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New carbon capture materials: Novel Approaches to Post-Combustion CO_2 Capture

Seyed Ali Nabavi[a, *], Sai Gu[a], Goran T. Vladisavljevic[b], Stella Georgiado[b]

[a] School of Engineering, Cranfield University, Cranfield MK43 0AL, United Kingdom.
[b] Department of Chemical Engineering, Loughborough University, Loughborough LE11 3TU, United Kingdom.
*E-mail address: s.nabavi@cranfield.ac.uk

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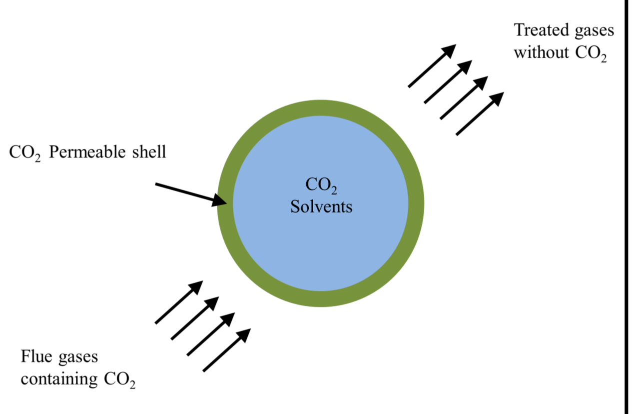
Introduction

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.

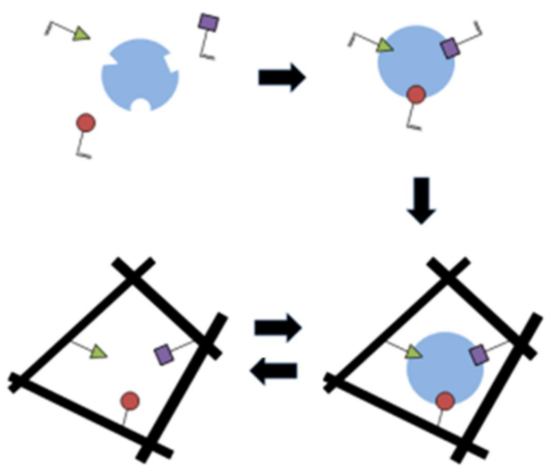
- **CO_2 solvent microcapsules** where the CO_2 solvents are encapsulated within a CO_2 permeable polymer shells.

  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.

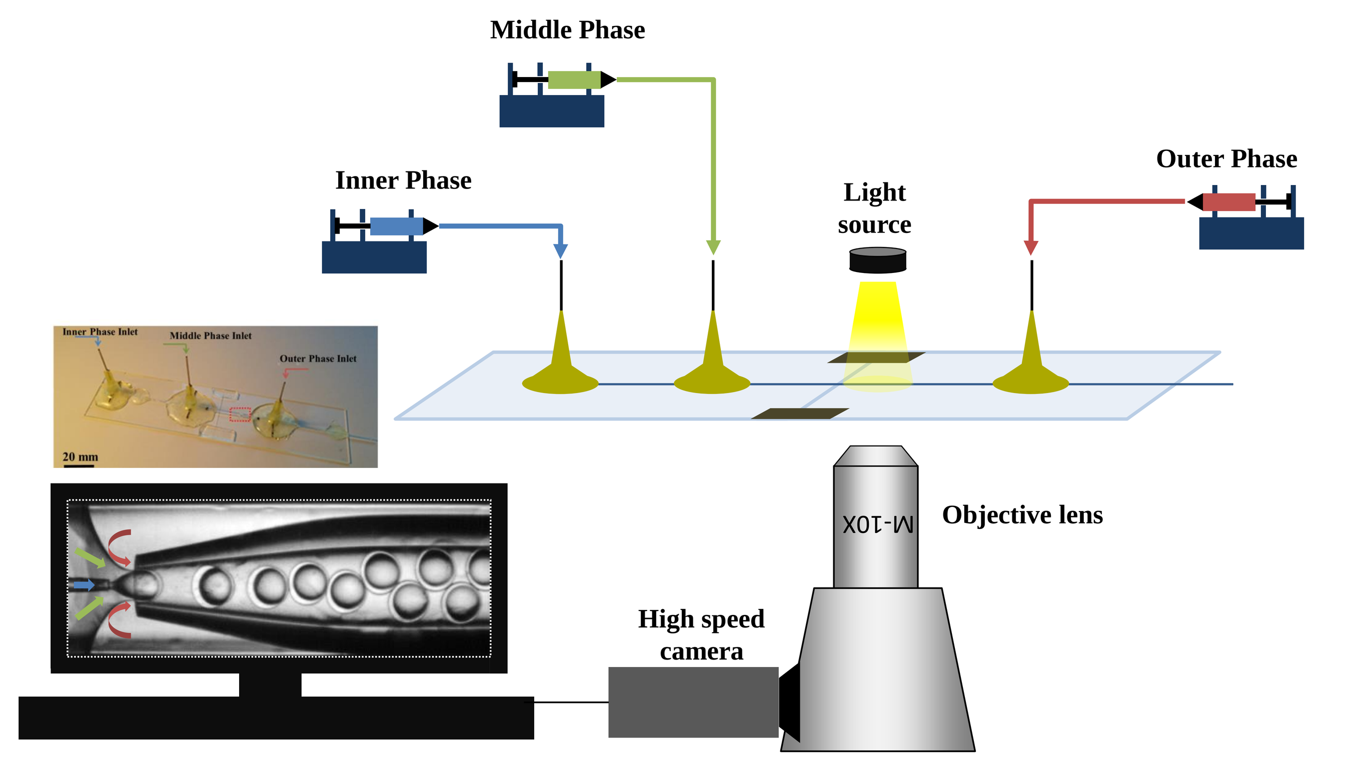


- **CO_2 based imprinted polymers (CO_2-MIPs)** where recognition cavities are created within the polymer, based on the target molecules (template)

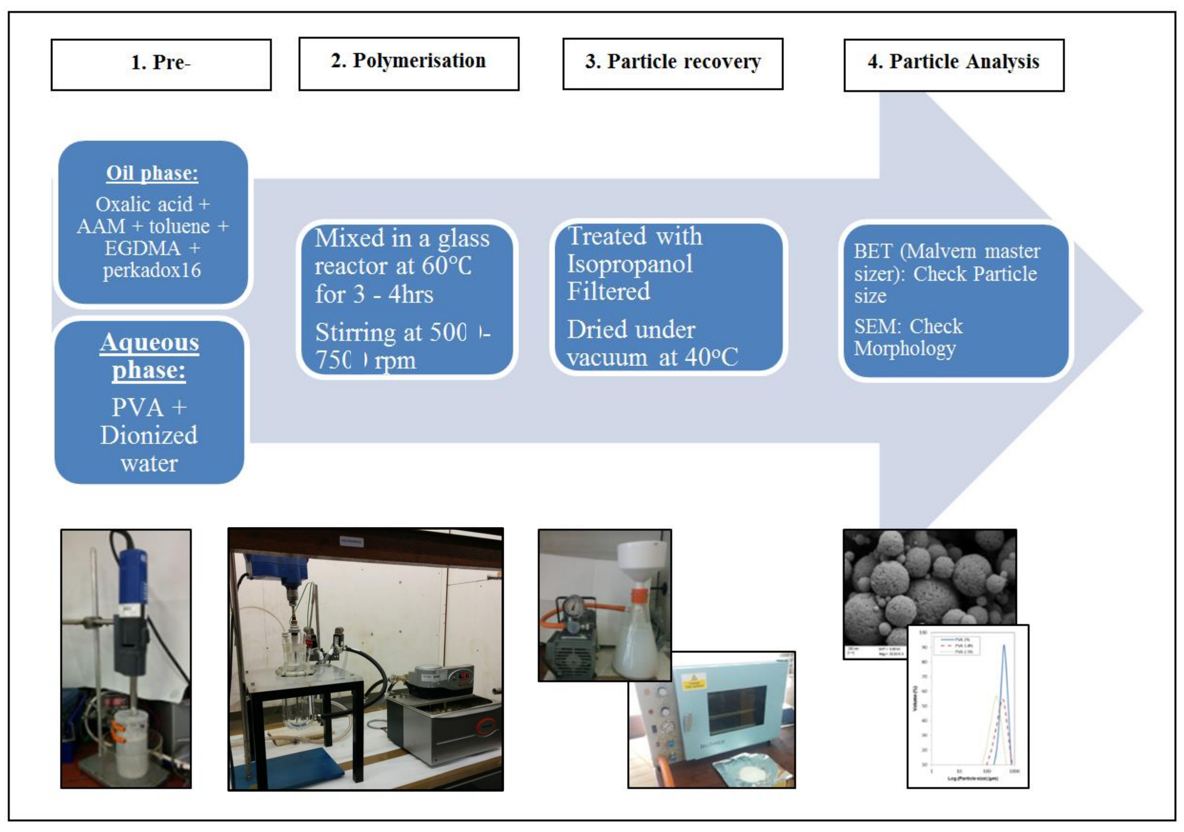
  Adv. 1. High selectivity.
  Adv. 2. Stable capture efficiency in present of impurities.
  Adv. 3. Stable capture efficiency in repetitive cycles.
  Adv. 4. Lower required regeneration energy.



Experimental Setup

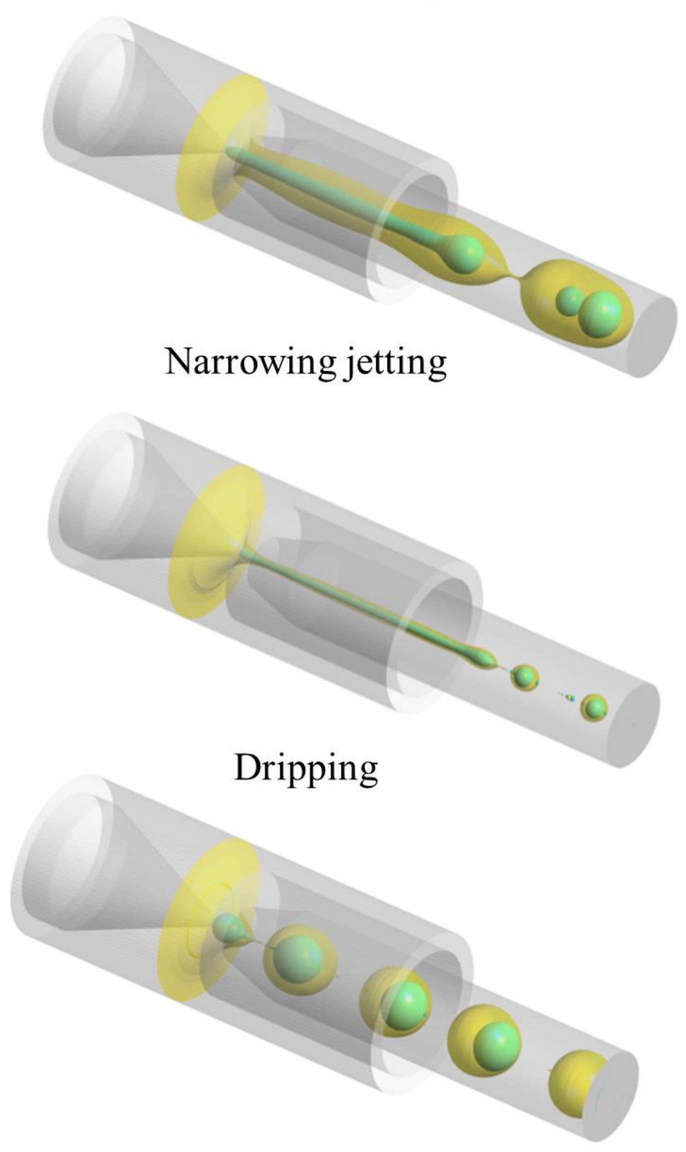


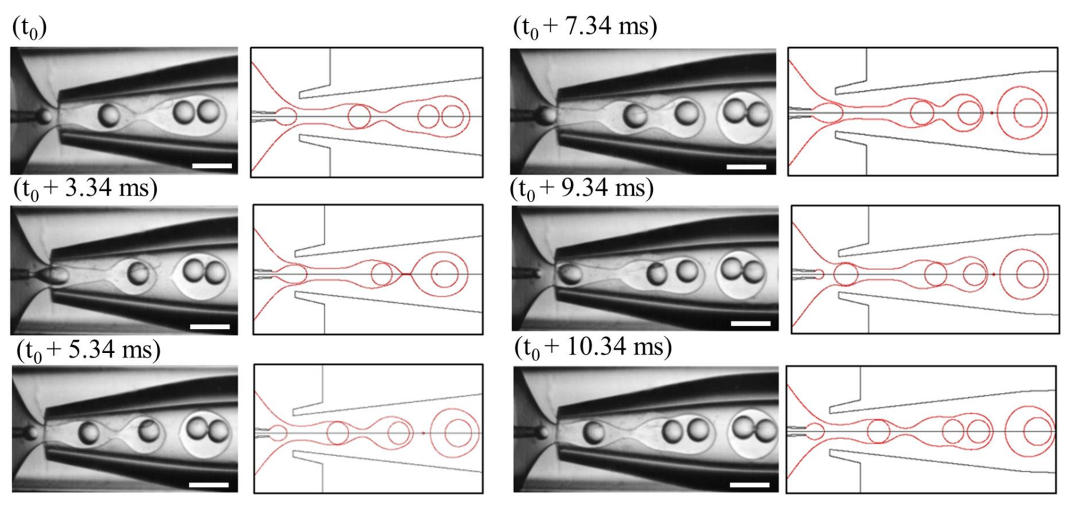
A fabricated three-phase glass capillary device for production of CO_2 solvent microcapsules. The direction of inner, middle and outer fluid is shown by the blue, green and red arrow, respectively.



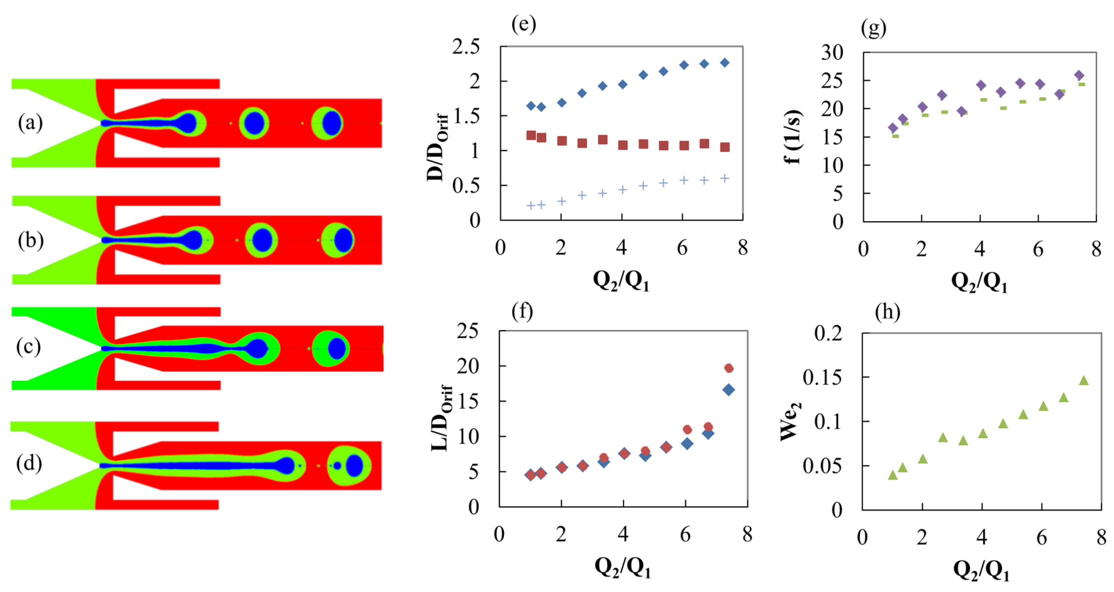
CO_2-MIPs production process using suspension polymerization approach.

Numerical and Experimental Results

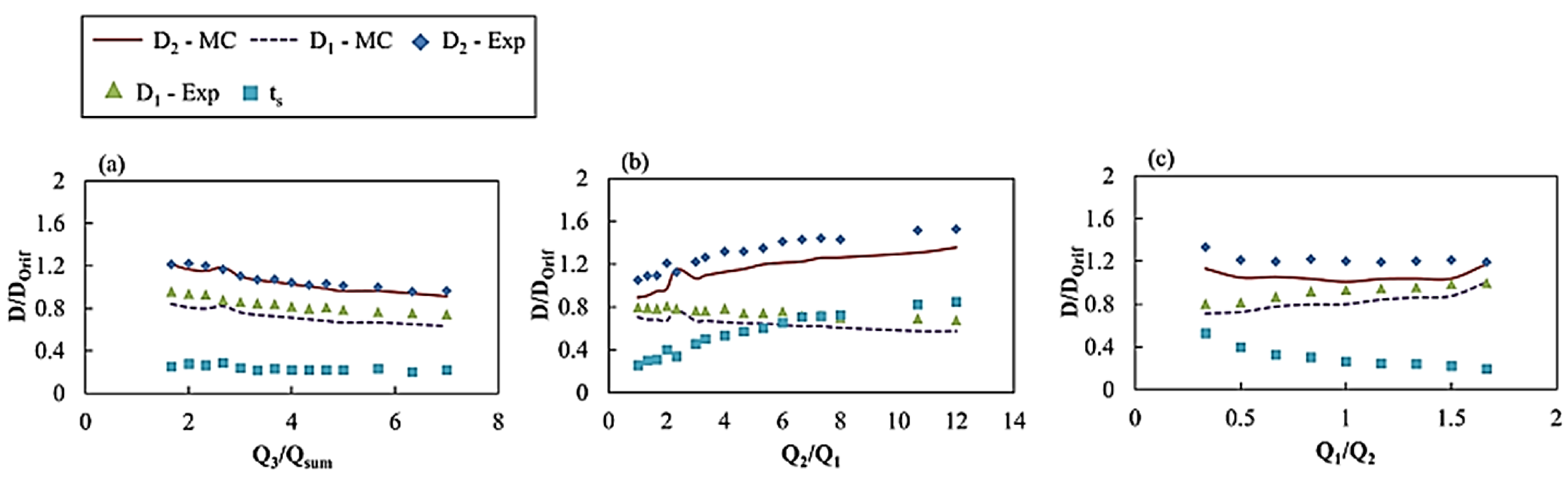




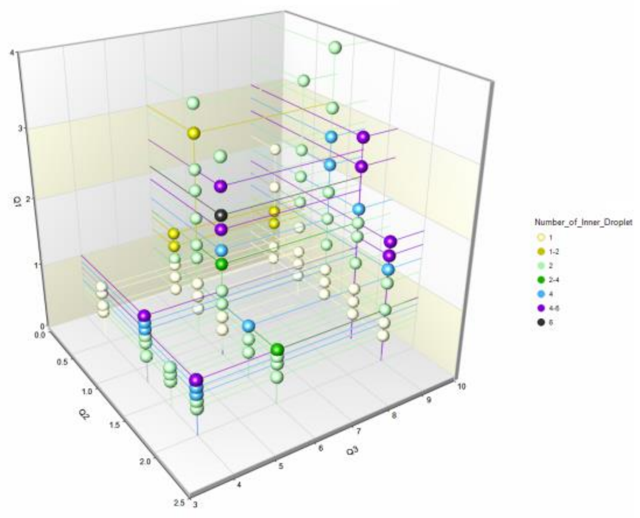
All scale bars 300 μm.

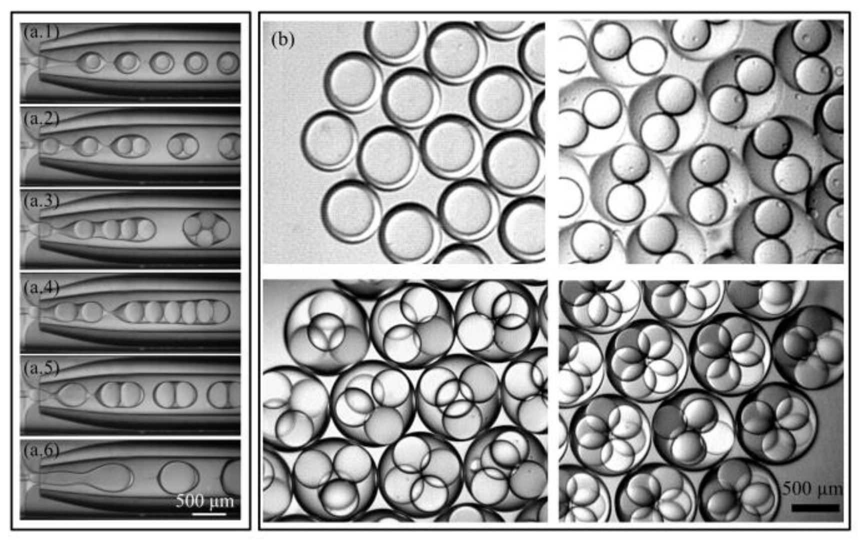


A VOF/CSF Numerical model has been developed and validated with experiments and analytical solutions.

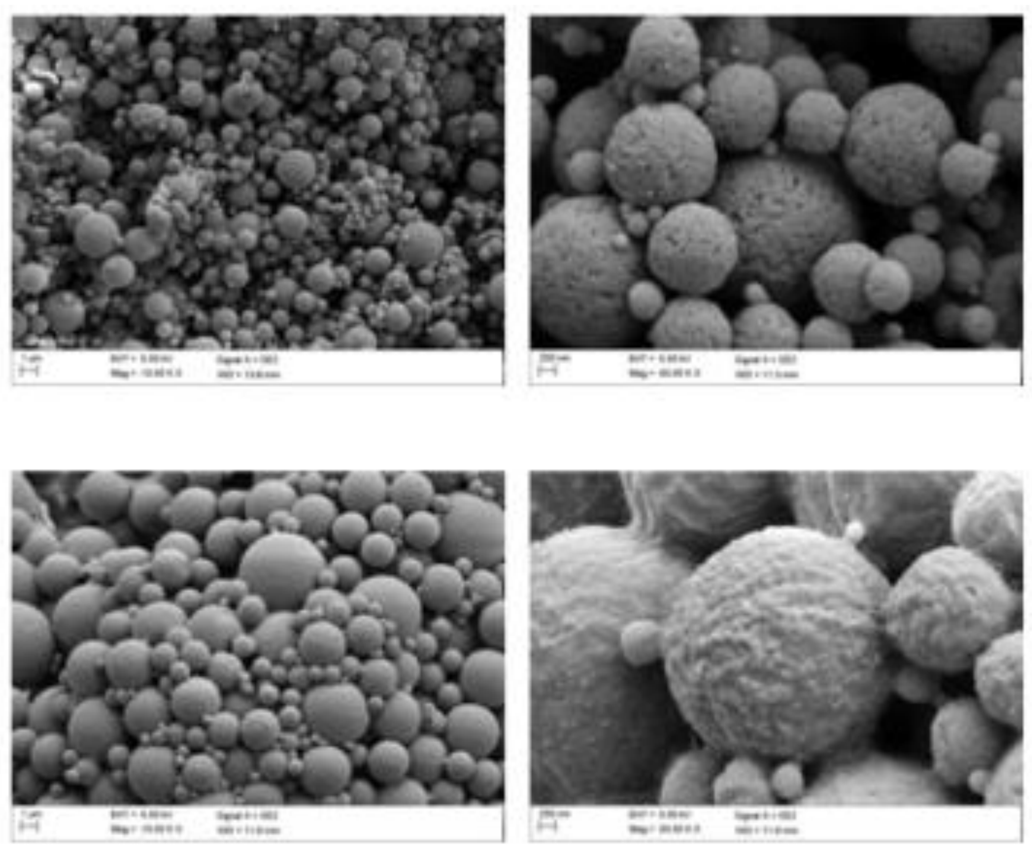


Experimental data: The size of inner and outer droplets, and the shell thickness as a function of phase flow rates.





The smaller inner or outer droplets, the higher reacting area with flue gases. Therefore, beside controlling the size of inner and outer droplet. The number of encapsulated droplet based on flow rates has been controlled.



SEM images of CO_2-MIPs morphology as a function choice of initiators: (a) Perkadox 16 (case 3), (b) AIBN; (c) the particle size distributions.

Conclusions

Production of two promising carbon capture material was investigated. Regarding the CO_2 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 rang of 50-600 μm were produced. Concerning CO_2-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.