Nanosheet-like Silica Nanomaterials (NSN) for Carbon Capture Applications

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Background

CO_2, which is produced from burning of fossil fuels, including coal, oil and natural gas, is the most important contributor to global warming. As fossil fuels are considered to be the major energy source in the next few decades, the exploration of effective ways to stabilize the atmospheric concentration of CO2 has become an urgent task for human beings. Current commercial CO_2 capture technologies, based on absorption of CO_2 by solutions of alkanolamines, ammonia or carbonates is expensive and energy intensive. Therefore, it is important to develop low-cost processes that utilize porous materials with high CO_2 adsorption capacity, high selectivity for CO_2, high diffusivity, high rates of adsorption, and high rates of regenerability.

Goals

The proposal aims to accomplish the following objectives:

1. Demonstrate a nanosheets-made silica nanosphere (NSN) platform as solid sorbent with spatial control of CO_2 capture amine functionality and high amine loading at least 7 mmol N/g sorbent, with hybrid absorption–adsorption capacity of at least 5 mmol CO_2 per gram of NSN sorbent.
2. Perform parametric and long-duration tests to demonstrate that the technology meets performance target of achieving of CO_2 capture at >90% of simulated flue gas with 15% CO2.
3. Engineer a gate-keeping polymeric layer of NSN surface (PolyNSN), designed to increase selectivity of CO_2 capture by excluding N_2 from in the capture process.
4. Perform parametric and long-duration tests to demonstrate proof-of-concept of nitrogen exclusion in selective CO_2 capture in PolyNSN.

Tasks

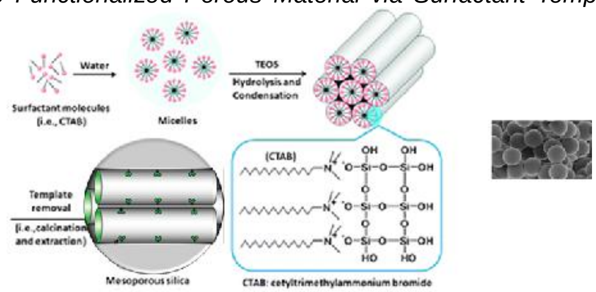
These goals are being served through :

Task 1. Functionalized hierarchical-pores NSN with high CO2 adsorption capability.

Task 2. Bi-Functional Nanosheet-made Silica Nanosphere Adsorbent for N_2-Phobic Highly Selective CO_2 Capture.

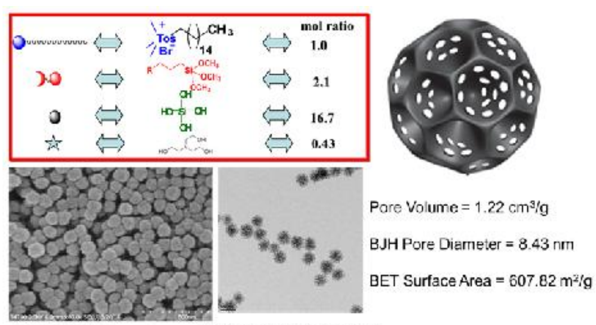
Methods

Step1 : Amino Functionalized Porous Material via Surfactant Templated Synthesis



Pitfall: Cylindrical pores of drive close-packing of amine groups and render inner amino groups inaccessible for CO2 capture

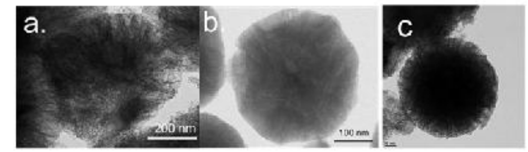
Step2: Synthesizing Hierarchical-Pores NanoSilica by changing Surfactant template changes and Directing agents



SEM of NSN Nanospheres TEM of NSN Nanospheres

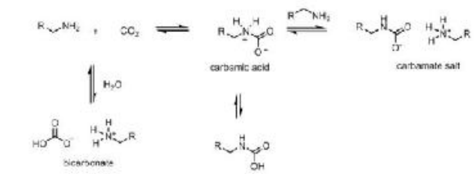
Step3: Co-solvent Assisted Hierarchical-Pores NanoSilica – Microstructure Studies

Material	NSN-1	NSN-2	NSN-3
BET Surface Area (m2/g)	1070	452.2	1398
Co-solvent	Ether	Ether Ethanol (2:1)	Ether –Ethanol (1:1)

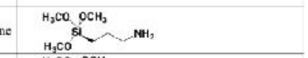
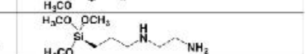
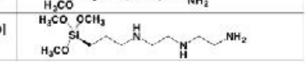


TEM images of NSN-1 (a) ,NSN-3(b) and NSN-2(C) showing the nanosheet-structure of the three novel materials

Step 4. In our approach, a modified co-condensation method that enables high-density and uniform distribution of amine containing functionalities will be utilized to achieve spatial location such that amine groups are in enough close proximity to capture CO2 in a stable fashion as indicated in Scheme 1.

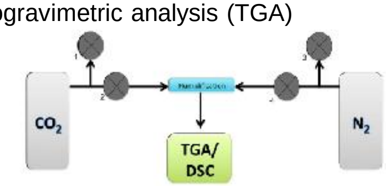


Scheme 1. Reaction between primary amines and CO_2

Name	Molecular Structure
3-Aminopropyl)trimethoxysilane	
N-(2-aminoethyl)-3-aminopropyltriethoxysilane	
N-[3-(trimethoxysilyl) propyl] diethylenetriamine	

Pathforward - NSN-based adsorbent for highly-efficient CO_2 capture experiment.

1. Determine absorption capacity of NSN via thermogravimetric analysis (TGA)



Scheme 2. TGA setting for CO2 capture experiments

Acknowledgements

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