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Optical properties and photoinduced superparamagnetism of γ-Fe_2O_3 nanoparticles formed in dendrimer

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A B S T R A C T

We are presenting the joint investigation of the optical and photoinduced superparamagnetic properties of a single-domain γ-Fe_2O_3 nanoparticles (NPs) formed in poly (propylene imine) (PPI)-dendrimer. The optical absorption studies indicated direct allowed transition with the band gap (4.5 eV), which is "blue"-shift with respect to the value of the bulk material. The influence of pulsed laser irradiation on the superparamagnetic properties of γ-Fe_2O_3 NPs was studied by Electron paramagnetic resonance (EPR) spectroscopy. It has been shown that irradiation of the sample in vacuo and cooled in zero magnetic field to 6.9 K leads to the appearance of a new EPR signal, which decays immediately after the irradiation is stopped. We suppose that the generation of conduction band electrons by irradiation into the band gap of the γ-Fe_2O_3 changes the superparamagnetic properties of NPs.

1. Introduction

Iron oxides are technologically useful as pigments and semiconductors and magnetic properties [1]. Maghemite (γ-Fe_2O_3) is the second most stable polymorph of iron oxide. The stability and semiconductor properties of γ-Fe_2O_3 allow it to be used in solar energy conversion, photocatalysts, water splitting [2,3], while the magnetic properties of γ-Fe_2O_3 make it a common active component of high-density recording media [4]. Despite numerous investigations, the semiconductor and optical properties of γ-Fe_2O_3 at the nanolevel have not been well characterized. A better understanding of their optical and magnetic properties will be valuable in developing applications of iron oxide nanoparticles (NPs) in photocatalysis and magneto-optical devices. Apart from this, iron oxide NPs are also widely used in biomedicine for different applications like cell separation, drug delivery in cancer therapy, magnetic induced hyperthermia, MRI contrast agent, because their magnetism allows remote manipulation with external fields, while they are biocompatible and potentially non-toxic to humans [5–7]. Another promising application is in the field of spintronics, where it has been suggested that γ-Fe_2O_3 can be used as a magnetic tunneling-barrier for room-temperature spin-filter devices [8,9].

The magnetic structure of γ-Fe_2O_3 basically consists of an alternation of two opposed and unequal magnetic sublattices, i.e. the ferrimagnetic structure [10]. The atomic Fe^{3+} moments within each sublattice are coupled parallel, whereas those of the A (tetrahedral) and B (octahedral) sublattices are coupled antiparallel through an intervening O^{2-} anion. The unit cell of γ-Fe_2O_3 is cubic, with both octahedrally and tetrahedrally coordinated Fe^{3+} sites (defect spinel structure).

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