Aerosol-made NiCu-SiO_2 mesoporous materials as promising catalysts for non-oxidative ethanol dehydrogenation

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Ethanol produced by fermentation of biomass is a promising platform chemical [1]. Thus, acetaldehyde made by ethanol dehydrogenation is a process of renewed interest because it is widely employed as a preservative, flavouring agent in food engineering and strategic intermediate for other chemicals as pyridines, ethylacetate, glyoxal etc. Many Efforts have been made to develop improved ethanol dehydrogenation catalysts. Among the employed metals for this reaction, Cu has the brightest future because it is cheaper than noble metals-based materials and because it is selective to acetaldehyde [2]. However, deactivation by coking has been clearly identified as a major limitation on such Cu-based catalysts (even if catalyst regeneration is possible), together with sintering (which mostly irreversible) [3]. However, with the introduction of a second metal, and by varying the atomic composition and the atomic arrangement, it is possible to furtherly tailor the catalysts activity and stability. In particular, in the formulation of bimetallic catalysts, one of the two components should have a higher melting point. Therefore, the choice is crucial because alloying not only influences the physical properties of the nanoparticle (i.e. the thermal stability), but may also alter the chemical properties and hence the catalytic activity and/or selectivity of the catalyst. Among the choices, it was already reported [4] that Ni is a suitable candidate to improve thermal stability and catalytic activity of Cu. Thus, leveraging on an effective one-pot synthesis technique that we have recently disclosed (Aerosol Assisted Sol Gel method (AASG) [5]), a series of bimetallic Ni/Cu silica supported catalyst was obtained. Different Ni and Cu ratios were introduced in the catalyst formulation. The synthesized materials have been extensively studied investigating also the deactivation effects, by a complete characterization survey, on both fresh and spent catalysts, and tested in ethanol dehydrogenation reaction. Remarkably, while the Cu-based catalyst suffered slow deactivation on stream, the bimetallic catalysts were more stable, and the best formulation maintained a constant ethanol conversion (55%) after 8h test at 573 K.

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