# THE USE OF CARBON NANOFIBRES AS HYDROGEN STORAGE MATERIALS

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## Introduction

Carbon nanofibres prepared from the decomposition of $CO:H_2$ mixtures over Fe:Ni:Cu alloys have been investigated for their use as hydrogen storage materials. Variation of key processing parameters such as catalyst composition, ratio of the gaseous reactants and deposition temperature, is under examination. The aim of the programme is to optimise the production of nanofibres of high hydrogen storage capability. In this paper the effect of process gas composition is examined.

## Experimental

Carbon nanofibres were synthesised at 500°C by passing varying $CO:H_2$ ratios over a 90 % Fe, 5 % Ni, 5 % Cu catalyst, prepared according to the procedure of Best and Russell [1]. A total flow rate of 300 ml/min was used in all cases and growth was continued over a 3-hour reaction period. After deposition the fibres were allowed to cool under an inert gas stream before the weight of fibre was recorded.

Subsequent characterisation of the nanofibres was performed using various techniques, particularly TEM, selected area electron diffraction and nitrogen BET surface area determination.

Hydrogen storage was followed at 120 bar using a specifically designed high pressure apparatus, measuring uptake as a differential pressure between the sample relative to that of a blank chamber, Figure 1. The use of a differential pressure measurement is considered important as this eliminates potential errors due to low precision in high pressure gauges and also due to non-ideality of the hydrogen gas. The apparatus used is capable of reproducible measurement of hydrogen uptakes as low as 0.1% on a 100mg sample.

## Results and Discussion

It was found, in agreement with previous literature [2], surface areas of the carbon nanofibres increase with hydrogen concentration in the $CO:H_2$ feedstock. Figure 2 shows that surface area can be enhanced by approximately 33% upon increasing the hydrogen content from 10 to 80%.

Hydrogen storage measurements of the nanofibres, Figure 3, indicate that only low levels of uptake have been achieved, passing through a maximum of roughly 1 wt %, when using a 3:2 $CO:H_2$ nanofibre process feed. These values are considerably lower than those recently reported elsewhere [3]. The levels of storage are gravimetrically comparable to metal hydride systems currently in use [4].

Inspection of the surface area and hydrogen storage data shows an interesting trend. Hydrogen storage decreases with increased hydrogen in the process gas. Surface area by comparison is observed to increase over the same range of process conditions. The uptake cannot, therefore, be explained solely in terms of a non-site specific adsorption on the external surface of the nanofibres, as one would expect uptake to correlate with surface area. Therefore it would appear that hydrogen sorption occurs at specific sites within the nanofibre material.

## Conclusions

Although only low hydrogen uptakes have been measured for the current samples, these preliminary results are encouraging, as surface area and hydrogen storage measurements indicate that some site-specific sorption within the carbon nanofibres has been achieved.

Levels of sorption are currently comparable to a metal hydride system. This is quite promising when the markedly lower price of the nanofibre adsorbent is considered.

## References


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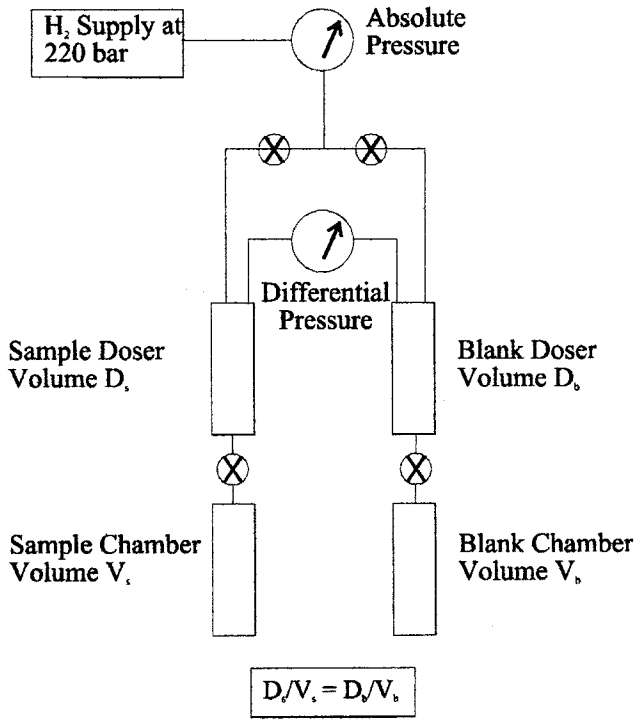


Fig 1. Schematic of the differential pressure hydrogen uptake measurement apparatus

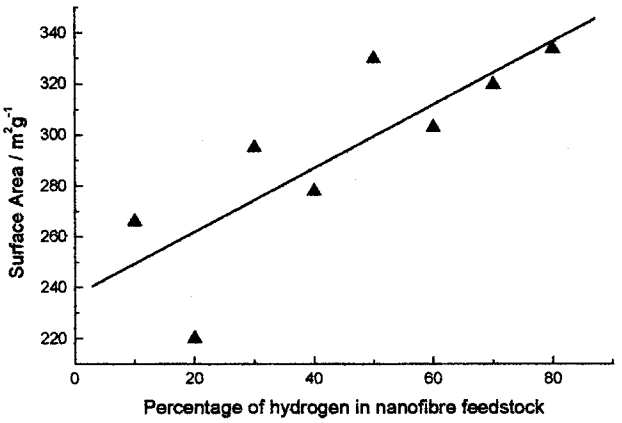


Fig.2. Effect of hydrogen concentration in the nanofibre feedstock upon surface areas of carbon nanofibres grown on a 90:5:5 Fe:Ni:Cu catalyst at 500°C.

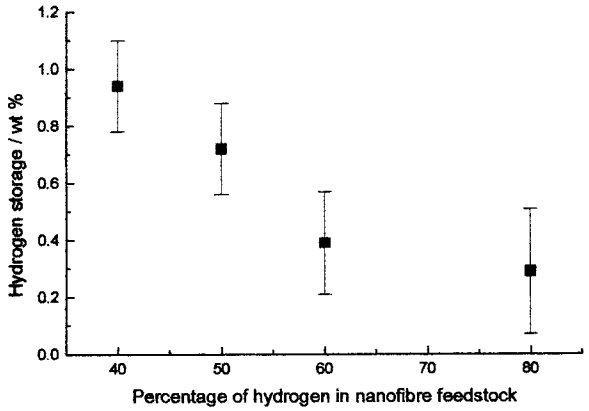


Fig 3. Effect of hydrogen concentration in the nanofibre feedstock upon hydrogen storage in carbon nanofibres grown on a 90:5:5 Fe:Ni:Cu catalyst at 500°C.