Fuel Gas Storage – The Challenge of Hydrogen


• URL: http://people.bath.ac.uk/cestjm; http://people.bath.ac.uk/vt233
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Global issue

• Increasing demand for energy
• Population growth
• Increasing wealth per capita
• Demand for new sources of energy
• Global warming and air quality
• Depletion of fossil fuels

Solution:

• Using hydrogen as a clean energy vector!

Benefits:

• Highest energy content of any chemical fuel on a mass basis
• Abundant in the form of water, biomass or hydrocarbons
• If combusted or used in a fuel cell with pure oxygen, its only product is water
• Can be used as a wide-scale clean energy vector

Analysis

We do the analysis and modelling of excess isotherms, in order to compare with alternative storage methods, and to study the fundamentals of the adsorption process.

$$m = (\rho_a - \rho_b) V_p \theta_a$$

$\rho_a$ = excess uptake
$\rho_b$ = adsorbate density
$\rho_b$ = bulk density
$V_p$ = pore volume
$\theta_a$ = fill factor

The analysis allows us to determine the optimum conditions for physisorption

Inelastic neutron scattering

We used inelastic neutron scattering as it allowed for the verification of our model

INS integrated elastic peak and spectra for TE7

Kinetics

We have studied the kinetics of hydrogen adsorption for some carbons and shown that the mass transfer coefficients follow an Arrhenius relationship

$$y = -1.8507x + 4.4182$$

Computer simulations

We use computer simulations in order to verify our model, and to study the molecular dynamics of the system

Simulated isotherms for Silicalite-1 using MUSIC

Analysis

Systems

The analysis has been expanded to calculate the amount of hydrogen stored in tanks containing varying quantities of adsorbent, at any pressure or temperature.

Examples of compression and liquefaction $H_2$ tanks

Examples of porous materials

Adsorptive storage

Compressed gas

$P_C$ Storage pressure

Adsortion favoured

Compression favoured

An example design curve

Hydrogen storage

Problem:

• Hydrogen has a very low density
• Conventional methods of increasing the density is to compress or liquefy
• BUT, these require unfavourable conditions.

Solution:

• Adsorb the hydrogen inside nanoporous materials!

Materials

We synthesise, characterise, analyse and model a variety of different types of nanoporous materials including:

• Metal-organic frameworks
• Polymers of intrinsic microporosity
• Activated carbons
• Zeolites

Example synthesis: ZIF-12

Synthetic route:

$$(CH_2COO)_2Co \cdot 4H_2O + BIMCo(PhIM)_2$$

Polymers of intrinsic microporosity – organic frameworks

Clean energy chain

Hydrogen

Adsorb the hydrogen inside nanoporous materials!

Clean energy chain

Hydrogen

Synthetic route:

$$(CH_2COO)_2Co \cdot 4H_2O + BIMCo(PhIM)_2$$

Examples of porous materials

Examples of compression and liquefaction $H_2$ tanks

We used inelastic neutron scattering

Hydrogen Storage in Porous Materials

We have studied the kinetics of hydrogen adsorption for some carbons and shown that the mass transfer coefficients follow an Arrhenius relationship