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Effect of solvents on morphology, magnetic and dielectric properties of (α-Fe_2O_3@SiO_2) core-shell nanoparticles

Deepika P Joshi [a,*], **Geeta Pant** [a], **Neha Arora** [a], **Seema Nainwal** [b]

[a] *Department of Physics, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar Uttarakhand, India*

[b] *Department of Physics, Uttaranchal College of Bio Medical Science & Hospital, Dehradun, Uttarakhand, India*

* Corresponding author.

E-mail address: deepikakandpal@gmail.com (D.P. Joshi).

Abstract

Present work describes the formation of α-Fe_2O_3@SiO_2 core shell structure by systematic layer by layer deposition of silica shell on core iron oxide nanoparticles prepared via various solvents. Sol-gel method has been used to synthesize magnetic core and the dielectric shell. The average crystallite size of iron oxide nanoparticles was calculated ~20 nm by X-ray diffraction pattern. Morphological study by scanning electron microscopy revealed that the core-shell nanoparticles were spherical in shape and the average size of nanoparticles increased by varying solvent from methanol to ethanol to isopropanol due to different chemical structure and nature of the solvents. It was also observed that the particles prepared by solvent ethanol were more regular and homogeneous as compared to other solvents. Magnetic measurements showed the weak ferromagnetic behaviour of both core α-Fe_2O_3 and silica-coated iron oxide nanoparticles which remained same irrespective of the solvent chosen. However, magnetization showed dependency on the types of solvent chosen due to the variation in shell thickness. At room temperature, dielectric constant and dielectric loss of silica nanoparticles for all the solvents showed decrement with the increment in frequency. Decrement in the value of dielectric constant and increment in dielectric loss was observed for silica

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coated iron oxide nanoparticles in comparison of pure silica, due to the presence of metallic core. Homogeneous and regular silica layer prepared by using ethanol as a solvent could serve as protecting layer to shield the magnetic behaviour of iron oxide nanoparticles as well as to provide better thermal insulation over pure α-Fe_2O_3 nanoparticles.

Keywords: Engineering, Materials science, Nanotechnology

1. Introduction

As nanoparticles are smaller than bulk material and larger than individual atoms and molecules, therefore they don't follow absolute quantum chemistry and laws of classical physics. It has been seen that many conventional materials change their optical, thermal, magnetic properties, strength and reactivity in nano form because of quantum effect and increased surface area [1, 2, 3]. Currently, different kinds of magnetic nanoparticles [4, 5, 6, 7, 8, 9], nano-composites [10, 11], doped ferrite nanomaterials [12] and materials with nanostructures [13, 14] have been paid much attention concerning their advance properties.

The magnetic nanoparticles made up of elements having magnetic properties, like cobalt, iron, and nickel show immense potential in many fields such as optical fibre, data storage, tissue targeting, biomedical and medicinal fields etc. [15, 16, 17, 18]. They possess the unique property of superparamagnetism due to their very small particle size [19, 20, 21, 22, 23]. Superparamagnetic nanoparticles offer a high potential for several biomedical applications, such as contrast agents in magnetic resonance imaging (MRI), hyperthermia magnetic separation in microbiology and detoxification of biological fluids. Hematite is the most attractive and important phase amongst all phases of iron oxide nano particles. Considering the ambient condition of all iron oxides, it is most stable. It was able to drawn the attention of researchers because of its enhanced properties. Hematite shows different magnetic properties at different temperatures, it shows antiferro-magnetic properties below its Morin transition (T_M) which is around 260 K and weak ferromagnetic behaviour between its Morin transition ($T_{M;\ 260\ K}$) and Neel temperature (T_N; 948 K) [24, 25, 26, 27].

Dielectric properties of nano materials depend on size, shape, composition as well as the way they are fabricated. Information about conduction phenomenon can be gained by studying the influences of frequency and temperature on dielectric properties of nano substances [28, 29, 30, 31, 32]. **S**ilica nanoparticles have gained importance in recent years because of their applications in various areas and easy synthesis process. Surface modification opens up the door for its future application in the field of biotechnology and medicine such as for cancer treatment, dental filling composites and drug delivery [33, 34].

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