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Influence of Sintering Time on Structural Behaviour of Copper Ferrite Nanoparticles

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ABSTRACT: This investigation represents the notable influence of sintering time on the crystal phase development of copper ferrite nanoparticles synthesized using sol-gel auto-combustion method. Characterization of sintered materials were performed by X-ray diffraction technique and Fourier transform infrared (FTIR). The XRD analysis shows that ferrite nanoparticles show tetragonal crystal structure.

Keywords: Nanoparticles, sintering, structure.

INTRODUCTION: Nanotechnology incorporates fundamental study of the properties and nature of nanoparticles and nanostructures. Mainly nanotechnology concern with materials of the size 100 nanometer or smaller in dimensions and includes synthesizing materials in that size limit. In recent time, magnetic oxide nano particles have drawn the significant consideration of researchers and technologists because of their unique and exceptional properties both from the academic and fundamental perspective which is completely unique in relation to their bulk counterpart. Research to grow such a material was being carried out in different laboratories because of their extensive variety of uses [1-]. One of the difficulties faced by material researchers today is the preparation of materials with required structure, composition and properties for particular applications.

The properties of ferrite materials mainly depends on the synthetic conditions such as sintering time, sintering temperature, concentration of dopant, pH etc. Various methods [5-9] can be used to synthesize ferrites such as solid state reaction technique, sol-gel, coprecepitation, revese micelle, mechanical milling etc.

Among the spinel ferrites the copper ferrites have remarkable magnetic and electric properties. Copper ferrite shows either cubic or tetragonal crystal structure depending upon the Cu^{2+} ion concentration and heat treatment. Copper ferrite is distinctive from other spinel ferrites since it undergoes a structural phase transition due to the Jahn-Teller effect. $CuFe_2O_4$ is useful in many applications like catalysis, gas senor, hydrogen fabrication, Li-ion batteries etc.

MATERIALS AND METHODS: Nanocrystalline $CuFe_2O_4$ was synthesized by self ignited sol-gel auto-combustion method. The schematic presentation of formation of copper ferrite nanoparticles by sol-gel auto-combustion technique is depicted in Fig. 1.

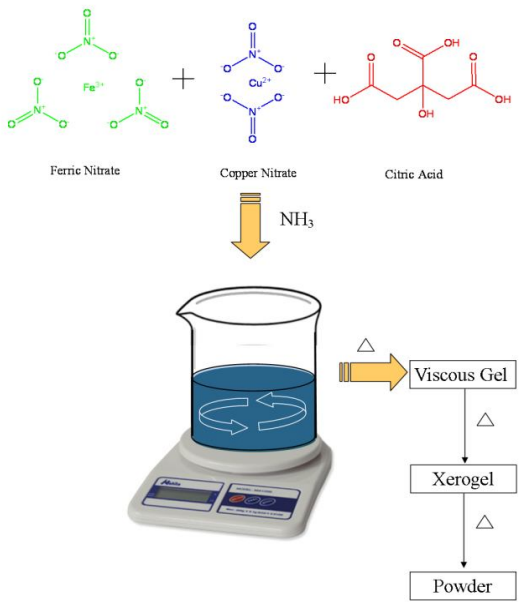

Figure 1: schematic presentation of sol-gel auto-combustion technique.

Analytical grade copper nitrate, ferric nitrate and citric acid were dissolved in distilled water to obtain a homogeneous solution. The metal nitrate to citric acid molar ratio was 1:3. The ammonia was added drop wise to maintain the pH of solution at 8. Using a magnetic stirrer and keeping the temperature at 70 °C the solution was constantly stirred until the gel formation. The gel so formed was dried at 80 °C and finally ground to form a fine powder. The produced fine powder was sintered at 600 °C with varying sintering time (6h and 8h). The detailed synthesis mechanism was reported in our previous work [10].

The samples sintered at 600 °C for 6h and 8h were structurally characterized by X-ray diffraction technique (XRD) with θ-2θ geometry using Cu-K_α. In addition, Fourier transformation infrared spectroscopy was carried out in a KBr medium at wave numbers ranging from 400 to 4000 cm^{-1}.

RESULTS AND DISCUSSION: The crystal phase identification was performed on an X-ray diffraction technique (XRD). Figure 2 shows the XRD patterns of copper ferrite nanoparticles sintered at 600 °C for 6h and 8h.

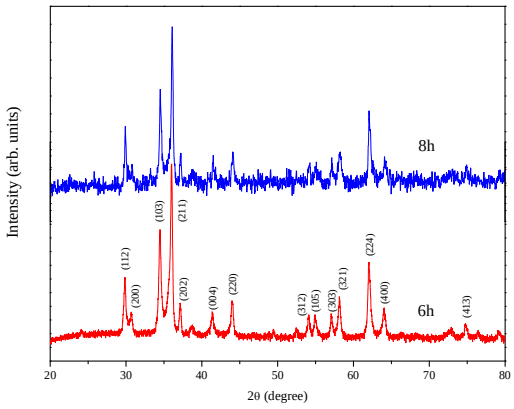

Figure 2: X-ray diffraction pattern of CuFe2O4 nanoparticles sintered at 600 °C for 6h and 8h.

Analyzing the X-ray pattern shows we found the formation of tetragonal structure of copper ferrite. The sample sintered for 6 h shows well formation of tetragonal crystal phase and no impurity phases were observed in the XRD pattern. The well defined peak with (211) reflection appears to be the most intense indicating the predominant growth of crystallites in this direction. On the other hand, the samples sintered 600 °C for 8h shows small changes in structural peaks with increasing sharpness of reflections in the diffractograms suggests polycrystalline nature of the samples. The values of lattice parameter varies slightly with sintering time (a =5.83, c = 8.72 for sintering time 6h and a =5.85, c = 8.78 for 8h sintering time. The particle size of each samples were obtained by Scherrer's formula [11] and is in the range of 25 to 50 nm.

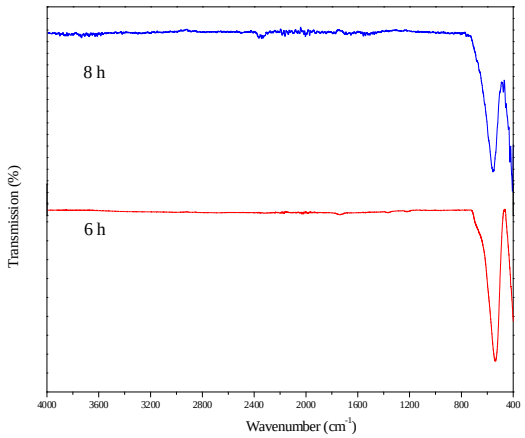

Figure 3: Fourier infrared spectra of $CuFe_2O_4$ nanoparticles sintered at 600 °C for 6h and 8h.

Figure 3 shows Fourier infrared spectra of $CuFe_2O_4$ nanoparticles sintered for 6h and 8h recorded in the range of 400-4000 cm^{-1}, reveals useful information about nature and structure of nanocrystalline copper ferrite material. The spectra of all samples reveal the presence of two metal-oxygen absorption band in the range of 400-600 cm^{-1} [12]. In the FTIR spectrum (Fig. 3) absorption band observed in the range of 530 - 550 cm^{-1} was assigned to intrinsic stretching vibrations of the metals at the tetrahedral site (A), and the band observed at 400 cm^{-1}, is assigned to octahedral (B) metal stretching [13] which confirms the formation of spinel ferrite material. Small shifting in the vibration bands were observed for samples sintered for 8h.

CONCLUSION: Pure nanocrystalline copper ferrite material is synthesized by Sol-gel auto-combustion technique. The X-ray diffraction pattern indicates the formation of pure tetragonal phase and peak intensity increases with sintering time. Fourier infrared spectra indicates small shift in absorption bands with sintering time.

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