The influence of the SBA-15 porosity on the H_2 adsorption of nickel-silica materials.

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INTRODUCTION

Hydrogen is considered as a promising renewable nonpolluting alternative to fossil fuels, which will play a major role in future energy system. However, hydrogen storage is one of the bottlenecks for the applications in automobile. Several storage methods have been investigated to develop efficient technologies. Hydrogen storage in sorbents is the most promising technology with respect to efficiency and safety [1].

In this work, ordered mesoporous SBA-15 materials were modified with Ni and were reduced in a H_2 flow. The materials were characterized and the hydrogen storage capacity of the materials was evaluated at 77 K and room temperature, and at low and high-pressure conditions respectively.

EXPERIMENTAL/THEORETICAL STUDY

The pure siliceous mesoporous material SBA-15 was synthesized as previously reported by Ferrero et. al [2]. The SBA-15 pure was modified with different Ni loadings (2.5 and 10 wt.%) by the wet impregnation method. The resulting materials were named Ni/SBA-15(x), where x indicates the nominal percentage of metal loading. The reduced materials were named: Ni/MCM-41(x)-R, where R indicates that the sample was reduced.

RESULTS AND DISCUSSION

The N_2 adsorption-desorption isotherms shapes are characteristic of ordered porous materials, with well-defined H1-type hysteresis. It is noteworthy the change of shape in the hysteresis loop for the nickel-loaded materials. The hysteresis loop of the Ni-loaded samples extends to relative pressures close to 0.47, indicating changes in the porous geometry in those materials compared to the original SBA-15. This behaviour could be assigned to the presence of nickel oxide nanoparticles inside the mesopores of the parent SBA-15.

The low angle XRD patterns of the nickel loaded samples are similar to that of the unloaded SBA-15, indicating that the structure was preserved regardless of the nickel loading. On the other hand, the TEM images of the reduced also show the preservation of the host structure.
For TPR profiles of the Ni/SBA-15 samples, only one reduction peak could be distinguished, about at ~660 K assigned to reduction of Ni^{2+} to Ni^0 from NiO on the external surface of SBA-15.

Figure 1 shows the hydrogen excess isotherms of all the samples. The maximum capacity of hydrogen adsorption was reached for this sample at about 1.2 wt.%. Moreover, the sample Ni/SBA-15(10) presents the lowest hydrogen storage capacity. This fact could be due to the increased number of NiO particles that cause a decrease in the S_{BET} and the pore volume, by obstructing the access of hydrogen towards some mesopores channels. Although, the reductive treatment diminishes the hydrogen adsorption of the corresponding non-reduced samples [3].
From the hydrogen adsorption isotherms at 293 K up to 40 bar, the following order in H_2 uptake was observed: Ni/SBA-15(2.5) > Ni/SBA-15(2.5)-R > SBA-15 > Ni/SBA-15(10) ≈ Ni/SBA-15(10)-R.

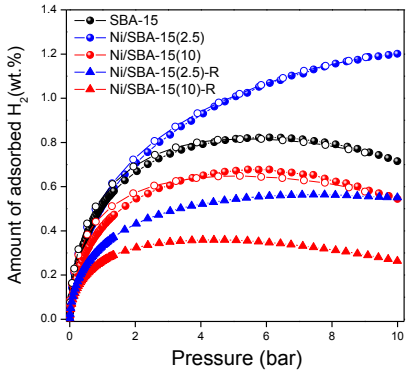

Fig. 1 H_2 adsorption-desorption isotherms of the unreduced and reduced Ni/SBA-15 materials at 77 K.

CONCLUSION

The reduction treatment does not improve hydrogen adsorption on Ni/SBA-15 at 77 K and 293 K. This behavior was correlated with the textural properties of the SBA-15 (the size of the mesopore channels and its pore interconnectivity), that affect the properties and behavior of the supported nickel nanoparticles subjected to heat treatment.

REFERENCES

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