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Experimental investigation of optical and magneto optical effects of chemically synthesized cobalt nanocolloids

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Abstract

Surfactant coated (oleic acid) cobalt nanocolloids are synthesized using the chemical reduction technique. The colloidal cobalt particles are characterized by x-ray diffraction, transmission electron microscopy and a superconducting quantum interference device. Structural characterization of the samples confirms the formation of cobalt in fcc form. The magnetic field induced optical anisotropy is probed through Faraday rotation for both concentrated and diluted colloids. The magneto optical signals for different concentrations are analysed and it is observed that the behaviour can be fitted for a Langevin curve for diluted suspensions, while the deviation is higher for concentrated suspensions. Optical absorption spectra show quantum confinement of nanoparticles leading to a blue shift in the electronic energy band gap. The band gap varied from 2 eV to 4 eV showing semiconductor like behaviour.

1. Introduction

Nanomaterials exhibit fascinating physical and chemical properties due to the enhancement in surface to volume ratio. The morphologies and sizes of the materials are important factors that determine properties of nanomaterials. In recent decades, colloidal magnetic metal nanoparticles with a wide range of particle sizes have been synthesized by different methods [1]. The special properties of magnetic nanocolloids are used in technologically important applications such as field induced sensors, field induced optical limiters, storage devices, etc, and are also widely used in biomedical applications such as drug targeting and magnetic hyperthermia [2].

3D transition metals at nanoscale exhibit size dependent properties including optical, magnetic, electronic and magneto optical properties [3–5]. Metal nanoparticles such as cobalt have great potential due to their remarkable application in high density magnetic recording, nonlinear optical absorption, medical diagnosis electromagnetic (EM) waves, microwave absorption, etc [6, 7]. Cobalt is ferromagnetic in nature. Size induced effects in nanoparticles lead to variation in magnetic properties. Materials at nanoscale are often superparamagnetic at room temperature because thermal energy overcomes anisotropy energy when the size is reduced to the nanoregime. The optical property of a nanomaterial is largely controlled by quantum confinement of electrons. The energy levels become discrete upon reducing the size of the material. This leads to a blue shift in the energy band gap, which in turn leads to many interesting optical properties.

It is well known that magneto optical properties originate in the interaction between EM radiation and the magnetic domain of the nanoparticle. The magnetic domain of the particle changes the polarization states of the EM waves in an external magnetic field. The magneto optical properties of spinel ferrites and doped ferrites have been reported by several researchers [8, 9]. Ferromagnetic materials such as iron and cobalt have been analysed by various researchers for their properties by embedding nanoparticles in amorphous Al_2O_3, MgO, SiO_2 and AlN matrices [10–13]. Materials with magneto optical properties find application in many technological