HYDROGEN STORAGE IN CARBON NANOTUBES

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1. Introduction

Energy resources and environmental pollution are essential problems that are concerned with sustainable development and demand prompt solution. Hydrogen is considered to be an ideal energy source and carrier, since it is clean and abundantly reserved. To store and transport hydrogen safely and cheaply is a key step to the utilization of hydrogen energy, thus effective means for hydrogen storage and transportation have been continuously investigated. Carbon materials, especially one-dimensional nano-structured materials, such as carbon nanofibers and carbon nanotubes (CNTs), which consist of 1-D nano-tunnels and unique inter-tube pore structures, have attracted great interest for their prospect as effective hydrogen storage materials[1, 2]. In this study, we report the synthesis and hydrogen storage properties of carbon nanotubes, both multi-walled and single-walled.

2. Experimental

2.1 Synthesis. Multi-walled carbon nanotubes (MWNTs) were synthesized by the catalytic decomposition of hydrocarbons at 1100 [3]. The MWNTs thus obtained have an average diameter of about 50 nanometers, and are in high purity (~80%). Single-walled carbon nanotubes (SWNTs) for hydrogen storage measurements were synthesized by a hydrogen arc discharge method[4, 5], and the products can be either film-like, web-like, or rope/ribbon like. In Figure 1, we show TEM images of the CNTs we obtained. The yield of the MWNTs and SWNTs can be 5g/h and 0.5g/h, respectively.

2.2 Pretreatment. The as-prepared CNTs need pretreatments to remove the impurities and to modify their surface characteristics. Sonication, hydrothermal treatment, acid-washing, air-oxidation, and high-temperature vacuum treatment were involved in the pretreatment process.

2.3 Hydrogen storage. Hydrogen storage measurements of the CNTs were performed at room temperature and under a moderately high pressure of 120 atms[5]. The apparatus used for hydrogen adsorption experiments consists of a copper sample cell, a stainless steel hydrogen reservoir container, a hydrogen source, a vacuum system, a pressure sensor, and high-pressure bellows valves through which above components are all connected. In the hydrogen adsorption experiments, CNT samples were placed in the sample cell and heated to 423K. Then the system was vacuum-degassed for several hours. When the sample cell was cooled down to room temperature, hydrogen gas was admitted into the apparatus to a certain pressure and the hydrogen adsorption began. The process of hydrogen adsorption was monitored by a computer connected to the pressure sensor.

3. Results and discussion

The hydrogen storage capacities of CNT samples and that of $LaNi_5$, which

was employed for comparison, are summarized in Tab. 1. We can see high hydrogen storage capacities of 4-6 wt. % were achieved for the pretreated CNTs. The MWNTs showed higher hydrogen storage capacities than for the SWNTs, and this may be attributed to the inter-layer pores of MWNTs, which provide extra host for hydrogen.

In comparison to the web-like SWNTs, more hydrogen can be stored in the inter-bundle spaces of the rope-like SWNTs, therefore the hydrogen storage capacity of the macroscopic SWNT ropes are higher than that of web-like SWNTs. Further studies on the pretreatment process to obtain a cleaner and more active surface suitable for hydrogen storage are being conducted.

In summery, the access of large-scale production and high hydrogen storage capacities of the CNTs indicate that CNTs are a promising hydrogen storage material.

References

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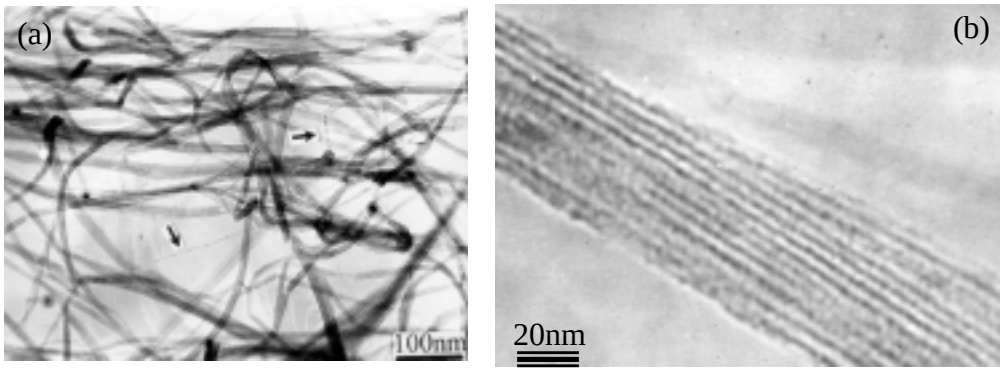

Fig. 1. TEM images of MWNTs (a), and SWNTs (b).

Tab. 1 The hydrogen storage capacities of CNT samples

Sample type	Weight (g)	Press (MPa)	Mass density (wt. %)
MWNTs (As-sythesized)	~0.5	12.0	3.1
MWNTs (Pretreated)	~0.5	12.0	6.0
Web-like SWNTs (As synthesized)	~0.5	12.0	2.3
Web-like SWNTs (Pretreated)	~0.5	12.0	4.2
Ropes of SWNTs (As synthesized)	~0.5	12.0	2.6
Ropes of SWNTs (Pretreated)	~0.5	12.0	4.7
$LaNi_5$	1.7628	10.8	1.38-1.41