A COMPARATIVE STUDY OF HYDROGEN ADSORPTION ON SUPERACTIVATED CARBON VERSUS CARBON NANOTUBES

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On-board storage of hydrogen constitutes the bottleneck of hydrogen vehicles. The techniques of storage available presently cannot afford hydrogen vehicle competition potential with oil-fueled vehicles. Carbon nanotubes seemed promising at beginning [1]; however, cons [2-10] may be as many as pros [11-18]. On the other hand, adsorptive storage of hydrogen on activated carbon proposed earlier [19,20] still seems interesting. A comparison was made with respects to adsorption isotherms and isosteric heats of adsorption between the two hydrogen carriers presently.

The sample of activated carbon used was the well-known AX-21. It possesses specific surface area of about 3000 m^2/g and pore volume of about 1.3 cm^3/g. The multiwalled carbon nanotube (MWNT) sample was prepared by catalytic decomposition of acetylene in a fluidized-bed reactor over the pre-reduced $LaCoO_3$ catalyst, and was thoroughly purified. Both the wall thickness and the inner diameter of the tube were about 10 nm, which were estimated from the scale of TEM photo. The BET surface area determined basing on the adsorption isotherm of N_2 at 77 K was 137 m^2/g [21]. Adsorption measurement was carried out by a typical volumetric method. The temperature of reference cell was constant within ±0.05 K and the pressure was detected with relative error less than 0.05 % for the whole range of 20 MPa. The compressibility factor of hydrogen was calculated from the data of molar volume [22].

The adsorption isotherms were collected for the range 233-298 K with 20 K increment, and one more isotherm at 318 K was obtained for MWNT. About 20 g AX-21 sample and 8.61 g MWNT sample were used in measurements. The results are shown in Fig.1 where the ordinate for MWNT was double enlarged, however, the isotherms for MWNT are still lower than that for activated carbon. Besides, the effect of temperature on adsorption is not as strongly for MWNT as for activated carbon. However, all isotherms possess the same shape, which is classified as type-I isotherm [23]. Since each type of isotherm corresponds to a specific mechanism of adsorption, the adsorption on activated carbon and that on MWNT are motivated by the same mechanism.

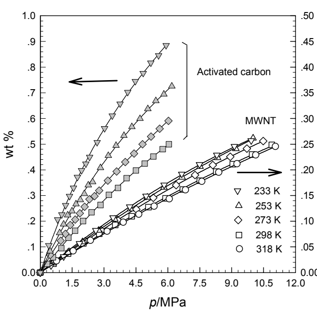

Figure 1 Weight percentage of H_2 adsorbed on activated carbon and on MWNT samples

Figure 2 A comparison of the amount adsorbed on activated carbon and on MWNT samples at 6 MPa for 233-298 K basing on the weight percentage

Figure 3 Variation of the isostric heat of adsorption with the amount adsorbed

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Heat of adsorption is a measure of the strength of interaction between gas molecules and the surface of adsorbent. The isosteric heat of adsorption is defined by the Clausius-Clapeyron equation:

$$-\Delta H = -R\left[\frac{d\ln f}{d(1/T)}\right]_n \qquad (1)$$

where f is the fugacity corresponding to the equilibrium pressure, p, and $f \approx p$ for most conditions tested. The average heat of adsorption, $\overline{\Delta H}$ = -1.7 kJ/mol, was evaluated from a series of ln$p$ versus 1/T plots. Shown in Fig.3 is the variation of the isosteric heat of adsorption with the amount adsorbed. The heat of adsorption on activated carbon was -6.4 kJ/mol [20]. It seems the interaction between H_2 molecules and the surface of MWNT is weaker than with the surface of activated carbon. The specific surface area of nanotubes is limited by its geometry and cannot be comparable with superactivated carbon. Therefore, carbon nanotubes seem not be a promising carrier of hydrogen for practical purpose.

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