NANOSTRUCTURED FERRITES FOR ENERGY APPLICATIONS

Nanocrystalline metal oxides represent solid compounds extensively studied because of the peculiar properties arising from the nanoscale domain, which significantly differ from those associated with conventional bulk materials. Among oxide compounds, spinel ferrites emerge as subjects of intense research activity, mainly due to the magnetic properties exhibited by this class of materials. Besides well-known applications related to data storage, new fields utilizing magnetic nanosized particles are emerging particularly in the biomedical technologies development. Ferrites also play a significant role in thermochemical hydrogen production from water-splitting cycles [1, 2]. ENEA activity on nanostructured ferrites is mainly focused on energy applications and significant competences have been developed in the synthesis of nanosized ferrites. In fact, nanomaterials syntheses are routinely performed by using solid state and wet chemical methods such as mechanical assisted reactions, coprecipitation of metal salts in aqueous solution and in water-in-oil micellar systems, high-temperature decomposition of organometallic compounds.
Mixed sodium-manganese ferrite cycle is a two-step metal-oxide based water-splitting thermochemical cycle that can be exploited for sustainable solar hydrogen production process. Hydrogen gas production and successive regeneration of initial reactants take place according to the following reactions (1) and (2):

$$2MnFe_2O_{4(s)} + 3Na_2CO_{3(s)} + H_2O_{(g)} \rightarrow 6Na(Mn_{1/3}Fe_{2/3})O_{2(s)} + 3CO_{2(g)} + H_{2\,(g)} \quad (1)$$

$$6Na(Mn_{1/3}Fe_{2/3})O_{2(s)} + 3CO_{2(g)} \rightarrow 2MnFe_2O_{4(s)} + 3Na_2CO_{3(s)} + \tfrac{1}{2}O_{2(g)} \quad (2)$$

The $MnFe_2O_4/Na_2CO_3$ mixture evolves hydrogen (reaction 1) at the contact interface among ferrite/carbonate solid phases and water steam. As a consequence, hydrogen evolution rate is strongly influenced by the contact area among solid phases and by the solid-gas interface extension. Then, the utilization of nanomaterials is pursued to enhance reaction kinetics.

Mechanically activated solid state process by High Energy Ball Milling (HEBM) and reverse micellar systems synthetic routes were employed for the synthesis of manganese ferrite. The synthesized materials were compounded with Na_2CO_3 and tested for hydrogen production reaction (1). When compared with microscrystalline compound, nanocrystalline ferrites blended with sodium carbonate were able to produce hydrogen with a significantly improved kinetic as reported in figure 1 for HEBM synthesized

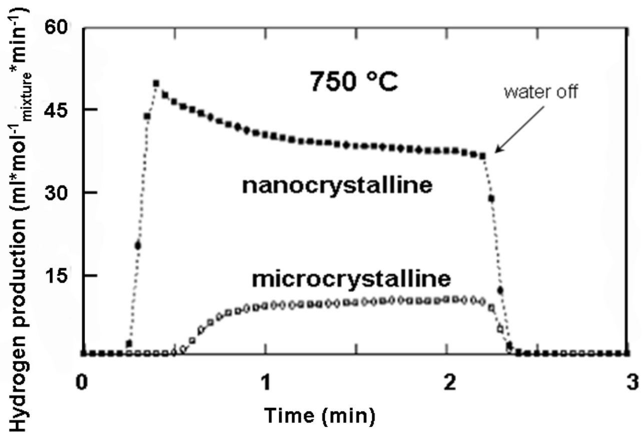

Figure 1. Hydrogen generation rate from water utilizing microcrystalline and nanocrystalline $MnFe_2O_4$ blended with Na_2CO_3.

materials. Even better results were obtained from manganese

Ferrites synthesized by water-in-oil micellar systems. These synthetic routes produce nanoparticles with a narrow size distribution (figure 2). The use of nanoferrites and their stable dispersions (ferrofluids) in energy and other application fields of nanotechnology as well as the evaluation of potential toxicity of the produced nanomaterials is seen as an integral part of ENEA research activity [3, 4].

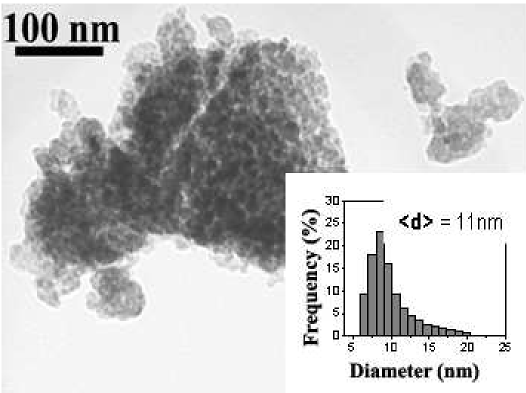

Figure 2. TEM micrograph of $MnFe_2O_4$ nanoparticles synthesized in a water-in-oil micellar systems.

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