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Complex ferromagnetic nano-objects displaying both heating and catalytic properties

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Monosdisperse and air stable iron based nanoparticles are highly desirable for energy resource conversion processes, such as CO and CO_2 hydrogenation. Iron carbides nanoparticles are particularly attractive since they combine high magnetization, air stability and the possibility to modulate the magnetic anisotropy and catalytic properties as a function of the carbon content. But so far, these nanomaterials have been much less investigated than iron oxide or iron(0) nanostructures, because there are still big challenges in the synthetic strategy of iron carbide nano-objects of controlled composition and size. Recently, we reported the first versatile chemical synthesis of monodisperse iron carbide as well as that of core/shell iron/iron carbide nanoparticles of controlled size and composition (1,2). The synthesis deriving from Fischer Tropsch mechanism is based on the decomposition of $Fe(CO)_5$ in different mild conditions, on a colloidal solution of preformed Fe(0) nanoparticles. We have now extended this approach to other bimetallic materials such as Fe/Ru, Fe/FeCo, Fe/Mn or FeC/Ru, FeC/Mn and FeC/Co, by the decomposition of $Ru_3(CO)_{12}$, $Co_2(CO)_8$ and $Mn_2(CO)_{10}$ on preformed Fe(0) nanoparticles (3).

Full characterization by transmission electron microscopy (TEM), high resolution transmission electronic microscopy (HR-TEM), Squid Magnetometry, and Mossbauer spectroscopy evidenced the presence of different homogenous samples. By optimizing the synthesizing conditions, we were able to tune the carbon contain in the ferromagnetic core from pure Fe to FeC_x, and the catalytic surface with Ru or Co.

These particles display large heating powers when placed in an alternating magnetic field (50-300kHz and 30-70mT). The combination of magnetic core and catalytic surface properties of these novel objects were used to demonstrate a new concept: the possibility of performing Fischer-Tropsch syntheses and Sabatier reaction in a cold reactor. Here, only the nanoparticles are heated through hysteresis losses induced by the external alternating magnetic field.

Keywords: Magnetic Nanoparticle, Iron, Bimetallic, Catalysis, Fischer-Tropsch, magnetic induction

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