Materials Today: Proceedings xxx (xxxx) xxx

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Effect of nickel doping on structural and magneto-optical properties of Fe_3O_4 ferrofluids

P.A. Francis Xavier [a,b,c,*], Swapna S. Nair [b], M.R. Anantharaman [c]

[a] Department of Physics, Mar Athanasius College Kothamangalam, Kerala 686 666, India
[b] Department of Physics, Central University of Kerala, Kasaragod, Kerala 671 316, India
[c] Department of Physics, Cochin University of Science and Technology, Cochin, Kerala 682 022, India

ARTICLE INFO

Article history:
Received 14 December 2019
Accepted 2 January 2020
Available online xxxx

Keywords:
Ferrofluids
X-Ray diffraction
Lattice parameter
Optical anisotropy
Dichroism
Birefringence
Classical dipole model
Neel's two sublattice model

ABSTRACT

Magnetic fluids, often called ferrofluids doped with Nickel belonging to the series $Ni_xFe_{1-x}Fe_2O_4$ were synthesized by standard co-precipitation technique. Their structural properties were investigated using X-Ray Diffraction (XRD) technique. XRD analysis confirm that the magnetic particles are phase pure and nanometric. It is also evident that the particle size decreases with increase in doping concentration. The samples exhibit spiking when subjected to perpendicular magnetic field. The lattice parameter is evaluated for all the samples belonging to the series assuming cubic symmetry. Magnetic measurements have been carried out using a ferrofluidic film with thickness 50 μm. The magnetization seems to decrease with increase in doping concentration. Magneto-optical characterization have been carried out using standard ellipsometer method. The result shows that the variation of magneto-optical signal resembles the variation of the saturation magnetization. Structural parameter, anisotropy constant is calculated from the magneto-optical data. The behavior of the samples in the applied magnetic fields is explained by modified form of classical dipole model and Neel's two sub-lattice model.

Selection and peer-review under responsibility of the scientific committee of the International Conference on the Science and Technology of Advanced Materials.

1. Introduction

Magnetic fluids are stable suspensions of single domain nanomagnetic particles dispersed in a base fluid [1]. They are important from the application point of view owing to their numerous physical, engineering and medical application potentials. Engineering applications of these rheological fluids include that in rotary seals, pressure sensors and in loud speakers. Ferrofluids are potential candidates in many of the biomedical applications like that in drug delivery and in cancer therapy [2].

Owing to their small grain size and large surface to volume ratio, they are ideal templates to study magnetism and optics at the nanolevel. The optical properties of these rheological fluids have been widely studied [3–5]. Optical characterisation of ferrofluids is important from the fundamental point of view as ferrofluids are ideal templates for studying the band structure and energy levels of magnetic particles at the ultrafine regime. Their magnetic field induced structural anisotropy gives rise to many special magneto-optical properties like field induced optical birefringence, linear and circular dichroism, Faraday rotation and ellipticity [6]. Also, there are reports of birefringence and dichroism at zero applied field, which is in contradiction with the existing classical theories. The influence of a magnetic field on these thin films will have a profound influence on the birefringent properties of these fluid films. Cluster formation in presence of applied magnetic field determines many of the magneto-optical properties exhibited by these fluids.

Nickel ferrite crystallises in an inverse spinel configuration with nickel having exclusive octahedral site preference. They exhibit superparamagnetism characteristic of a nanoferrite having the size distribution of a few nanometers. In nickel ferrite particles, due to a non-collinear spin structure, there is a strong reduction in the magnetization value compared with the bulk value. It is reported that due to the spin-glass-like layer wrapped around a uniformly magnetized core, hysteresis loop often shows open loop behaviour even at very high applied fields.

The cold co-precipitation technique is an excellent method for the preparation of powder precursors for ferrofluids, as it yields

* Corresponding author at: Department of Physics, Mar Athanasius College Kothamangalam, Kerala 686 666, India.
E-mail address: fxavier@macollege.in (P.A. Francis Xavier).

https://doi.org/10.1016/j.matpr.2020.01.039
2214-7853/
Selection and peer-review under responsibility of the scientific committee of the International Conference on the Science and Technology of Advanced Materials.