Ain Shams University
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Crystallographic and Magnetic Properties of M /$NiZnFe_2O_4$ Nano crystalline doping with some ions Preparing by Sol-gel Process.

A Thesis

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Abstract

Abstract

The citrate sol-gel process used for preparation of modified M/Ni Zn Fe_2O_4 (M = Al, Ce, Sm, and Zr) nanostructures and calcined at 800°C for 3h, in the air. The sol-gel process was used because of its potential for making fine, high purity and homogeneous powders. Sol-gel is a facial chemical method that has the possibility of preparing a reproducible material in nanoscale and the advantage of the calcination of reducing the total processing time and the calcination temperature. At this study it was added some cations through $Ni_{0.5}Zn_{0.5}Fe_2O_4$ such as Al_2O_3, Ce_2O_3, Sm_2O_3, Zr_2O_4 as the formula $Al_xNi_{0.5-x}Zn_{0.5}Fe_2O_4$, where (x = 0.0, 0.1, 0.2, 0.3), $Ce_xNi_{0.5}Zn_{0.5-x}$ Fe_2O_4 , where (x = 0, 0.1,0.2,0.3), $Sm_xNi_{0.5}Zn_{0.5-x}Fe_2O_4$, where (x = 0, 0.2, 0.4, 0.5) and $Sm_{0.4-X}Zr_XNi_{0.5}Zn_{0.1}Fe_2O_4$,where (x= 0.2,0.3), to study their effective structural, phase purity and magnetic properties. Prepared nano-sized pure and doped $Ni_{0.5}Zn_{0.5}Fe_2O_4$ were characterized by X-ray diffraction to investigate the crystalline phase and morphological characterization analyses, High-resolution transmission electron microscopy and scanning electron microscopy to confirm the formation of Ni-Zn ferrite nanoparticle and estimate the particle sizes, Fourier transforms infrared spectroscopy ensures the characteristic absorption bands of ferrites, investigate and confirmed the formation of spinel structure and Vibrating sample magnetometer to investigate the magnetic induction of the as-prepared sample. X-ray diffraction for pure and doped $Ni_{0.5}Zn_{0.5}Fe_2O_4$ nano-structure confirms the formation of single phase cubic structure. The estimated crystallite sizes are changes from 27– 31 nm for the prepared nanomagnetic. SEM and HR-TEM results revealed that pure and doped $Ni_{0.5}Zn_{0.5}Fe_2O_4$

nanocrystalline appeared some aggregate nanostructure with spherical shapes with average size ~29 nm. Infrared absorption spectroscopy shows the spinel ferrite two absorption bands corresponding to the tetrahedral and octahedral sites, which are the significant bands of $-Fe_2O_4$ groups, which is due to the formation of $Ni_{0.5}Zn_{0.5}Fe_2O_4$ nano-structure. The saturation magnetization (M_s) and coercivity (H_c) values were 47.894 and 70.37 G; for pure $Ni_{0.5}Zn_{0.5}Fe_2O_4$ nanocrystalline. The values of both saturation magnetization (M_s) and coercivity (H_c) for the doped samples were varying according to the type and concentration of the dopants.

Aim of the Work

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Recently, magnetic nanostructures have been investigated as a modified engineering material at a lower temperature for different applications such as magnetoelectric devices, magnetoelectric memories, waveguides, transducers, high-quality filters, actuators, drug delivery and sensors [1]. New developments in powder composites make magnetic nano-materials interesting for applications in magnetoelectrical fields and advanced materials when combined with traditional rules and new production techniques. Spinel ferrites have the general formula AFe_2O_4 (where A^{2+}= Co, Ni, Zn, etc.) and the unite cell contains 32 oxygen atoms in cubic cross link packing with 8 tetrahedral (T_d) and16 octahedral (O_h) occupied site. The inverse spinel ferrite can be identified by the formula $(Fe^{3+})_{tet.}$ $(A^{2+}, Fe^{3+})_{oct.}$,O_4^{2-} (A= Ni, Cu, etc.) where the "tet" and "oct" indices represent the tetrahedral and octahedral sites, respectively. Exchange divalent cations enable us to obtain a large range of different physical and magnetic properties. These $NiZnFe_2O_4$ nanomagnetic materials have several advantages, such as reduction in weight, high surface area, and nano-sized scale. $NiZnFe_2O_4$ is one of the most practical spinel ferrite, soft magnetic material [22]. Soft magnetic $NiZnFe_2O_4$ ferrites have low coercivity and intermediate saturation magnetization. Therefore, this work aims to introduce different dopant types in $NiZnFe_2O_4$-base for production of nanomagnetic materials with advanced properties and an interesting strategy to modify its physicochemical properties.

The main aim objectives of the present work can be summarized as follows,

1- Preparation of pure $Ni_{0.5}Zn_{0.5}Fe_2O_4$ nanoparticles by citrate sol-gel process. We chose this host because of its optimum characteristics, which can be good examination of the properties doped material.

2- Studied the effect of introducing of some modifiers in $Ni_{0.5}Zn_{0.5}Fe_2O_4$ nano-sized base such as (Al, Ce, Sm and Zr) as in the formulas; $Al_xNi_{0.5-x}Zn_{0.5}Fe_2O_4$, where (x = 0.1, 0.2, 0.3), $Ce_x Ni_{0.5}Zn_{0.5-x} Fe_2O_4$ where (x = 0.1, 0.2, 0.3), $Sm_xNi_{0.5}Zn_{0.5-x}Fe_2O_4$, where (x = 0.2, 0.4, 0.5) and $Sm_{0.4-x}Zr_xNi_{0.5}Zn_{0.1}Fe_2O_4$, where (x=0.2, 0.3) respectively.

3- All the prepared matrices were prepared by citrate sol-gel method and dried at 200°C before calcination at 800°C for 3h, in the air.

4- Study the structural and morphological properties of prepared pure and doped $Ni_{0.5}Zn_{0.5}Fe_2O_4$ nanoparticles using powder X-ray diffractometer, High-resolution transmission electron microscopy, Scan electron microscopy, and Fourier Transform Infra-Red analysis.

5- The phase purity, a lattice constant, the crystal strain of the prepared nano ferrites powders was studied.

6- Study the magnetic properties of prepared pure and doped using vibrating sample magnetometer at room temperature.

Key Words

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- Nano crystalline.

- Sol-gel technique.

- Spinel ferrite.

- Soft ferrites.

- X-ray diffraction.

- SEM.

- HR-TEM.

- FT-IR.

- VSM.

- Rare Earth elements.

- Nano magnetic materials.

Summary

Summary

Nanotechnology is a manipulation of matter with at least one dimension sized from one to 100 nanometers. Nanotechnology as defined by size is naturally very broad, including fields of science as diverse as surface science, organic chemistry, molecular biology, semiconductor physics, microfabrication, etc. The associated research and applications are equally diverse, ranging from extensions of conventional device physics to completely new approaches based upon molecular self-assembly, from developing new materials with dimensions on the nanoscale to direct control of matter on the atomic scale. Nanotechnology may be able to create many new materials and devices with a vast range of applications, such as in medicine, electronics, biomaterials energy production, and consumer products. On the other hand, nanotechnology raises many of the same issues as any new technology, including concerns about the toxicity and environmental impact of nanomaterials, and their potential effects on global economics. $NiZnFe_2O_4$ is soft spinel ferrite. Some of its application is High quality filters, Pollution control, Radio frequency circuits, Magnetic drug delivery, Microwave applications, Transformer core, Personal communication devices (mobile phone), Gas sensors, Inductors, etc. In this study the citrate sol-gel process used for preparation of modified $M/Ni_{0.5}Zn_{0.5}Fe_2O_4$ (M = Al, Ce, Sm, and Zr) nanostructures and calcined at 800°C for 3h, in the air to study their effective structural, phase purity and magnetic properties. X-ray diffraction analysis used to investigate the crystalline phase and morphological characterization. High-resolution transmission electron microscopy and scanning electron