

Magneto Induced Catalysis with Organometallic Nanoparticles

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Magnetic nanoparticles display both interesting core physical properties and interesting surface chemical properties. The composition of the particles allows to modulate their magnetic properties in terms of saturation magnetization, magnetic anisotropy and Curie temperature and hence heating power. Thus magnetic nanoparticles heat when submitted to an alternating magnetic field. Magnetic heating is instantaneous and in principle the best way to transform electrical energy into heat.

We have developed in Toulouse a new generation of iron based nanoparticles (NPs) of unprecedented heating power. We have prepared iron carbide particles by carbidization of preformed monodisperse Fe(0) nanoparticles under a CO/H₂ atmosphere at 150°C. They consist essentially of crystalline Fe_{2.2}C, display a SAR (heating power) of up to 3.3 kW/g and are able to hydrogenate CO₂ into methane in a flow reactor after addition of a catalytic Ru or Ni layer and excitation by an alternating magnetic field.¹ Iron Cobalt NPs have been prepared from {Fe[N(TMS)₂]₂}₂ and the relative {Co[N(TMS)₂]₂}₂. These soft magnetic bimetallic FeCo NPs² with a high Curie Temperature allow performing high temperature catalytic reactions such as propane dehydrogenation or methane and propane dry reforming. Iron nickel nanoparticles have been synthesized from iron amide and nickel amidinate precursors and found very active for CO₂ hydrogenation. In addition, submitting nanoparticles of iron carbide or iron nickel to magnetic heating in solution leads to high local over-heating and to perform in apparent mild conditions and under a low H₂ pressure difficult reactions typically performed at high temperature and pressure such as such as hydrodeoxygenation of biomass derived platform molecules.

The lecture will briefly present the synthesis of the particles, their magnetic properties, their surface modification to deposit a catalytic layer and their catalytic properties for heterogeneous CO₂ hydrogenation^{1,3} in a flow reactor, dry reforming of methane⁴ and in solution hydrodeoxygenation or hydrogenolysis of biomass derived platform molecules.^{5,6} Further developments of the technique for liquefaction or gasification of waste plastics and for water electrolysis will also be described.⁷

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