

NEW EVIDENCES ON THE METAL-SUPPORT INTERACTION OF COBALT AND NICKEL NANOCATALYSTS

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The activity of the solid catalysts depends on the extent of the surface area. A high surface area is achieved by using porous materials as supports on which the catalytically active component, often a metal, is deposited. Depending on the catalyst preparation method [1], in some cases the active component forms separated particles dispersed on the support, while in other cases the result is a more complex active phase that exhibits metal-support interactions. In the present work, several characterization techniques are used to study the effect of the preparation method and the nature of the support on the development of metal-support interactions in cobalt and nickel nanoporous catalysts.

The catalyst samples were prepared by two methods, incipient wetness impregnation and precipitation-deposition, using two commercially available oxides, γ -Al₂O₃ (Rhône-Poulenc) and SiO₂ (AF125, Kali Chemie) as supports. In the case of the incipient wetness impregnation, the required amount of an aqueous solution of Ni(NO₃)₂·6H₂O (Merck) or Co(NO₃)₂·6H₂O (Panreac, p.a.) was slowly added to the supports to give solids with a metal content of about 10 wt.%. In precipitation-deposition, the aqueous solution of metal nitrate was mixed with the support forming a slurry in which the metal precipitation was produced by a slow and homogeneous change in the pH, induced by the thermal decomposition of urea at 90 °C. All the precursors were dried at 120 °C for 16 h and then calcined at 550 °C for 4 h. Physicochemical characterization of the catalysts included nitrogen adsorption, X-ray diffraction (XRD), temperature-programmed reduction (TPR) and chemical analysis. A superconducting quantum interference device (SQUID) magnetometer was used to measure the magnetic properties of the supported metal catalysts.

The nitrogen adsorption data of these materials reveal that the majority of the pores have sizes in the range of 6 to 25 nm. The XRD patterns of the catalysts prepared by incipient wetness impregnation reveal the presence of the single metal oxides NiO and Co₃O₄. An antigorite-structure compound is detected in the catalysts prepared by the precipitation-deposition method. The performed magnetic characterization confirms the structural XRD analysis. While the catalysts obtained through incipient wetness impregnation display the characteristic magnetic behaviour of antiferromagnetic metal oxide nanoparticles, the precipitation-deposition method leads to a more complex magnetic structure (i.e. spin glass behaviour). The TPR results confirm the presence in the catalysts of the single metal oxides and compounds difficult to reduce. Their formation must be related to the high pH used in the precipitation-deposition preparation and the high reactivity of alumina with cobalt and nickel.

References:

[1] G. Ertl, H. Knözinger, J. Weitkamp (Eds.), Preparation of Solid Catalysts, Wiley-VCH (1999).