Synthesis of CO_2 capture materials via innovative emulsification routes

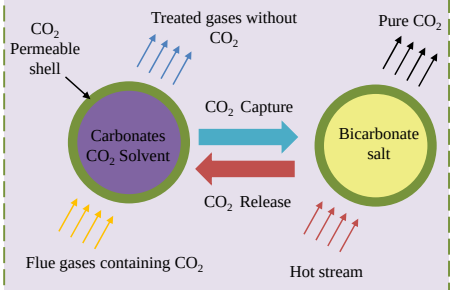
Seyed Ali Nabavi[a, *], Goran T. Vladisavljevic[b], Stella Georgiadou[b], Vasilije Manovic[a]

[a] *School of Energy, Environmental Technology and Agrifood, Cranfield University, United Kingdom.*
[b] *Department of Chemical Engineering, Loughborough University, United Kingdom.*

*E-mail address: s.nabavi@cranfield.ac.uk

Double emulsion: encapsulated CO_2 solvent

1. Concept



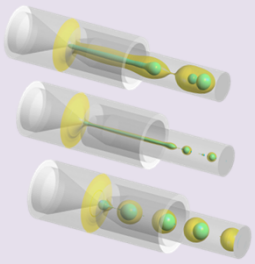
2. Numerical modelling

2D incompressible axisymmetric numerical model based on volume of fluid - continuum surface force (VOF-CSF) approach.

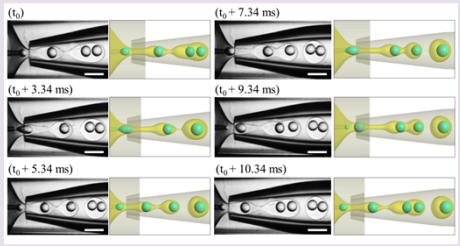
$$\frac{\partial \rho}{\partial t} + \frac{\partial (\rho U_i)}{\partial x_i} = 0$$

$$\frac{\partial (\rho U_i)}{\partial t} + \frac{\partial (\rho U_i U_j)}{\partial x_j} = -\frac{\partial P_i}{\partial x_i} + \frac{\partial}{\partial x_j}\left(\mu \frac{\partial U_i}{\partial x_j}\right) + F_\gamma$$

$$\frac{\partial f}{\partial t} + \frac{\partial (U_i f)}{\partial x_i} = 0 \qquad F_\gamma = \sigma \kappa \nabla f$$

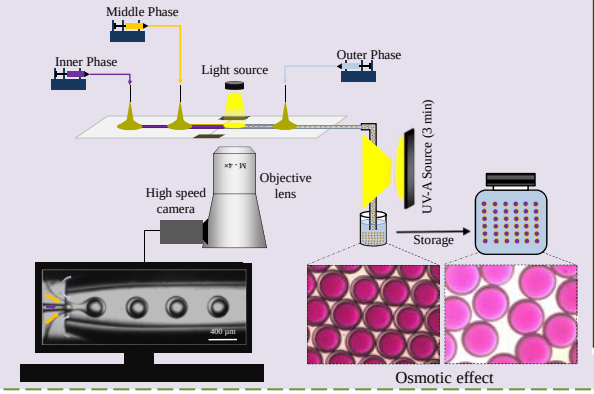


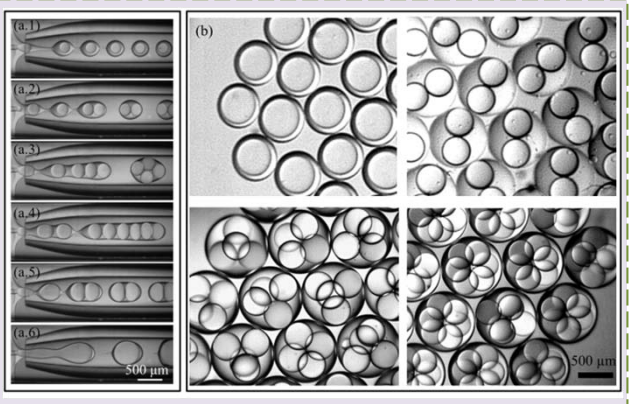
Numerical results



Validation of numerical model with experimental data

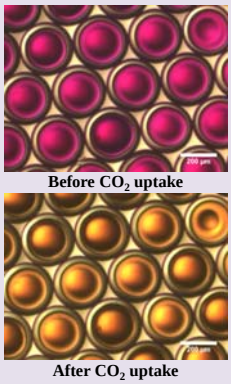
3. Particle synthesis





Production of multi-cored double emulsions

4. CO_2 capture test

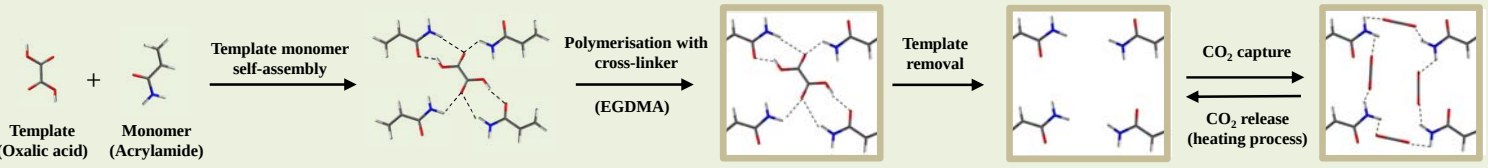


Before CO_2 uptake

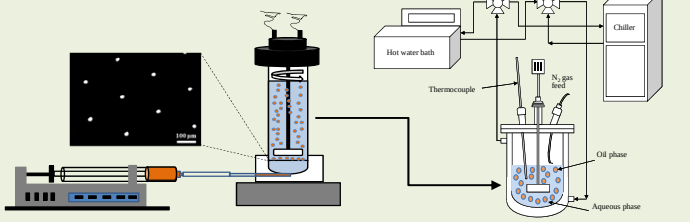
After CO_2 uptake

Single emulsion: CO_2 molecularly imprinted polymers

1. Concept

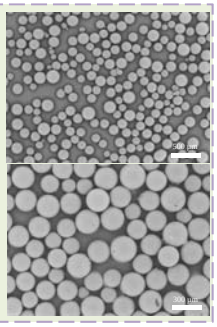


2. Particle synthesis

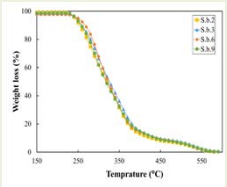


Membrane emulsification (single emulsion production)

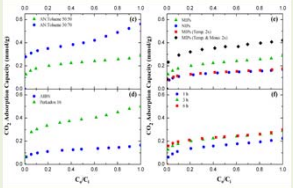
Suspension polymerisation



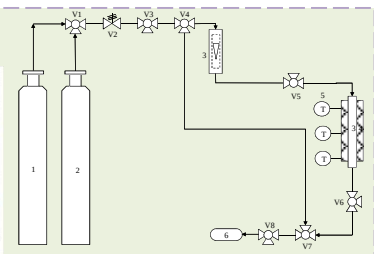
3. CO_2 capture test



Thermal stability analysis



CO_2 adsorption isotherms



Experimental apparatus for fixed-bed adsorption

Conclusions

- Development of An axisymmetric VOF-CSF model. The model was capable of reproducing droplet formation in dripping, narrowing and widening jetting regimes, as well as complex phenomena such as satellite and multi-cored droplet formation.
- The model was not able to prevent the droplet coalescence in the collection tube since the kinetics of adsorption of surfactants at fluid–fluid interfaces was not taken into account, which should be further investigated.
- Successfully Production of encapsulated CO_2 solvent within a three phase glass capillary microfluidic device via on-the-fly photo-induced polymerisation approach in less than 3 minutes.
- Successfully production and characterisation of a highly selective CO_2 sorbent based on molecularly imprinting technology and oxalic acid template using a combination of membrane emulsification and suspension polymerisation approach.

References

[1] Nabavi, S. A., Vladisavljevic, G., Gu, S., Ekanem, E.; Double emulsion production in glass capillary microfluidic device: Parametric investigation of droplet generation behaviour, Chem. Eng. Sci, 130, 181, 2015.
[2] Nabavi, S. A., Gu, S., Vladisavljevic, G., Ekanem, E.; Dynamics of double emulsion break-up in three phase glass capillary microfluidic devices , J. Colloid Interface Sci., 450, 279, 2015.
[3] Zhao, Y., Shen, Y., Ma, G., Hao, R.; Adsorption Separation of Carbon Dioxide from Flue Gas by a Molecularly Imprinted Adsorbent, Environ. Sci. Technol., 48, 1601–1608, 2014.