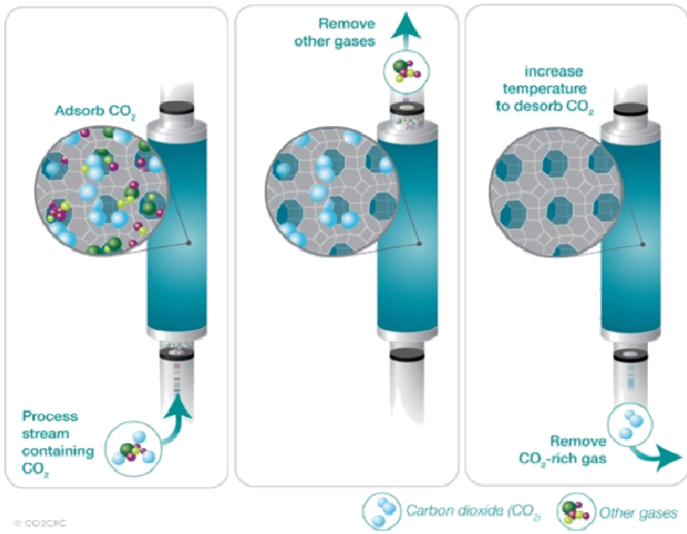
Adsorption Materials and Processes for Carbon Capture from Gas-Fired Power Plants: AMPGas (EPSRC: EP/J02077X/1)



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Objectives:

- Develop novel design and synthesis routes for adsorbent materials for carbon capture from flue gases of gas-fired power plants
- Develop methodologies for rapid screening of materials based on equilibrium and kinetic properties
- Develop rapid thermal swing cycles to reduce plant size
- Predict the performance of an integrated adsorption carbon capture process coupled to a gas fired power plant
- Interact closely with stakeholders and end users to define case studies and enhance the uptake of the results of the research.

Challenges:

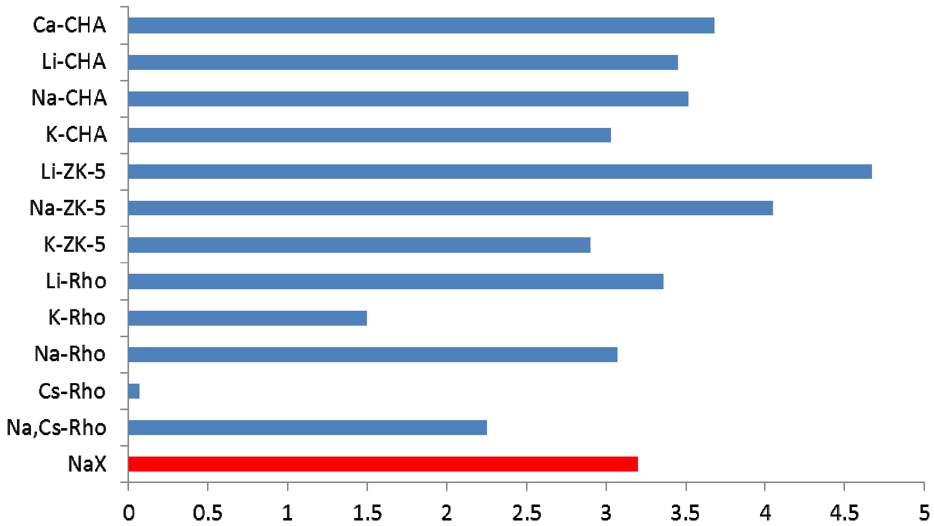
- Low CO_2 concentration in the flue gas (4% by volume)
- Conventional amine processes have a large energy penalty and the presence of high concentration of O_2 leads to high amine deactivation rates
- Not possible to consider pressure swing adsorption for adsorbent regeneration (due to very low partial pressure of CO_2)
- Need highly selective materials and regeneration by thermal cycling

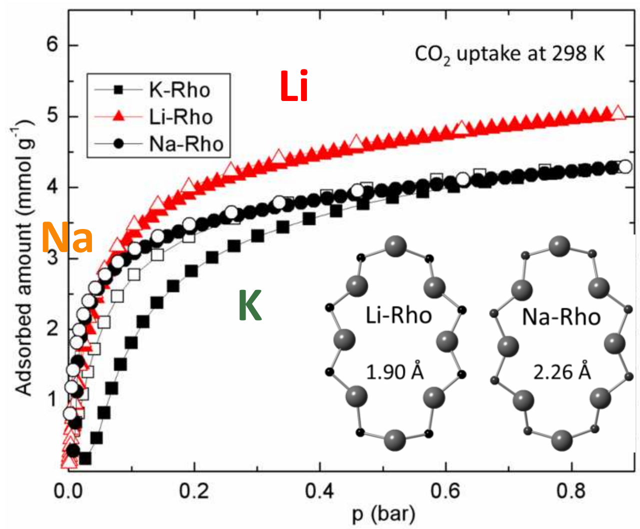
The Project

1. Design of adsorbents for CO_2 capture from very dilute gas streams
2. Evaluation of adsorbents
3. Development of bench scale prototype of rotary wheel adsorber and detailed dynamic model

Achievements in 'Innovative gas separations for carbon capture'

Optimised adsorption of CO_2 at 0.1 bar, 303 K over microporous solids

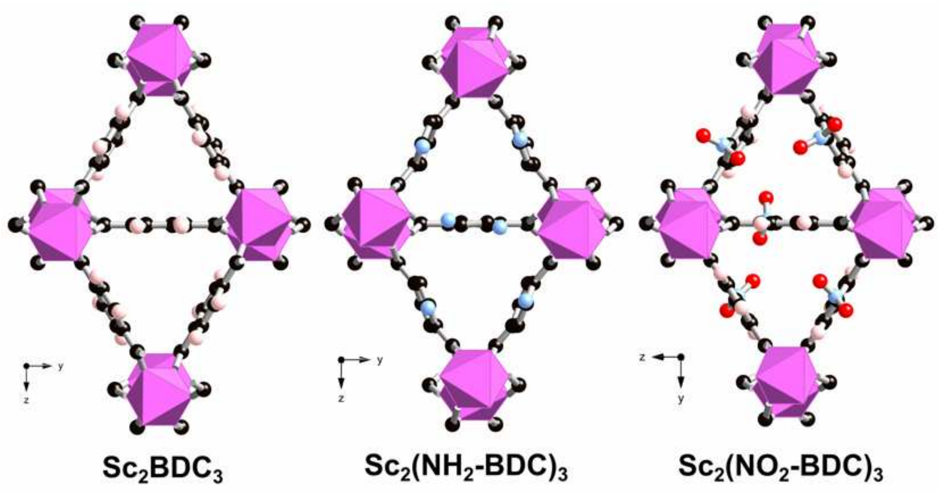


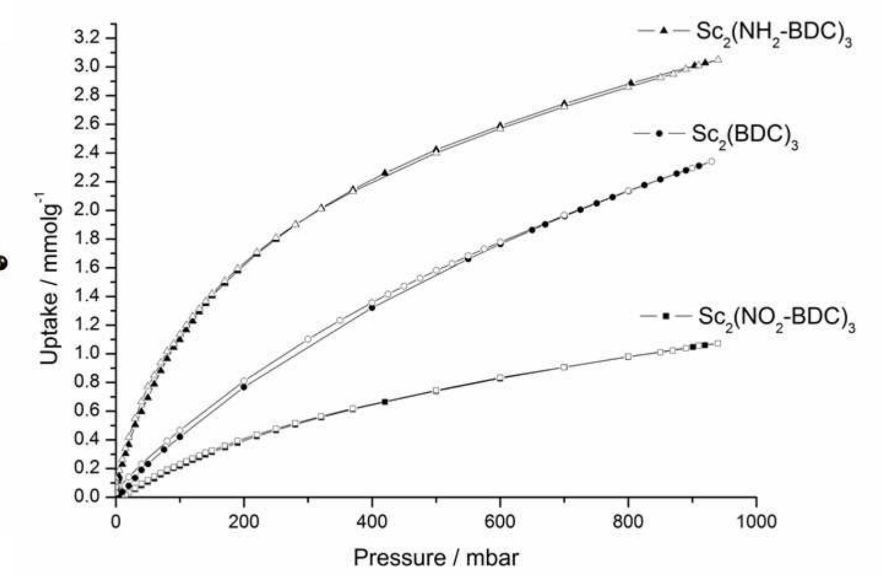


- selectivity in small pore MOFs by functionalisation
- uptake in a rigid zeolite structure (ZK-5) by cation exchange
- uptake and selectivity in a flexible zeolite structure (Rho)

Paul Wright

Functionalised Metal Organic Framework





All solids hydrophobic

Functionalising with amine increases CO_2 uptake (by chemoselectivity)

Adding nitro groups increases selectivity for CO_2 (by molecular sieving)

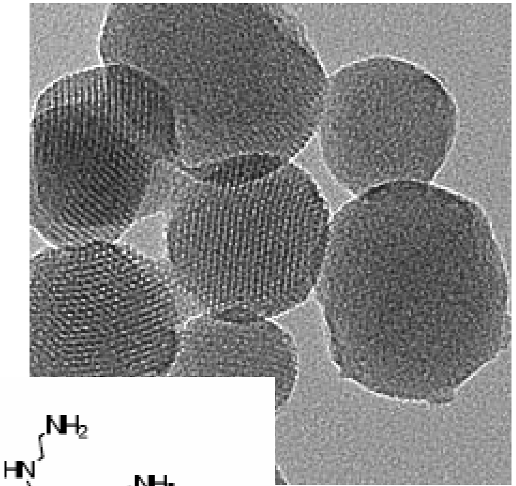
J. P. S. Mowat, P. A. Wright et al. *Inorg. Chem*. 2011, 50, 10844-58

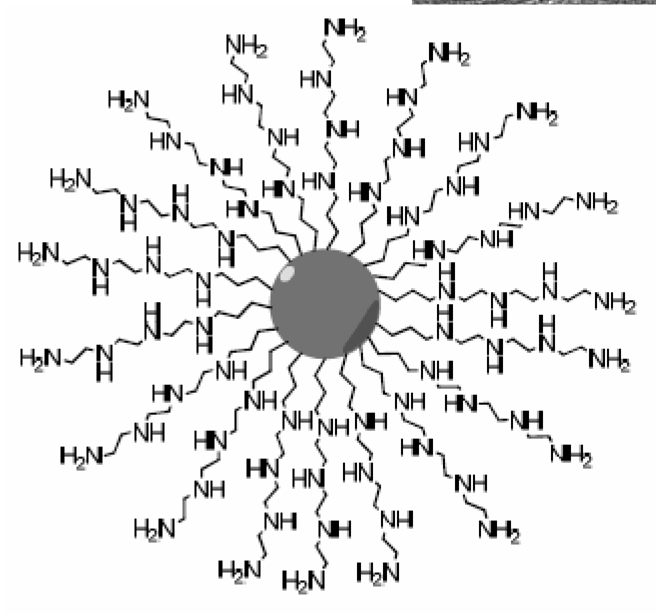
CO_2 uptake using mesoporous silica

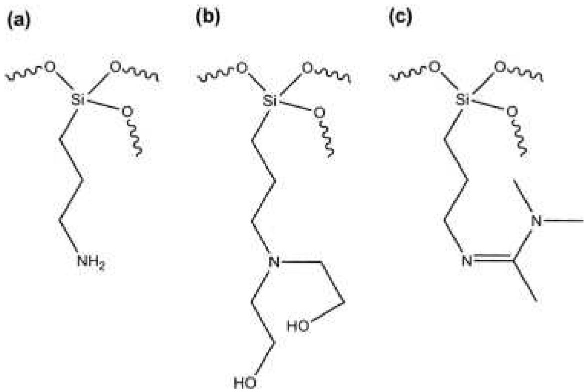
Mesoporous silica properties:

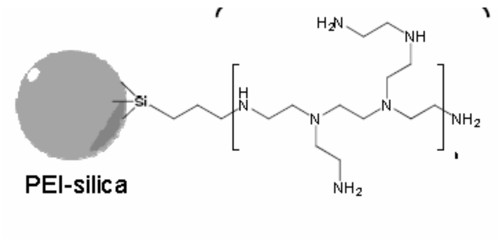
High surface area
→ high functional group loading

High pore volume (tunable)
→ Potentially high CO_2 storage capacity









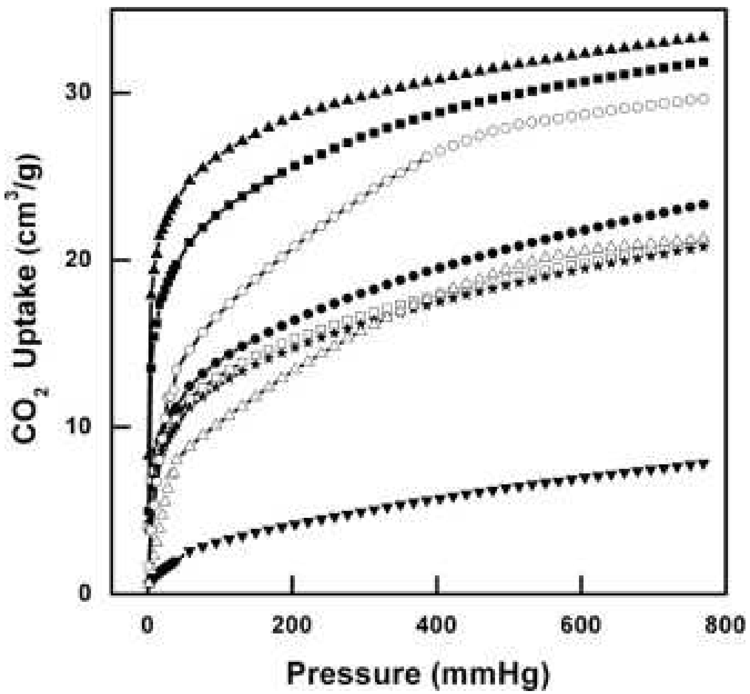
Humphrey Yiu

CO_2 adsorption isotherm

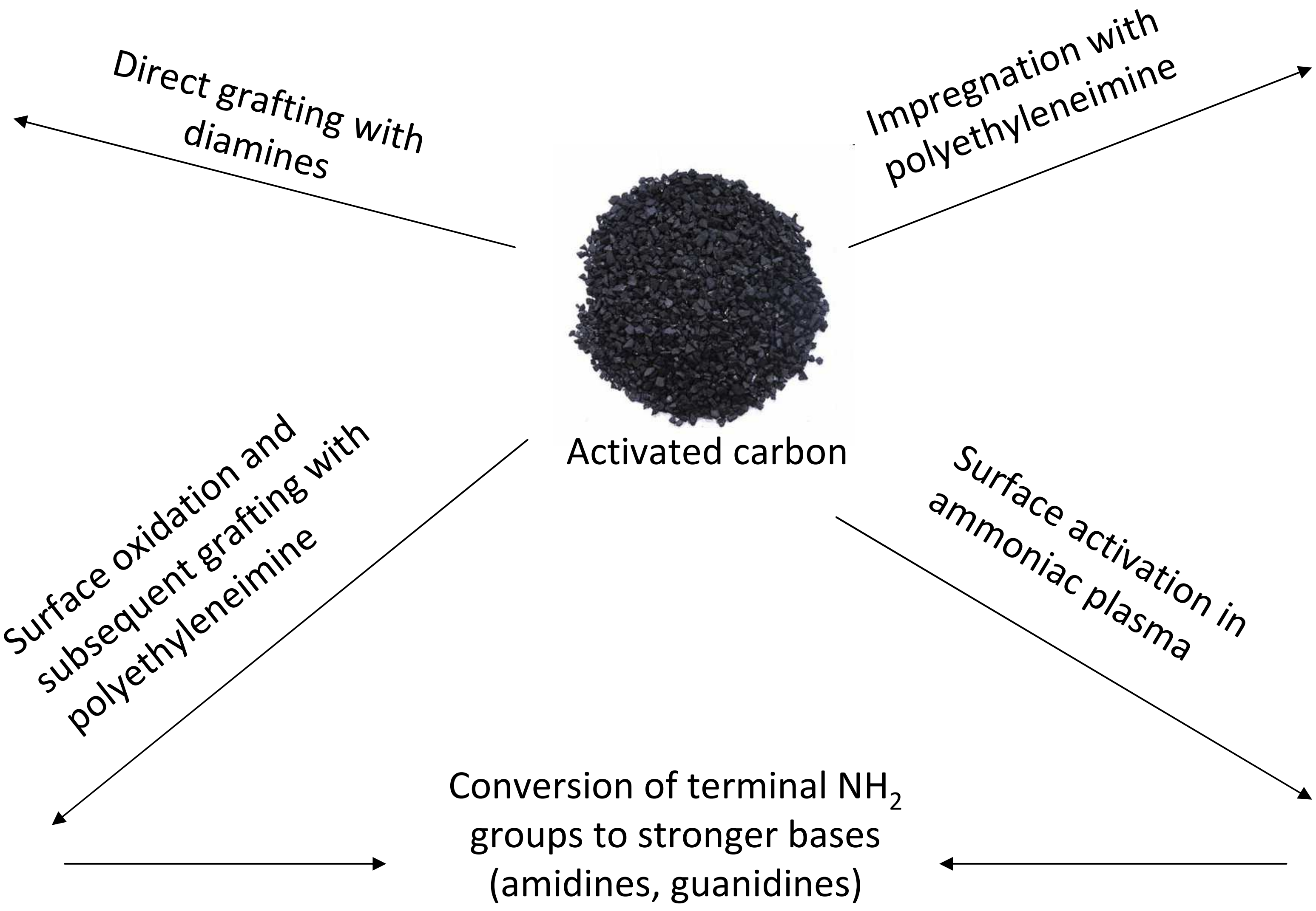
CO_2 adsorption capacity of functionalised mesoporous silica can be up to 1.4 mmol g^{-1} (▲, functionalised with APTES aminopropyltriethoxysilane)

Remarkably, higher adsorption of CO_2 (2.13 mmol g^{-1}) was recorded in presence of water.

"N efficiency" ≈ 0.7

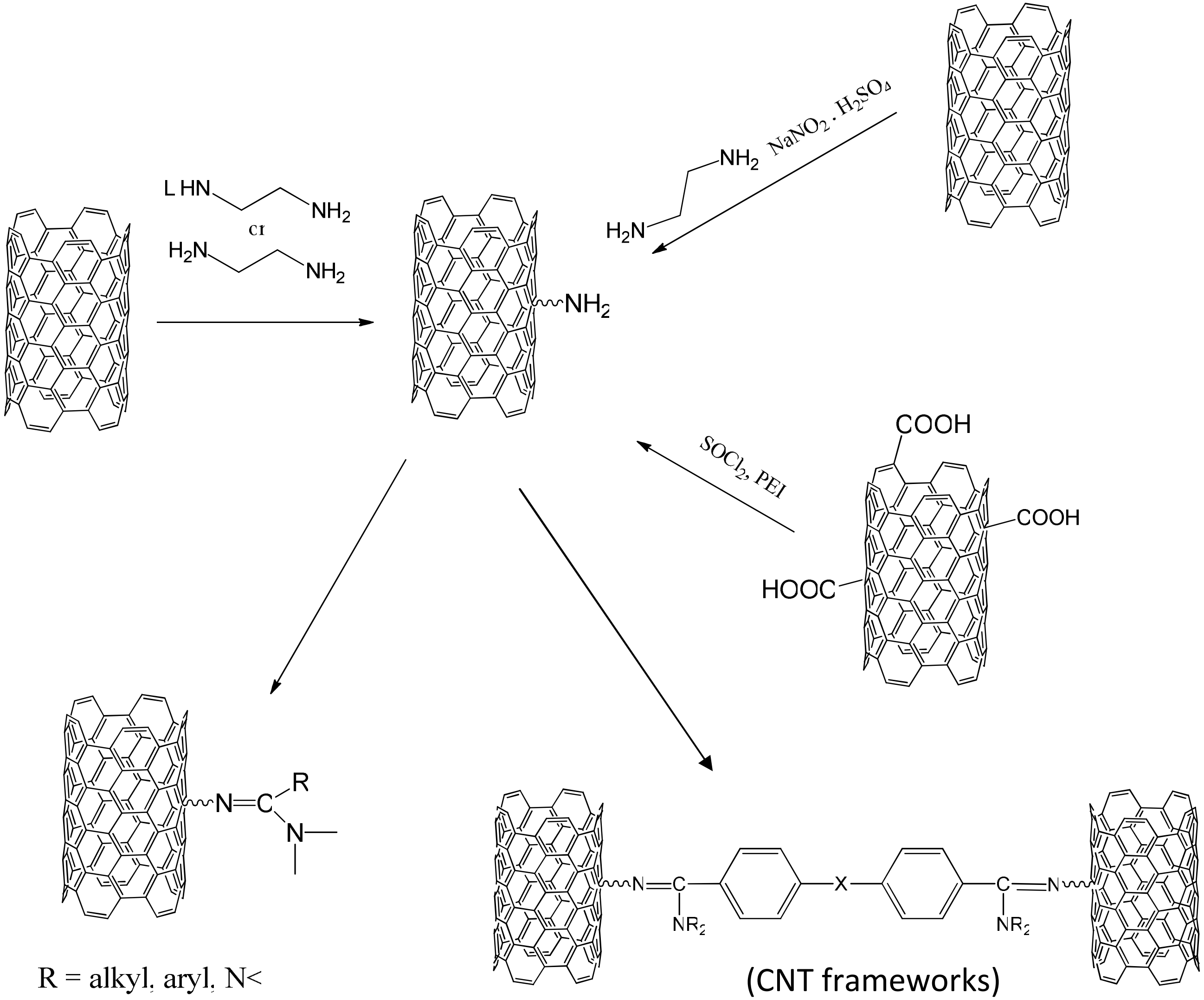


surface modification of porous carbon with organic bases



Eleanor Campbell

Functionalised Carbon Nanotubes for CO_2 capture



R = alkyl, aryl, N<
(amidine, guanidine)

(CNT frameworks)

EPSRC Feasibility Study: Nanotubes for Carbon Capture

Eleanor Campbell

Evaluation

Zero Length Column technique: use of small quantities of materials to screen for the most promising materials (at 3-7% CO_2)

Most promising materials upscaled and tested with PSA and ESA/TSA

Prototype System

Design and construction of bench scale system
(collaboration with Howden)
demonstration of technology feasibility.

1GW plant produces 380 tonnes CO_2 per hour.
Require fast cycling time to reduce amount of adsorbent required

Stefano Brandani