CARBON NANOTUBES FOR HYDROGEN STORAGE

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ABSTRACT

One major constrain in utilizing hydrogen, as an energy carrier is the absence of practical means to store them. Research on carbon nanotubes (CNTs) has been carried out tremendously due to the potential capacity to absorb hydrogen. This paper is an overview of what are CNTs, some experimental results on the hydrogen storage and our existing equipment to embark this work.

INTRODUCTION

Hydrogen produces no pollution and no green house effect when burning in pure oxygen and is considered by many to be a clean energy of the future and a replacement for fossil fuels when current reserves run out. However, whilst its energy content on a mass-for-mass basis is better than petrol, hydrogen has difficulty competing with the fossil fuel because it is a gas. As such, hydrogen storage is an area of work that must not be over looked. A hydrogen gas fuel tank that contains a store of energy equivalent to a petrol tank would be more than 3 000 times bigger than its conventional cousin. Compressing or liquefying the gas is expensive. Currently, metal alloys are used, but they are very heavy and become brittle after repeated use. Carbon nanotubes (CNT) are thought to be the best candidate to store hydrogen gas. It should be noted that more energy could be stored by absorbing them in a medium rather then by compressing them.

WHAT ARE CARBON NANOTUBES

Carbon nanotubes are fullerene-related structures that consist of graphene cylinders close at each end with caps containing pentagonal rings. The central core contained variety of closed graphitic structures including nanoparticles and nanotubes. An ideal nanotube can be thought of as a hexagonal network of carbon atoms that has been rolled up to make a seamless cylinder. The cylinder can be tens of microns long, and each end is "capped" with half of a fullerene molecules. In 1991, Sumio Ijima, of NEC Laboratory in Tsukuba, used high-resolution transmission electron microscopy (TEM) to observe carbon nanotubes [2].

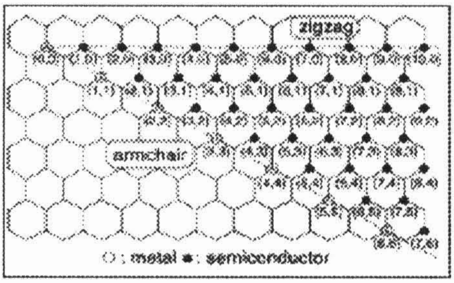

Figure 1 : Basic structure in graphite layer

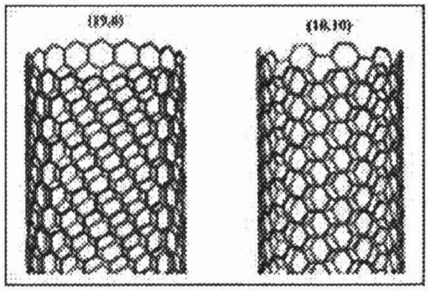

Figure 2: Zigzag (19,0) and Armchair (10,10)

Figure 1 illustrates a basic graphite structure. The mapping of these structures specifies the number of unit vectors required to connect two atoms in the planar hexagonal lattice to form a seamless tube. These numbers specify a "vector" for the mapping, commonly expressed as (m,n), where m and n are integers. Any tube "named" (n,0) has carbon-carbon bonds that are parallel to the tube axis, and form, at an open end, a "zig-zag" pattern; these tubes are referred to as "zig-zag" tubes (Figure 2). These two basic types are achiral, meaning they do not have a distinct mirror image, like left and right hands. All the other tubes, named (m,n), where m does not equal n, and neither is 0, are chiral, and have left-and right-handed variants [1].

ADSORPTION CHARACTERIZATION OF CARBON NANOTUBES

Some studies have been done to determine the hydrogen adsorption performance of these nanotubes (Figure 3 and Table 1). Cao and his friends compared the capacity of hydrogen adsorption on an aligned and random multi wall nanotubes (MWNTs). They concluded that aligned MWNTs have a greater capacity of hydrogen adsorption. Other researchers concluded that purity, pressure and temperature play a significant role on the adsorption of hydrogen by the CNTs.

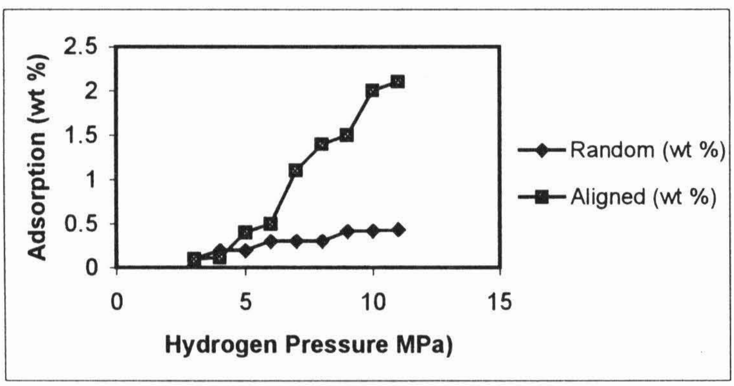

Figure 3 : Hydrogen Adsorption of Aligned and Random Samples [3]

Table 1: Summary of experimental reported hydrogen storage in carbon nanostructures [4]

Material	Max wt% H_2	T [K]	p [MPa]
SWNTs (low purity)	5-10	133	0.040
SWNTs (high purity)	8.25	80	7.18
SWNTs (~50 wt% pure)	4.2	300	10-12
GNFs (tubular)	11.26	298	11.35
GNFs (herringbone)	67.55	298	11.35
GNFs (platelet)	53.68	298	11.35
Graphite	4.52	298	11.35
Li-GNFs	20,0	473 ~ 673	0.101
Li-Graphite	14,0	473 ~ 673	0.101

SYNTHESIS OF CARBON NANOTUBES

Carbon nanotubes can be prepared by laser vaporization of carbon target. A cobalt-nickel catalyst helps the growth of nanotubes , presumably because it prevents the tube ends from being capped during the synthesis process. Subsequently, these tubes can be sintered in a furnace at 1200 °C. Currently, the Physics Department of UPM has a PLAD system (Figure 4) that could produce nanosized particle/films. However, in-situ sintering cannot be done by this system.

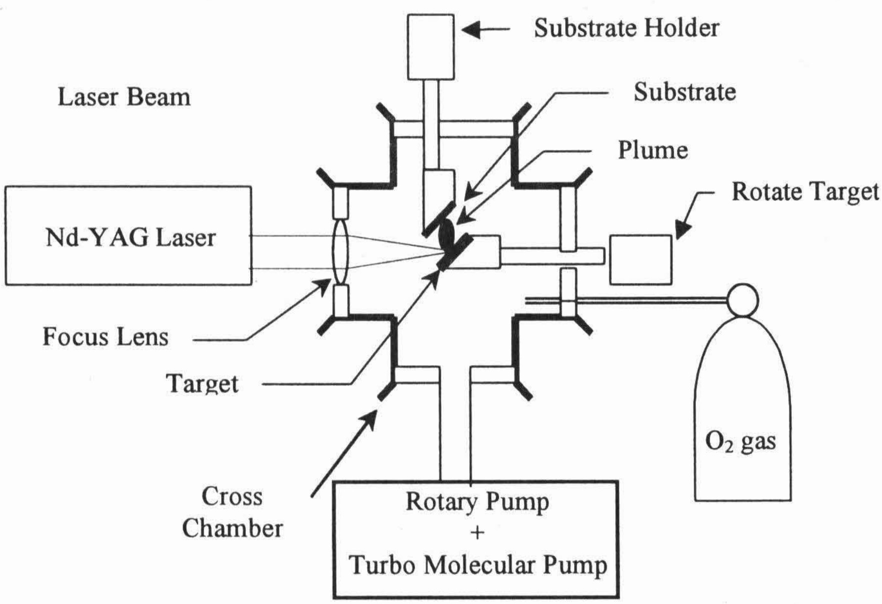

Figure 4 : Pulsed Laser Ablation Deposition (PLAD) System

CONCLUSION

The experimental and theoretical work to investigate the ability of CNTs to absorb hydrogen by carbon-based materials is increasing tremendously. Our immediate plan is to establish a state of the art capability for synthesizing, modifying and doping CNT for hydrogen storage as well as to establish reliable means for characterizing these materials. The characterization effort involved material characterization using existing equipment in the university, such as TEM, SEM, EDAX, etc. Hydrogen sorption characteristics will be done by using TGA, DCS, Physisorption etc.

REFERENCES

Sumio, Science, **269** 1550-1553 (1995)

Jia, Z. Wang, J. Liang, B. Wei and D. Wu, *"Production of short Multi Walled Carbon Nanotubes"*, Carbon, **37** 903-906 (1999)

Cao, H. Zhu, X. Zhang, X. Li, D. Ruan, C. Xu, B. Wei, J. Liang, and D. Wu, *"Hydrogen Storage of densed-alligned Carbon Nanotubes"*, Chemical Physics Letters **342** (5-6) 510 – 514 (2001).

S.E. Iyuke, F.R. Ahmadun and M.F. Al-Khatib, *"Transport and Storage Phenomena of Hydrogen in Carcon Nanotubes"*, Proceeding of 2nd World Engineering Congress, 189-193, (2002).