Abstract

Metal nanoparticles immobilized at various supports have outstanding catalytic activity in hydrogenation reactions. Zeolites are used as supports, mainly due to their porous structure. In this work, metal nanoparticles were immobilized on MFI nanosponge zeolites. Zeolite nanosponges (pure silica and degallated) were impregnated with pure platinum and platinum mixed with rare-earth elements (cerium, lanthanum, and yttrium) to form alloys. The main aim of this work was to investigate the activity of bimetallic nanoparticles immobilized on zeolite nanosponges in hydrogenation of cinnamaldehyde. It is a versatile model reaction to investigate catalysts, due to the presence of three different reducible groups (C=C bond, C=O bond and benzene ring) in the cinnamaldehyde molecule. The objective was to focus on selectivity effects of various catalyst towards three possible products of cinnamaldehyde hydrogenation (hydrocinnamaldehyde, cinnamyl alcohol and hydrocinnamyl alcohol).

The metal alloys evolution is more feasible on the degallated zeolites due to the defects in the structure called silanol nests. These defects stabilize bimetallic nanoparticles. Moreover, samples prepared with use of degallated support showed larger surface areas. Pure-silica zeolites impregnated with metals were also prepared for comparison.

Powder X-ray diffraction, scanning electron microscopy, transmission electron microscopy, energy dispersive X-ray analysis and argon sorption were used to investigate the structure, crystals morphology, dispersion of nanoparticles in the zeolite matrix, and textural properties of these materials, respectively.

Pt-Ce bimetallic samples showed high selectivity (at 30% conversion) to hydrocinnamaldehyde, while catalysts with only platinum nanoparticles were selective (at 30% conversion) towards cinnamyl alcohol. Samples with Pt-La nanoparticles also showed selectivity towards hydrocinnamyldehyde, but the preference of the C=C bond reduction is lower than in the case of Pt-Ce catalysts. In the case of Pt-Y samples, the catalyst based on pure-silica support were more selective to cinnamyl alcohol, while catalyst based on degallated support were selective to hydrocinnamaldehyde.