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Preparation of nanocrystalline materials for selective oxidation reactions

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Nanocrystalline materials have emerged as sustainable alternatives to conventional materials, as robust, high surface area heterogeneous catalysts and catalyst supports. The nano-sized particles increase the exposed surface area of the active component of the catalyst, thereby enhancing the contact between reactants and catalyst dramatically and also, the activity and selectivity of nano-catalyst can be manipulated by tailoring chemical and physical properties like size, shape, composition and morphology. The development of new heterogeneous catalysts systems with high activity and selectivity towards the desired product for catalytic oxidations is a crucial need. Due course of time, many oxidizing agents have been applied for selective oxidations; however, from the environmental concern molecular oxygen is the best option. Directly using molecular oxygen as an oxidant would therefore not only reduce the cost, but will also eliminate many environmental issues. The selective method for the catalytic fictionalization of carbon-hydrogen bonds in saturated hydrocarbons still remains a major challenge in chemistry. Of particular importance the selective oxidation of methane to methanol, benzene to phenol, propylene to propylene oxide using molecular oxygen is regarded as holy grains of catalysis. The low temperature dehydrogenation of ethane to ethylene is also a very important reaction from industrial point of view. Different nanocatalysts like Cu supported on $CuCr_2O_4$ spinel nanoparticles, Ag supported on WO_3 nanorod, Pt supported on nanocrystalline Ceria and Mo supported on TiO_2 nanorod were prepared and characterized by XRD, ICP-AES, XPS, TPR, BET- surface area, FESEM, HR-TEM and EXAFS. This Cu supported $CuCr_2O_4$ spinel nanoparticles catalyst is very active for selective oxidation of benzene to phenol. A benzene conversion of about ~ 29% with ~ 96% phenol selectivity was achieved at vapour phase using air as oxidant. Ag-nanoparticles supported on WO_3 nanorod catalyst are very active for selective oxidation of propylene to propylene oxide and a propylene conversion of about ~ 36% with >99% propylene epoxide selectivity was achieved in the vapour phase using solely molecular oxygen as oxidant. Pt-supported on ceria was tested for the methane to methanol transformation reaction and a methane conversion of ~ 6% with ~ 56% methanol selectivity was achieved with molecular oxygen. Mo supported on TiO_2 nanorod gives the dehydrogenation of ethane to produce ethylene with 86% conversion and 95% selectivity in a continuous fixed bed reactor.

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