosive and required high regeneration energy. In addition, volatilisation of MEA at elevated temperature and its release to the atmosphere can lead to major human and environment concerns. In this study two alternative carbon capture materials have been investigated:

- **CO₂ solvent microcapsules** where the CO₂ solvents are encapsulated within a CO₂ permeable polymer shells.
  - Adv. 1. Prevents direct contact of solvents with system.
  - Adv. 2. Reduction in solvent volatilisation.
  - Adv. 3. Provides much larger surface area and consequently increases the capture rate.

- **CO₂ based imprinted polymers** (CO₂-MIPs) where recognition cavities are created within the polymer, based on the target molecules (template)
  - Adv. 2. Stable capture efficiency in present of impurities.
  - Adv. 4. Lower required regeneration energy.

Numerical and Experimental Results

Experimental Setup

![Experimental Setup Diagram](image)

**Experimental Setup**

A fabricated three-phase glass capillary device for production of CO₂ solvent microcapsules. The direction of inner, middle and outer fluid is shown by the blue, green and red arrow, respectively.

![SEM images of CO₂-MIPs morphology as a function choice of initiators](image)

**Numerical and Experimental Results**

![Numerical and Experimental Results](image)

**Numerical and Experimental Results**

Widening jetting

Narrowing jetting

Dripping

![A VOF/CFD Numerical model has been developed and validated with experiments and analytical solutions](image)

**A VOF/CFD Numerical model has been developed and validated with experiments and analytical solutions.**

![Experimental data: the size of inner and outer droplets, and the shell thickness as a function of phase flow rates](image)

**Experimental data: the size of inner and outer droplets, and the shell thickness as a function of phase flow rates.**

Conclusions

Production of two promising carbon capture material was investigated. Regarding the CO₂ solvent microcapsules both experiments and numerical modelling were used to study the effect of flow rates, fluid properties and microfluidic geometry to achieve an active control on the microcapsule size, shell thickness and the number of encapsulated inner droplets. The microcapsules with size over the range of 50-600 µm were produced. Concerning CO₂-MIPs, suspension polymerisation method was used to achieve spherical particles with controllable size over the range of 1-100 µm. The effect of operative parameters on particle morphology has been investigated. Both materials due to wide range of particle size can be used for industrial and domestic applications.