

# FAU-TYPE ZEOLITE NANOCASTED CARBON REPLICAS FOR THE H<sub>2</sub> PURIFICATION.

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## Introduction

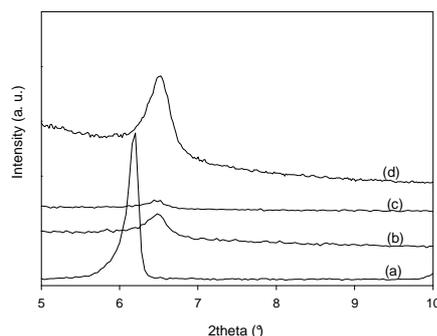
The most used industrial process for H<sub>2</sub> production is the steam reforming of natural gas that leads to formation of impurities such as CO<sub>2</sub>, CH<sub>4</sub>, CO, and N<sub>2</sub>. Their separation from H<sub>2</sub> is obtained by a pressure swing adsorption (PSA) process based on a multilayer adsorbent bed. Nevertheless, there is room for improvement of the adsorption properties of the carbon phase used for H<sub>2</sub> purification, in terms of their working capacity and selectivity. In this context, ordered microporous carbon materials prepared by nanocasting from a zeolitic template [1-3] are interesting new candidates for this application.

## Experimental

Microporous ordered carbon have been synthesized by the nanocasting process from zeolite Y by using acetylene (Ac) and furfuryl alcohol (FA) as carbon precursors as described elsewhere [4]. The resulting carbons, prepared with different infiltration conditions (precursor, temperature, duration) are denoted FA+Ac-600/700-4/1, Ac-600/700-4/1 and FA+Ac-650-5. They were characterized by X-ray diffraction, nitrogen physisorption at 77K. The potential of these materials for the adsorptive separation of light gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>) was evaluated by studying, at room temperature, high pressure single component adsorption isotherms of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>. Their separation properties for CO<sub>2</sub>/CH<sub>4</sub> and CO<sub>2</sub>/N<sub>2</sub> mixtures were evaluated using the ideal adsorbed solution theory (IAST). These data were compared with those obtained with commercial activated carbon AC35 and BG-ENO.

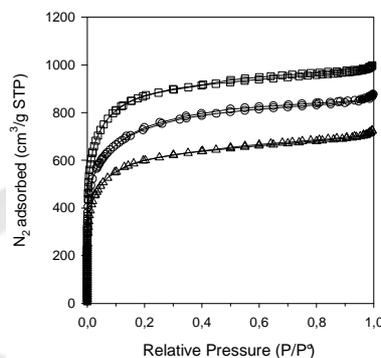
## Results and discussion

Depending on the synthesis conditions, these nanocasted carbons can display one diffraction peak at around 6° (2θ) (Figure 1).



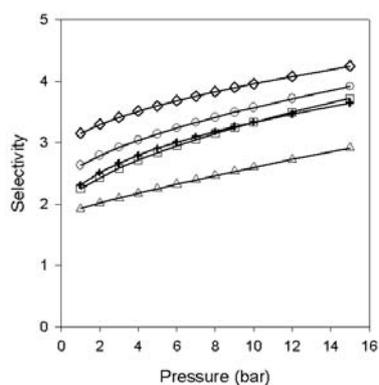
**Fig. 1** XRD patterns (Cu K<sub>α1</sub> radiation) of (a) the zeolite Y and the carbon replicas (b) Ac-600/700-4/1, (c) FA+Ac-650-5, (d) FA+Ac-600/700-4/1.

This peak, located at the same position of the (111) interspacing planes distance of zeolite Y, indicates that the carbon replicas display a nano-structuration having the same symmetry as the host material. The nitrogen physisorption isotherms (77K) are reported Figure 2.

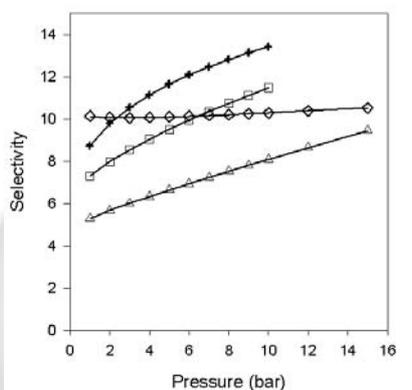


**Fig. 2** N<sub>2</sub> adsorption/desorption isotherms (77K) of the carbon replicas prepared by (○) Ac-600/700-4/1, (△) FA+Ac-650-5, (□) FA+Ac-600/700-4/1.

The samples present a large specific-surface area (2200 - 3200 m<sup>2</sup>/g) and a high pore volume (1.1 - 1.6 cm<sup>3</sup>/g). Most of the pore volume is due to micropores (0.9 - 1.4 cm<sup>3</sup>/g). Interestingly, there is a correlation between surface area and pore volume and the intensity of the XRD peak at 2θ = 6°. Their pore size distribution is partly controlled by the wall thickness of the zeolite template. The high-pressure CO<sub>2</sub>, N<sub>2</sub> and CH<sub>4</sub> adsorption isotherms at 298 K of carbon replicas were performed and an estimate of the selectivity was given by the IAS theory (Figures 3 and 4) for CO<sub>2</sub>/CH<sub>4</sub> and CO<sub>2</sub>/N<sub>2</sub> mixtures, respectively.



**Fig. 3** Evolution of the predicted selectivity of mixtures  $\text{CO}_2/\text{CH}_4 = 50/50$  depending on the pressure, ( $\circ$ ) Ac-600/700-4/1, ( $\Delta$ ) FA+Ac-650-5, ( $\square$ ) FA+Ac-600/700-4/1, (+) Ac35 and ( $\diamond$ ) BG-ENO.



**Fig. 4** Evolution of the predicted selectivity of mixtures  $\text{CO}_2/\text{N}_2 = 50/50$  depending on the pressure, ( $\Delta$ ) FA+Ac-650-5, ( $\square$ ) FA+Ac-600/700-4/1, (+) Ac35 and ( $\diamond$ ) BG-ENO.

Among these materials, there is clear correlation between the selectivity and the XRD structural quality; the higher is the quality of the nanocasted carbon, the higher is its selectivity. Compared to commercial activated carbons, these materials display equivalent selectivities.

## Conclusions

The separation properties of zeolite-nanocasted carbon replicas were evaluated through the ideal adsorbed solution theory with high pressure adsorption of  $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{N}_2$  data obtained at room temperature. A clear correlation exists between their selectivity, their porosity and their replicated structural quality. It appears that although the selectivities of nanocasted carbons are equivalent to those of activated carbons, their higher adsorption capacities improve the efficiency of the separation process. They are therefore promising candidates for gas separation in, for instance, pressure swing adsorption process.

## References

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