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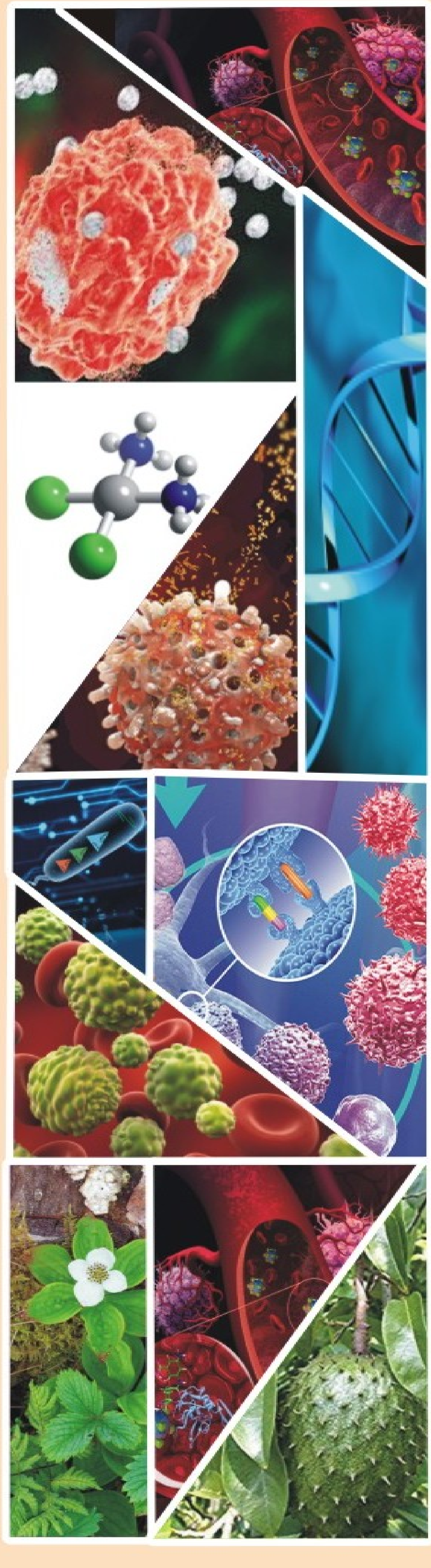

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A REVIEW ON COPPER FERRITE AND METAL DOPED COPPER FERRITE MATERIALS: SYNTHESIS AND ITS MAGNETIC PROPERTIES

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Abstract

In recent years, copper ferrite ($CuFe_2O_4$) nanomaterials has gained much attention for researchers due to its diverse application in the field of science and technology. Herein we report some synthetic method of preparation of copper ferrite and metal doped copper ferrite nanomaterials. A versatile way in which $CuFe_2O_4$ nanoparticles can be fabricated and the influence of the method used on the physical and magnetic properties of the materials

Keywords: copper ferrite, spinel ferrite, metal doped nanoparticles, magnetic properties.

1.INTRODUCTION

Spinel ferrites are given by general chemical formula AB_2O_4 where Aand B are metal cations placed at tetrahedral and octahedral sites, respectively. Spinel ferrite should contain ferric (Fe^{3+}) ion in its chemical formula. The most common examples of spinel ferrites are represented by MFe_2O_4 (where M can be any metals with an oxidation state of +2, such as Co^{2+},Cu^{2+}, Fe^{2+}, Mn^{2+}, Ni^{2+} and Zn^{2+}[1–5]. $CuFe_2O_4$ is a spinel ferrite material having capacity to modify its physical properties such as semiconducting, magnetic, electrical, phase transitions, electrical switching and stability occurs if they treated under various environmental conditions. Copper ferrite can be described as a cubic close-packed arrangement of oxygen ions, with Cu^{2+} and Fe^{3+} ions at two different crystallographic sites. Additionally they are considered as low-cost magnetic material. Copper based nanomaterials act as catalysts, in electrocatalysis, photocatalysis, and gas-phase catalysis. The structural, morphological, and optical properties of nanomaterials were characterized extensively by techniques such as FT-IR, XRD, EDX, SEM, TEM, and UV–vis. Various methods have been adopted to prepare copper ferrite nanomaterials since the size, shape and morphology of nanomaterials prepared will depends on the method of synthesis. There are several synthesis methods available for $CuFe_2O_4$ such as hydrothermal, coprecipitation, sol-gel auto combustion, thermal treatment, high energy ball milling, combustion, Microemulsion, solid state reaction, polyol route, microwave-assisted hydrothermal and mechanochemical method. Co- precipitation method is environmentally favourable in view of the fact that only deionized water is used as a solvent, whereas the other methods use organic solvents.

2.SOL-GEL METHOD

Sol-gel is a low temperature, cost effective and highly controllable method for the production of homogeneous, highly stoichiometric and high quality ultrafine nanomaterials. Also, a wet-chemical technique that uses a chemical solution or colloidal particles to produce a gel. copper ferrite ($CuFe_2O_4$) nanoparticles prepared through a modified sol–gel method using copper (II) nitrate, iron (III) nitrate and starch as starting materials in water as solvent. The photocatalysis results reveal that the decolorization of 53 % for methyl orange occurred with $CuFe_2O_4$ nanoparticles in 90 min under UV light irradiation[6].

3.CHEMICAL CO-PRECIPITATION METHOD

Chemical co-precipitation is a very facile and convenient way to synthesize nanoparticles from aqueous salt solutions by the addition of a base under inert atmosphere at room temperature or at elevated temperature. Copper ferrite were synthesized by chemical coprecipitation reaction using iron chloride, $FeCl_3.6H_2O$, copper chloride, $CuCl_2.2H_2O$ and octanoic acid ($C_8H_{16}O_2$) of HPLC grade as surfactant. The sample showed a typical ferromagnetic behavior at room temperature with finite coercivity of 245.5 Oe at 300 K[7].

4.AUTO- COMBUSTION METHOD

Manganese substituted copper ferrite nanoparticles were synthesized by an auto-combustion technique using metal nitrates and urea for gas sensor application. The products were characterized by XRD, SEM, EDX, TEM and VSM techniques. The effect of annealing temperature on the particle size, magnetic and dielectric properties of Mn–Cu ferrite nanoparticles was analyzed. The size of the particles is in the range of 9–45 nm[8].

5.DOPING OF COPPER FERRITE

Hydrothermal synthesis technique was chosen as it can provide good homogeneity, crystallinity, low reaction temperatures, inexpensive, less power consumption, easy sample preparation, high purity and stability. Barium doped $CuFe_2O_4$ by hydrothermal method showed cubic spinel structure with an average crystallite size of 24 nm and exhibiting super para magnetic in nature[9]. Cerium doped copper ferrite nanoparticles by auto combustion method achieved using lactose and glucose as the two capping agents and found that increasing the concentration of the lactose and glucose causes to increase the particle size of final products. Simultaneously, products lead to agglomeration of nanoparticles[10]. Mg doped copper nanoferrite was prepared by standard ceramic and wet method with particle size ranging from 8.7 to 41.1 nm. Bismuth substituted copper ferrite nanoparticles are prepared by solution combustion route by using metal nitrates. The relative humidity of $Bi_xCuFe_{2-x}O_4$ nanoparticles in the range from 10% RH to 90% RH at room temperature is generated. With the substitution of bismuth, the sensitivity factor is decreased at low relative humidity[11].

6.MAGNETIC PROPERTIES OF COPPER FERRITE

$CuFe_2O_4$ are considered to be part of a group of soft magnets. There are several factors such as synthesis method, crystalline size, pH, calcination temperature, doping and dopant type have been investigated and were found to have an influence on the physical and magnetic properties of $CuFe_2O_4$ as well as other spinel ferrites. It is alleged that the Ms of $CuFe_2O_4$ increase with an increase in the crystalline sizes which is supported by the dead layer like a core-shell model theory, which suggests that when the crystalline sizes are small, the magnetic NPs are shielded inside by a nonmagnetic layer while the dead layer refers to the disorder of the surface spins. Hence, this increase in the surface spins which is observed with a decrease in crystallinity contributes greatly to low Ms[12-13].

7.CALCINATION TEMPERATURE

Calcination temperatures between 200 and 1100°C employed on $CuFe_2O_4$ NPs resulted in an increase in Ms Values with an increase of temperature. This observed increase is attributed to two different reasons. Firstly, to the phase change of $CuFe_2O_4$ NPs from the cubic phase which is observed for at low temperature to tetragonal phase that is observed at higher sintering temperatures[14-16]? Secondly to the increase in particle size and the high crystallinity that is observed on $CuFe_2O_4$ NPs. Nevertheless, the increase in sintering temperature was found to increase the Hc and this is attributed to the phase evolution, an increase in anisotropy and growth of the $CuFe_2O_4$NPs. However, the Hc can also be reduced by increasing calcination temperature to a level where the grain size is large enough to decrease the grain boundary volume which leads to the pinning effect of the domain wall of $CuFe_2O_4$ NPs [17].

8.CONCLUSION

$CuFe_2O_4$ NPs using dopants, it is clear that random guessing was used to select the dopant. Different dopants have been added to the $CuFe_2O_4$ NPs with the aim of increasing its Ms, however, some dopants increased the Ms while others decreased it, thus the area requires more work in order to select the best dopant that improves the Ms values of $CuFe_2O_4$ NPs.

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