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Catalysis between innovation and tradition: new challenges and new opportunities for University and Industry

Synthesis and characterization of gold nanoparticles for an industrial chemistry based on renewable resources

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Up to now, little attention has been given to develop the use of biomass as a raw material for the production of industrial chemicals. Therefore, a huge challenge for chemists today is to provide the chemical industry with new tools to convert renewables into useful chemicals in an economically viable fashion. Actually, there are no well developed process for the C5 fraction (xylose). Furfural can be obtained from xyloses by dehydration in acidic media and it can be used in soil chemistry and as a building block in the production of Lycra®, etc. However, additional transformations of furfural are highly desired: among these, the synthesis of alkyl furoates can open very interesting perspectives for the use of xyloses, because they can be used either as solvent or extracting agents in many different industrial plants if produced in larger amounts and at low price. Suitable catalysts for the selective oxidation of furfural with O₂ are supported metal catalysts. Nanodispersed Au has been recognized as a very good catalyst for selective oxidation with molecular O₂ [1]. Experimental data, obtained for both propylene and styrene epoxidation [2, 3], indicate that there is a limiting size (1.5-2nm), dividing active from inactive catalysts. The limiting size appears related to an intrinsic modification of the electronic structure of Au clusters with respect to nanoparticles. Au clusters, supported on chemically and electronically inert materials, can adsorb and activate O₂, presumably by dissociating O₂ to yield O atoms that initiate the partial oxidation. Furfural can be quite easily converted in methyl furoate by an oxidative esterification with a NaCH₃O solution in CH₃OH with O₂ at 22 °C on a Au/TiO₂ reference catalyst purchased by the World Gold Council [4]. However, to be applied in a large scale production, this process must be optimised, starting from both composition and microstructure of the catalysts. The goal of this work is to verify if the clusters amount and their ability in the O₂ activation play a role in the oxidative esterification of furfural, even without NaCH₃O. Different Au samples have been tested. Au is dispersed on different supports, as ZrO₂, CeO₂: on all these samples gold clusters have been evidenced by quantitative CO chemisorption and by FTIR. A positive role of the basicity of the support and of the Au clusters size has been observed. A comparison with the Au/TiO₂ reference sample, where nanoparticles of 3.4 nm are present, has been performed [5]. Both interaction and chemisorption of furfural and furfural-oxygen at room temperature have been studied preliminarily, looking at the nature of the adsorbed species and at their dependence on the nature of the support by the analysis of the FTIR spectra. In addition, a study of the effect of NaCH₃O has been made. After reaction a detailed characterization has been carried out in order to verify if micro structural changes occurred.

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