Study of magnetic properties of iron doped of manganese oxide nanoparticles: Growth and characterization

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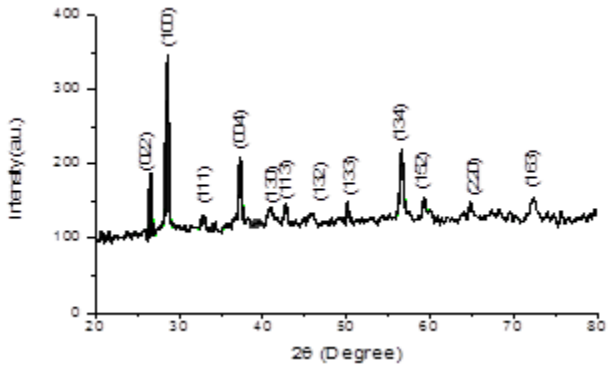
Abstract: Recently metal oxide nanoparticles have been the subject of much interest because of their unusual optical, electronic and magnetic properties, which often differ from the bulk. A large number of different manganese oxides are possible due to the availability of various oxidation states of manganese (II, III, IV). The magnetic properties of manganese oxide nanoparticles are of increasing research interest due to their intrinsic high atomic moment of Mn and its various magnetic alignments. The most commonly known manganese oxides Mn_3O_4, Mn_2O_3, and MnO have a wide range of applications in catalysis and battery technologies. Polymorphs of Mn_3O_4 have been used as catalyst for removing carbon monoxide, nitrogen oxide from waste gas. Researchers have shown considerable interest in the last few years in lithium intercalated Mn_3O_4 as an electrode material for rechargeable lithium batteries.

In this respect, nano sized Mn_3O_4 is expected to display better performance due to reduction in grain size and increased surface area. It is also used to prepare soft magnetic materials such as manganese, zinc ferrite, which is useful for magnetic cores in transformers for power supplies. It is used in the manufacture of welding rods and fluxes. It is one of the raw materials in the manufacture of professional grade ferrites. Various methods have been used for the preparation of nanocrystalline Mn_3O_4 powders such as hydrothermal, thermo chemical, spray pyrolysis, chemical liquid homogeneous precipitation, thermal decomposition and arc evaporation. For magnetic storage application, the material should be ferromagnetic. Iron is a ferromagnetic material with Curie temperature 1043 K. Mn_3O_4 (bulk) is an ferromagnetic material with Neel temperature 43 K. However, nano Mn_3O_4 has ferromagnetic nature at liquid nitrogen temperature. So that the study of iron doped Mn_3O_4 is very interesting one. The goal of this work is to synthesis and characterizes Mn_3O_4 nanosystems and its magnetic properties by doping iron ions.



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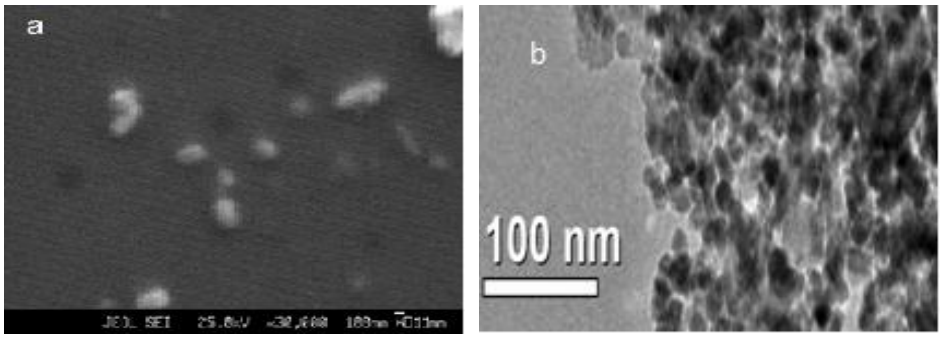

Figure shows the XRD, SEM and TEM of particle size of the product estimated from the X-ray peak broadening of the (100) diffraction peaks using the Debye Scherer formula is 50±5 nm showing that the synthesized powder contains nanometer sized crystallites and of orthorhombic structured manganese ferrite nanoparticles were synthesized by a thermal treatment method followed by calcinations at various temperatures. In the investigation, polyvinyl pyrrolidon (Peg) is used as a capping agent to control the agglomeration of the nanoparticles. The characterization studies were conducted by X-ray diffraction (XRD) and transmission electron microscopy (TEM). The average particle sizes of manganese ferrite nanoparticles were determined by TEM, which increased with the calcinations temperature from and they had good agreement with XRD results. Fourier transform infrared spectroscopy confirmed the presence of metal oxide bands at all temperatures and the absence of organic bands at 870 K. Magnetic properties were demonstrated by a vibrating sample magnetometer, which showed a ferromagnetic behavior for all samples and also saturation magnetization (Ms) increases by increasing the calcinations temperature. The magnetic properties were also confirmed by the use of electron paramagnetic resonance spectroscopy, which revealed the existence of unpaired electrons and also measured peak-to-peak line width, resonant magnetic field and the g-factor.

References:

[1] J. Amighian, M. Mozaffari, B. Nasr, Preparation of nano-sized manganese ferrite ($MnFe_2O_4$) via coprecipitation method, Phys. Status Solidi C 3 (2006) 3188–3192.

[2] C. Liu, B. Zou, A. J. Rondinone, Z. J. Zhang, Reverse Micelle Synthesis and Characterization of Superparamagnetic $MnFe_2O_4$ Spinel Ferrite Nanocrystallites, J. Phys. Chem. B 104 (2000) 1141–1145.

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