

PREPARATION OF NANO-STRUCTURED CARBONS FOR HYDROGEN STORAGE

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Introduction

Hydrogen is one of the most cleanest and idealized energy sources. In the past few years, several different technologies including compression, liquefaction, metal hydride and adsorbent materials were developed to be used for hydrogen storage. Among them, the application of adsorbents is safer and more efficient than any other technologies in terms of controlling hydrogen storage.

Porous carbons in their broadcast sense include a wide range of processed amorphous carbon-base materials. Porous carbons have a highly developed porosity and an extended interparticulate surface area. Their preparation involves two methods: a physical method which indicates the activation at high temperature with CO₂ or water steam stream and a chemical method which means the activation using the micro-explosion behaviors by a chemical agent. Normally, all carbonaceous materials can be converted into porous carbons, although the properties of the final product will be dependent on the nature of the raw materials used.

In this work, the porous carbons with high specific surface area were manufactured from ion-exchangeable polymeric precursors for hydrogen storage. The effects of specific surface area and pore radius on the hydrogen adsorption capacities of the porous carbons were investigated.

Experimental

For chemical activation, ion-exchangeable resins were impregnated by NaOH with 4:1 of weight ratio (NaOH : resin). An ultra-pure N₂ gas (50 cc/min) was fed into the furnace until target activation temperature (5 °C/min of heating rate) and then activation process was achieved for 2 h. The samples were prepared in the range of 500 to 1100 °C, and named as Na500, Na700, Na900, and Na1100.

N₂ and H₂ adsorption isotherms were measured using an ASAP 2010 (Micromeritics) at 77K in order to get textural properties and hydrogen adsorption capacity of the porous GNFs, respectively.

Results and discussion

Figure 1 shows the N₂/77K adsorption isotherms of the porous carbons prepared as a function of activation temperature. All carbons showed a rapid increase at low relative pressure, which means Type-1 of the BET classification. These type of isotherms indicates that porous carbons have well-developed micropores in the structure. For understanding pore structures in details, several methods (BET, D-R, and etc) were used, and the results were listed in Table 1.

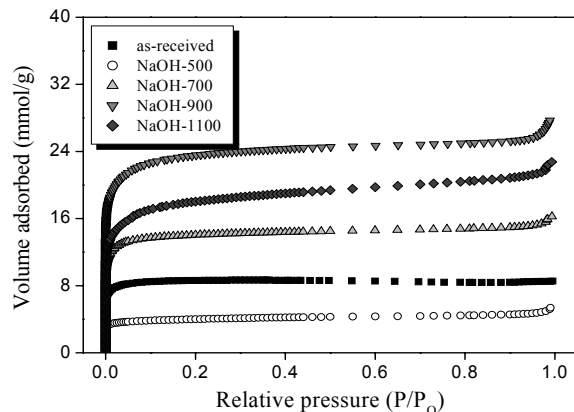


FIGURE 1: N₂/77K isotherm curves of the porous carbons as a function of activation temperature.

The specific surface area and total pore volume of as-received sample were 772 m²/g and 0.298 cm³/g, respectively. It was found that specific surface areas of the samples increase with increasing activation temperature.

Meanwhile, the fraction of mesopores in the porous carbons showed different behaviors. The as-received sample showed the smallest of mesopore volume, and Na500 was the largest. In case other samples, it increased with increasing activation temperatures from 10.8 to 25.2. Accordingly, except as-received sample, Na700 showed the smallest of mesopore volume, resulting in the narrowest of average pore radius (9.06 Å). However, the specific surface area of Na900 was the largest (2220 m²/g).

Figure 2 shows the H₂/77K adsorption isotherms as a function of activation temperatures. Like N₂/77K isotherms, all of the porous carbons showed higher H₂ adsorption capacity than that of as-received sample except Na500 which didn't developed micropores fully. It is worthy to note that H₂ adsorbed volume of Na700 is higher than that of Na900. In case of specific surface area, it was reverse. This result indicates that the specific surface area is not only key factor to determine the H₂ adsorption but also other components, such as possibly micropore volume, fraction of micropore, or average pore radius.

Table 1. Textural Properties of the Porous Carbons as a Function of Activation Temperature.

	S _{BET} ^a	V _T ^b	V _{mc} ^c	V _{ms} ^d	F _{ms} ^e	R _{mc} ^f
As-received	772	0.298	0.275	0.023	7.7	7.73
Na500	347	0.190	0.139	0.051	26.8	10.95
Na700	1251	0.567	0.506	0.061	10.8	9.06
Na900	2220	1.099	0.895	0.204	18.6	9.50
Na1100	1538	0.794	0.594	0.200	25.2	10.32

^a Specific surface area (m²/g), ^b Total pore volume (cm³/g), ^c Micropore volume (cm³/g),
^d Mesopore volume (cm³/g), ^e Fraction of mesopore (%), ^f Average pore radius (Å)

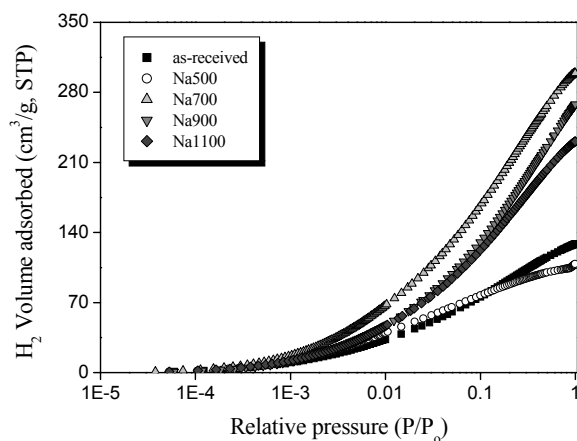


FIGURE 2: H₂/77K isotherm curves of the porous carbons as a function of activation temperature.

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