The hydrogen adsorption behavior of activated carbon
활성탄의 수소흡착거동

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1. Introduction

Carbonaceous materials have been known to adsorb hydrogen for many years. The adsorption capacity of activated carbon reaches approximately 0.5 wt.% at room temperature and 60 bar. This capacity increases up to 5 wt.% at cryogenic conditions and 60 bar[1-2]. Some activated carbon reached up to 1.5 wt.% at room temperature and 125 bar[3].

The aim of this work is to measure hydrogen adsorption capacity of several activated carbon samples and to see the effect of porosity on hydrogen capacity.

2. Experimental

Activated carbons used in this work are shown in Table 1. Eight samples are commercial ones and four samples are prepared by carbon dioxide gas activation (AC-1, 2, 12) and by phosphoric acid chemical activation (AC-3).

Volumetric gas adsorption apparatus(Micromeritics ASAP 2010) was used to get hydrogen adsorption isotherm up to atmospheric pressure at 77K.

A magnetic suspension balance (Rubotherm) was used to measure the hydrogen adsorption isotherm at 298K. The working pressure of this balance is 150 bar. The resolution of this balance 0.01 mg. The full schematic diagram of hydrogen adsorption apparatus is shown in Fig. 1. Hydrogen gas was pressured by pneumatic gas booster up to 120 bar. The adsorption temperature, 298K was kept constant by room temperature control. Buoyancy effect was corrected. The adsorbent was evacuated with double mechanical oil pump until pressure and mass did not change for 30 min. After evacuation, the hydrogen adsorption isotherm was measured up to 100 bar.

The porosity of activated carbon was analyzed from nitrogen adsorption isotherm at liquid nitrogen temperature (Micromeritics ASAP 2010). Area and volume are calculated through BET equation, t-plot, and Gurvitch rule.

Table. 1. activated carbon samples

sample	shape	precursor	maker (brand)
AC1	granule	coconut shell	-
AC2	granule	coal	-
AC3	granule	wood	-
AC4	powder	phenol	KANSAI (MSP15)
AC5	powder	phenol	KANSAI (MSP20)
AC6	powder	coal	KANSAI (MSC25)
AC7	powder	coal	KANSAI (MSC30)
AC8	powder	-	NORIT (A SUPRE EUR)
AC9	powder	-	KURARAY (BP25)
AC10	fiber	phenol	KURARAY (FR25)
AC11	fiber	pitch	OSAKA GAS (FN-200PS20)
AC12	fiber	phenol	-

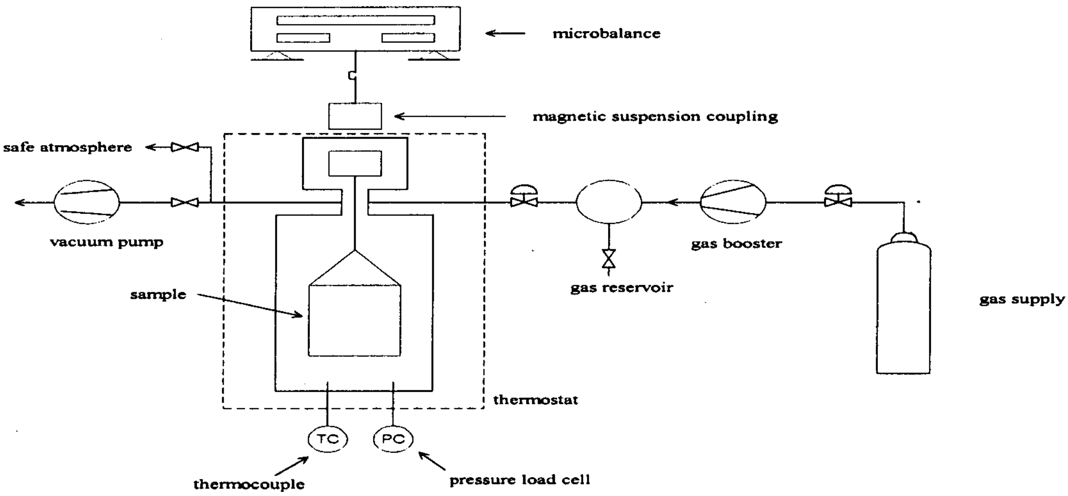

Fig. 1. The schematic diagram of hydrogen adsorption apparatus.

3. Results and discussion

3.1. Hydrogen adsorption isotherm

The hydrogen uptake increases linearly according to the increase of pressure showing a little the characteristic plot of Langmuir adsorption at 298K(Fig.2). The hydrogen adsorption capacity of samples at 100 bar ranges from 0.15 to 0.79 wt.%. AC4 and AC6 are readsorbed to see whether the adsorption mechanism is physical

adsorption or chemisorption. The hydrogen adsorption capacities of first and second adsorption are similar showing that physical adsorption is ruling.
Hydrogen adsorption isotherm shows typical langmuir shape at 77K (Fig.3).

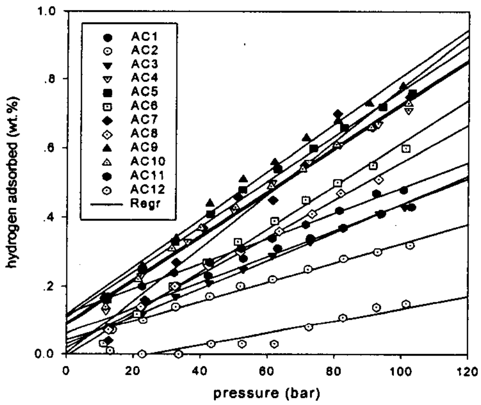

Fig. 2. Hydrogen adsorption isotherm (100 bar, 298 K)

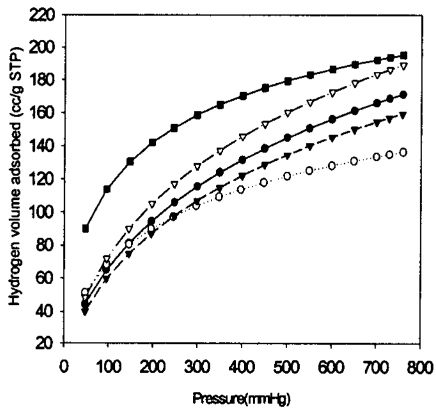

Fig. 3. Hydrogen adsorption isotherm (up to atm. pressure, 298 K)

3.2. the effect of porosity on hydrogen adsorption

Fig. 4 shows the relationship between micropore surface area and hydrogen adsorption capacity. It seems that the amounts of hydrogen adsorption increases according to the increase of micropore surface area. It is true of specific surface area, total pore volume and micropore volume as all of samples are microporous. The effect of mesopore on hydrogen adsorption capacity seems to be minor(Fig. 5).

4. Conclusions

The hydrogen adsorption isotherm of activated carbons were measured by isothermal gravimetric analysis, using a microbalance, at 298K up to 100 bar, resulting in the following conclusion.

1) The hydrogen adsorption isotherm is almost linear showing a little convex shape.
2) Hydrogen adsorption capacity of activated carbon is almost lineally increased

according to the increase of micropore surface area and micropore volume.

3) It seem that microporosity is more contributive than mesoporosity.

4) Most of the adsorbed quantity is due to physical adsorption and chemisorption is negligible.

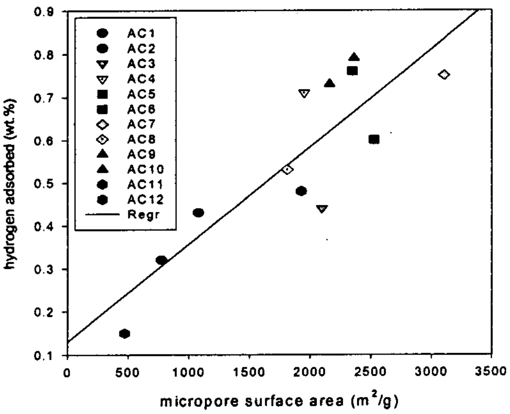

Fig. 4. Hydrogen adsorption capacity vs. micropore surface area (100 bar, 298 K)

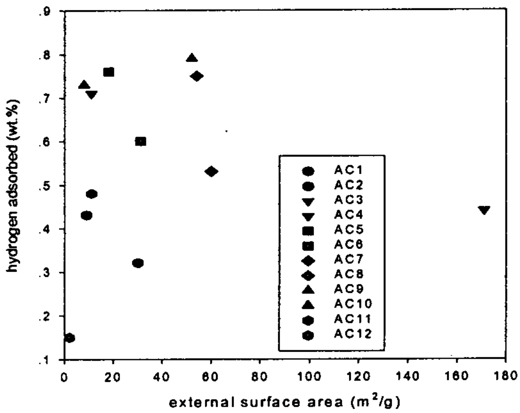

Fig. 5. Hydrogen adsorption capacity vs. external surface area (100 bar, 298 K)

Acknowledgements

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References

[1] R. Chahine, T. K. Bose,, Characterization and optimization of adsorbents for hydrogen storage, Proc. 11th World Hydrogen Energy Conf. Stuttgart, 1996, pp. 1259-1263.

[2] R. Chahine, T. K. Bose, Low-pressure adsorption storage of hydrogen, Int. J. hydrogen Energy 19(2), 1994, pp.161-164.

[3] R. Strobel, L. Jorissen, and et. als, Hydrogen adsorption on carbon materials, J. Power Sources 84, 1999, pp. 221-224