Sustainable Adsorbents for CO_2 Capture

C. Beattie, G. Sneddon, and H. H. P. Yiu

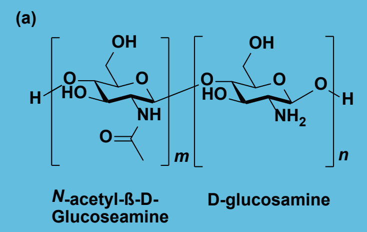
John Coulson Building, Heriot-Watt University, Edinburgh Campus, EH14 4AS

Introduction

- Increasing emission of "greenhouse gases" from industry, in particular, the energy sector.
- CO_2 carbon capture and storage (CCS) currently remains the only viable option.
- Current technology involves amine-solutions, which are effective, but are limited by their toxicity, high energy required for regeneration and high production cost amongst other drawbacks.
- Therefore, work has focussed on solid-state adsorbents, which are more energy efficient, easier to handle and cheaper to regenerate.

Why chitosan?

- Chitosan is a naturally occurring polysaccharide, containing D-glucoseamine units (see Scheme 1), which is entirely non-toxic to humans (many biomedical applications).
- It is an easily available sustainable product, since it is made from waste produced by the seafood industry (chitin)
- It has a high affinity for CO_2, due to the free amine groups ability to cooperatively absorb the gas molecule.



Scheme 1

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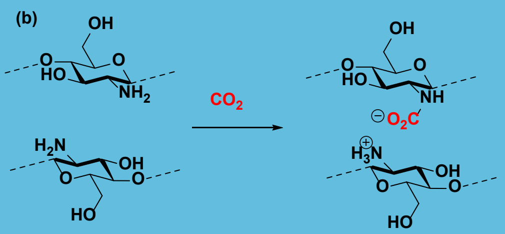
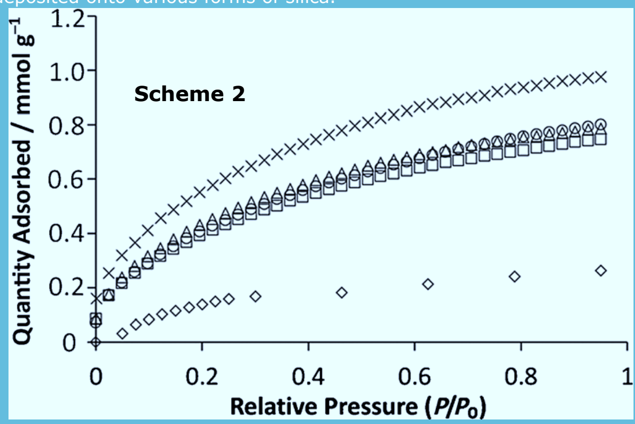


- (a) Shows structure of chitosan with a standard *N*-acetal-ß-D-glucosamine group next to a randomly distributed D-glucoseamine group.
- (b) Shows the cooperative adsorption of a CO_2 molecule by two neighbouring D-glucosamine groups.
- A problem associated with chitosan for this purpose is the relatively low surface area of the solid, when compared to other absorbents. This can be overcome by coating it to a highly porous medium, such as silica.

Testing various silica supports

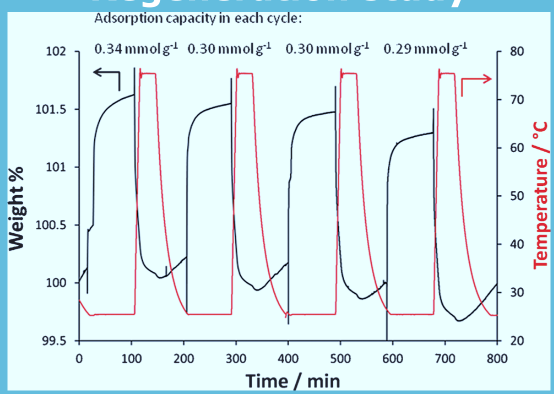
- Scheme 2 shows the quantity of CO_2 adsorbed by chitosan, when deposited onto various forms of silica.



- The graph shows the results of chitosan coated on fumed silica (◇, BET surface area = 123 m^2g^{-1}), SBA-15 (O, 376), MCF-3 (x, 187), MCF-6 (□, 210) and MCF-10(Δ, 241).
- Therefore silica chitosan coated on MCF-3 has the highest CO_2 adsorption capacity despite having a lower BET surface area to chitosan/SBA-15.
- A study was then carried out under artificial Flue gas streams in order to simulate real life conditions.
- Excellent results were obtained meaning that this has the potential to be used as a CO_2 adsorbent on an industrial scale.

Regeneration study

Scheme 3



- Scheme 3 shows the regenerations that were carried out by increasing temperature to remove "non-adsorptive" materials (red line shows the temperature). This could be carried out at a lower temperature (75 °C) than the amine solution equivalents.
- After regeneration the materials retained at least 88% of their CO_2 adsorption ability (black line).

Acknowledgement

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Conclusions

- A family of chitosan-coated mesoporous silica were prepared using a simple deposition method, which adhered to green chemistry principles.
- They were found to be able to adsorb CO_2 at an amount of over 16 times that of equivalent chitosan adsorption results, and were equivalent to amine solution (currently in use) which have many more disadvantages.
- They were found to be able to be regenerated via a much more environmentally friendly method, with only slight decrease in CO_2 adsorption.