UGC Minor Research Project

Summary

Minor Research Project

Title

"Synthesis, characterization and magnetic properpeties of dysprosium(Dy) substituted in Ni - nanoferrite by sol-gel autocombustion method"

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II. INTRODUCTION

Ferrite nanoparticles are of great interest because of their scientific aspect and various applications. The nanoferrites are interesting materials owing to their wide range of applications in modern science and technology . They have recently attracted considerable research interest on their structural, magnetic and electrical properties . These structures are attractive for microwave applications, magnetic sensors and catalytic materials owing to their great magnetic permeability and dielectric constant, low dielectric loss, high Curie temperature as well as mechanical strength and chemical stability at low frequencies . In addition, their magnetic properties can be controlled and tailored to practical applications through the appropriate choice from a number of divalent cations in their structure .

Particles with nanosize exhibit unique chemical and physical properties. In particular nano composite material composed of nanometric metal and metal oxide particles embedded in vitreous matrices reveal a variety of interesting magnetic, electric and catalytic properties. Ferrites are ferrimagnetic semiconductors that opened a new area in the physics of material science and the needful high resistivity ferrites led to synthesis of various ferrites. The electrical and magnetic properties of ferrites depend on the method of preparation , Magnetic properties of magnetic nano materials particularly in ferrites materials also depend on their chemical composition and methods of synthesis . The substitution effect and the change of the preparation condition are allowed to improve the properties of ferrites. Generally ferrites were commercially used in radio frequency circuits, transformer cores, antennas and for high speed digital tape.

METHODS OF SYNTHESIS OF FERRITES :

Sol-gel Method:

The most widely used synthetic technique for bulk metal oxides have been ceramic methods which are based of powder mixture. These reactions are completely controlled by the diffusion of the atomic or ionic species through reactants and products. To bring the reaction partners sufficiently close together and to provide high mobility, these solid state processes require high temperature and small particle sizes. Although the harsh reaction conditions only lead to thermodynamically stable phases preventing formation of the metastable solids, these approaches give access to a large number of new solid compounds ; enabling the development of structure properties relationships. However in comparison to organic chemistry where highly sophisticated synthetic pathways are employed to make and break chemical bonds in a controlled way,so ceramic method is a rather crude approach. Among the various soft chemistry routes, Sol-Gel procedures were particularly successful in the preparations of bulk metal oxides. (Example: ceramics, glasses, films, and fibers) and therefore it is used to applied for nanoparticle synthesis. But in spite of great efforts, the number of oxidic nanoparticles obtained by Sol-Gel chemistry is still rather small compared to the variety of compounds obtained via powder routes. It turned out that in many cases a synthesis protocol developed for a bulk metal oxide could not directly be adapted to its corresponding counter part on the nanoscale.

The Sol-Gel process can shortly be defined as the conversation of a precursor solution into an inorganic solid via inorganic polymerization reaction induced by water. In general, the precursor or starting compound is either an inorganic polymerization reaction (no Carbon), metal salts (Chloride, Nitrates, Sulphates etc) or metal organic compound such as an alcoxide. The metal oxides are most widely used precursor because they react readily with water and are known for many metals. In comparison with silicates from silicon alcoxides, the Sol-Gel processing of transition metal oxides has much less been studied mainly due to high reactivity of transition metal alcoxides.

CHEMICAL REACTION:

$$Ni(No_3)6H_2O + Dy(NO_3)_3.9H_2O + Fe(NO_3)_3.9H_2O + 3C_6H_8O_7 \xrightarrow[100^0C \text{ For 5hrs}]{\triangle} NiDyFe_2O_4$$

CHARACTERIZATION TECHNIQUE

1) **XRD Characterization :-**

2) **FTIR - SPECTROSCOPY:-**

3) Fourier-Transform Infrared Spectrometers

4) Ultraviolet/visible spectroscopy:

5) resistivity: DC electrical

6) SEM

7) TEM

RESULTS AND CONCLUSIONS :-

1. X-Ray Diffraction:-

Using Debye scherrer formula, particle size calculated from x-ray diffraction are 23.9 nm to 31.1 nm which is good agreement with particle size measured by TEM (20 to 35 nm) and SEM (36.1 to 53.7 nm) which is shown in above table .So it can be said that synthesized material is nanomaterial .The synthesized sample **$Ni\,Dy_y\,Fe_{(2-y)}\,O_4$** Shows several diffraction peaks which represent cubic structure. Also all diffraction peaks position matches with JCPDS data .

2. DC electrical resistivity :

Pellets of prepared sample was made .These are used in **TWO PROBE METHOD** and its D.C. electrical resistivity is measured. It is observed that as Dysprosium content increases , D.C. electrical resistivity of sample increases and is from 13430205 Ω.m to 55224756.98 Ω.m at 100^{0c} temperature . At 150^{0c} it increases from 895074.32 to 6220099.79 Ω.m . At 200^{0c} it increases from 614361.73 Ω.m to 904404.20 Ω.m Also it is observed that for same composition(y) if temperature of pellet increases , its D.C. electrical resistivity decreases .Shown in table.

3. FTIR- spectroscopy:-

As the wavenumber for first peak lies between 500 to560 cm^{-1} indicate that the prepared sample are ferrites which is confirmed . By using FTIR spectroscopy we can find bonding formation.

4. ***EDS :***

From energy dispersive spectroscopy test it is observed that whatever composition taken, is correct. No any other elements (impurities) are found .

5. **V.S.M** : As composition (y) of Dysprosium increases coersivity ‘ Hc’ decreases and remanent magnetization ‘ Mr ’ slowly increases . But magnetic saturation ‘Ms’ remain same . Hence it is observed that as Dysprosium composition increases area of hysteresis loop decreases.