HYDROGEN STORAGE IN ACTIVATED CARBON MATERIALS : ROLE OF THE POROUS TEXTURE

Nathalie Texier-Mandoki[1], Joseph Dentzer[2],Thierry Piquero[1], Patrick David[1] and C. Vix-Guterl[2].
[1] *CEA Le Ripault, BP 16, 37260 Monts (France)*
[2] *Institut de Chimie des Surfaces et Interfaces (ICSI), CNRS, 15 rue Jean Starcky, 68057 Mulhouse Cedex (France)*

Corresponding author e-mail address : CVix@uha.fr

Introduction

Nowadays, there is a strong increasing interest in the study of the hydrogen storage capacity of various mesoporous materials due to their potential use in mobile applications. In this frame, activated carbons appear as a very promising material due to their high surface area and their particular pore size distribution. The hydrogen storage capacity is dependant from the porous characteristics of the carbon materials and, the presence of a micro-mesoporosity is of prime importance as already mentioned in the literature [1-4]. Relationship between micropore volume and methane storage [5] or micropore volume and pollutant abatement [6] have been demonstrated for such kind of carbon materials . It is then of great interest to look if such tendency is also observed with hydrogen adsorption. In a previous work [7], the correlation between hydrogen adsorption capacity and micropore volume has been demonstrated for alumina and silica zeolite. The correlation was not effective for carbon materials. Physical adsorption of gases, and specially N_2 adsorption at 77K, is the most employed technique for the characterization of porous solid. In a recent study [8], the usefulness of CO_2 adsorption at 273K has been demonstrated since CO_2 can diffuse in the narrowest micropores (i.e. smaller than 0.7 nm), which are not accessible for N_2.

The hydrogen adsorption capacity of several activated carbon materials were determined in relationship with their textural characteristics and in particular their microporous volume. The original result of this paper is to demonstrate that a correlation exits between the microporous volume of the various tested carbon materials

(determined by CO_2 adsorption) and the hydrogen adsorption capacity. To the best of our knowledge, it is the first time that such relationship has been demonstrated.

Experimental

Synthetic and natural mesoporous carbon materials with different textural properties were selected. From the N_2 physisorption data , the total surface area, the total pore volume and micropore volume were determined (pore size smaller than 2 nm) whereas the adsorption of CO_2 at 273 K allows us to assess the narrowest micropores (pore size smaller than 0,7 nm). Hydrogen adsorption capacity measurements are carried out at 77K in the pressure range 1-10 bar. The carbon materials (around 1,5 gram) are loaded in a 20 cm^3 internal volume cell and then carefully heat treated under vacuum to eliminate adsorbed gases and water. The system can be immersed in a dewar filled with liquid nitrogen to reach a temperature of 77K. The H_2 storage capacity is calculated from de H_2 discharging volume. A blank volume is measured to determine the gas compressed volume in the cell. Therefore, using material skeleton density and the blank volume, the real H_2 adsorption capacity can be deduced.

Results and Discussion

Six different activated carbons have been characterized. The hydrogen adsorption capacity at 77K, for 1 bar and 10 bar, is plotted versus the total surface area as well as versus the N_2 and the CO_2 micropore volume, calculating using the Dubinin-Radushkevitch equations (Figures 1, 2, 3).

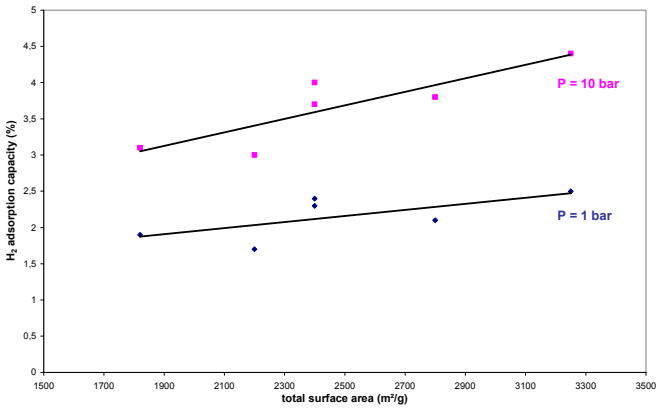

Figure 1 : H_2 adsorption capacity versus total surface area

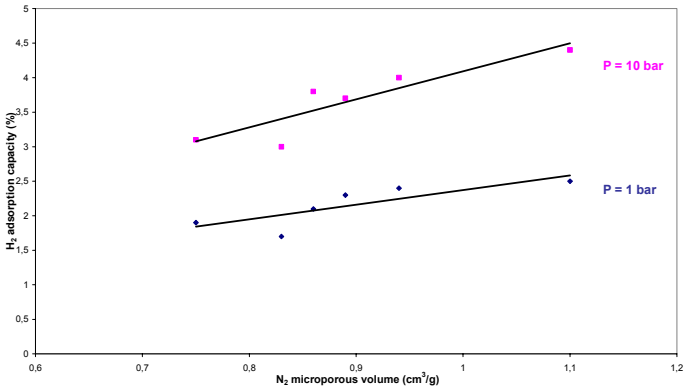

Figure 2 : H_2 adsorption capacity versus N_2 micropore volume (D < 2 nm)

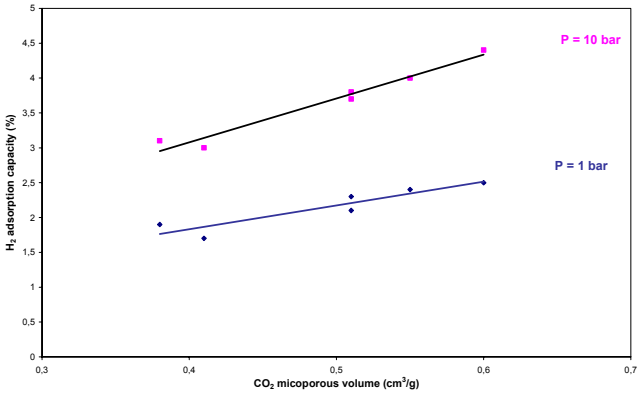

Figure 3 : H_2 adsorption capacity versus CO_2 micropore volume (D < 0,7 nm)

As seen in these figures, the hydrogen adsorption capacity increases with the total surface area and the micropore volume. The best correlation (linear one) is pointed out between the H_2 adsorption capacity and the CO_2 microporous volume, in the total pressure range. These observations confirm the importance of the microporosity, especially the narrow microporosity (smaller than 0,7 nm), for hydrogen storage.

It can be stated that valuable information for the characterization of the nanoporous texture can be obtained by CO_2 adsorption measurements.

Conclusions

This study points out the existence of an interesting relationship between the hydrogen storage capacity and the CO_2 microporous volume of various porous carbon materials. The characterization by CO_2 adsorption allows to assess to information of prime importance in the case of hydrogen storage applications.

References

1) Chahine R., Benard P., IEA Task 12 : Metal Hydrides and carbon for hydrogen storage, 2001, pp.104-107
2) Amankwah KAG, Noh J.S., Schwarz J.A., Int. J., Hydrogen Energy, 14 (1989) , pp.437-447

3) Carpetis C., Peschka W., Int. J., Hydrogen Energy, 5 (1980) , pp.539-554
4) Noh JS, Agarwal RK., Schwarz J.A., Hydrogen storage systemes using activating carbon, Int. J., Hydrogen Energy, 12 (1987) , pp.693-700
5) Lozano-Castello D., Cazorla-Amoros D., Linares-Solano A., Quinn D.F., Carbon ,40 (2002), pp. 989-1002
6) Lillo-Rodenas M.A., Carratala-Abril J., Cazorla-Amoros D., Linares-Solano A., Fuel Processing Technolmogy, 77-78 (2002), pp.331-336
7) Nijkamp M.G., Raaymakers JEMJ., Van Dillen A.J., de Jong K.P., Appl.Phys. A 72 (2001) , pp. 619-623
8) Cazorla-Amoros D.,Alcaniz-Monge J., dela Casa-Lillo M.A., Linares-Solano A., Langmuir 14 (1998), pp.4589-4596.