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SYNTHESIS AND CHARACTERIZATION OF COPPER FERRITE NANOPARTICLES AND ITS MEDICAL APPLICATIONS

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ABSTRACT

Nanoparticles has been widely used in various fields and now it can also be used for improvising the healthcare and to prevent deadly diseases. Bimetallic Nanoparticles have multifunctional properties when compared to monometallic nanoparticles. One such bimetallic nanoparticles synthesized is copper ferrite nanoparticles by auto combustion method. X-Ray diffraction, Ultraviolet, Fourier transform infrared Spectroscopy Characterization, Vibrostatic magnetometer has been analyzed for these synthesized Nanoparticles in order to know about the crystal size, fine structure, distribution and more details about the magnetic property of the Nanoparticles. The unique super paramagnetic property has been analyzed to observe its impact on the biomedical applications.

KEYWORDS: Nanotechnology, Bimetallic Nanoparticles, Copper Ferrite Nanoparticles, Super paramagnetic property.

INTRODUCTION

Nanotechnology may be defined as the branch of science and engineering that deals with the design, synthesis, Characterization, and its applications in various fields.

Especially for medical application, the material should be designed in such a way that it interact with cells and tissues at the molecular level. It doesn't emerged from a scientific

discipline but it is a combination of various disciplines.[1] Metal possess superior properties and functionalities so that they give alternate solution to various technological demands. They represent a special case of advanced material because of some of its properties like mechanical robustness and flexibility.[2] Basically a material should possess 4 basic properties, they are strength & rigidity, transparency, softness & resiliency and flexibility.[3]

Metal nanoparticles are most widely used nanoparticles in the field of science and research. They have been prepared from metal precursors. Metal particles have many synthetic techniques. The synthetic methods include chemical, electrochemical, photochemical and physical methods. In chemical method the particles are obtained through the mixing of metal precursor along with chemical agents such as aqueous solutions and reducing agents.[4] They have adsorption property and also possess surface energy. Metal nanoparticles have wide applications in research areas like imaging, biomolecules detection and in the field of environment. In this paper we have clearly discussed about our laboratory work on copper nanoparticles synthesis, characterization and its cytotoxic activity.

In recent years there has been tremendous increase in the development of Nano crystalline materials with ultrafine grain sizes lower than 100nm. These materials are often used for enhancing the structure of nanoparticles and sometimes novel, chemical and physical properties, when compared to conventional properties.[5] Copper is one of the highly beneficial materials in the field of electrical, due to its high melting point, catalytic, electrical conductivity, optical properties, and a low-cost.[6] Copper ions represent a source of reactive oxygen species (ROS) production.[7]

Copper nanoparticle (CuNP) has been utilized in sensing applications owing to above properties.[8] Moreover, CuNP is also used as the catalyst because of the high Selectivity and efficacy,[9] thermal conductivity[10] and the lubricant additive nature.[11]

Chemical agents and Equipments

In this study, all reagents have been purchased from Chemical shop. All the reagents have been purchased in terms of nitrate salts. In addition to this Urea has also been purchased since it acts as a fuel during auto combustion method. Copper Sulphate, Ferric Nitrate, Urea has taken in appropriate amounts for further synthesis. In all these experiments Distilled water has been used.

Synthesis

Nanoparticles has been synthesized through auto-combustion method. Hydrophilic copper ferrite nanoparticles were obtained through the technique of auto-combustion. In a beaker one mole of copper sulphate was taken. Approximately one mole has been taken with the help of weighing machine. In the same way Ferric nitrate has been taken in the ratio of 1:2 when compared to copper ratio. Then they are mixed with distilled water and kept in a Stirrer. After about a few hours of stirring, Urea has been added in a little amount to the dissolved mixture. Later the glass beaker containing the mixture has been kept at hot plate. After one hour there existed a fire flame inside the beaker. As a result of this, ashes are settled down in the beaker. Few minutes later ashes have been collected and grinded to be in a completely powdered form. Then the synthesized nanoparticles were given heat treatment at 450℃ and 750℃. There were three samples of obtained nanoparticles namely as prepared, 450℃ & 750℃.

RESULTS AND DISCUSSION

Synthesized nanoparticles has been given for testing such as XRD, FTIR, UV, Anti-cancer and Vibrostatic Magnetometer. XRD is used for finding out the structure and particle size of the nanoparticles. FTIR explains about the blended composition as well as molecular dimension of the nanoparticle. VSM study is used for analyzing the presence of magnetic characteristics. Through XRD the Structure of the nanoparticles was found to be in Cubic type lattice structure. Size of the nanoparticle was also estimated to be in the order of 18nm to 35nm. The prepared Copper ferrite (CuF) Nanoparticles, whose structure was characterized by using Powdered X ray Diffractometer system (XPERT-3). The resultant XRD patterns in Fig (1) shows that all peaks are corresponding to the characteristic peaks of CuFe2o4 in the JCPDS card. It has a cubic type lattice structure, whose major peak is obtained at the height of 2103.48(cts). The grain size of the ‘as prepared’ sample was calculated for the intense peak (311) plane by using Debye Scherrer equation and the obtained size is 65nm (approx.). While comparing as prepared sample with 450℃ and 750℃ annealed sample in Fig (1), the crystallinity increases as temperature increases. Though the sample was annealed, there was no change in the crystalline structure. Hence all the XRD patterns in Fig (1) reveals cubic lattice structure. There was no extra peak obtained on annealing. This ensures phase purity. Hence, the average particle size of ‘as prepared’ and annealed samples (450℃&750℃) are 28.2nm, 43.6nm and 51.4nm respectively.

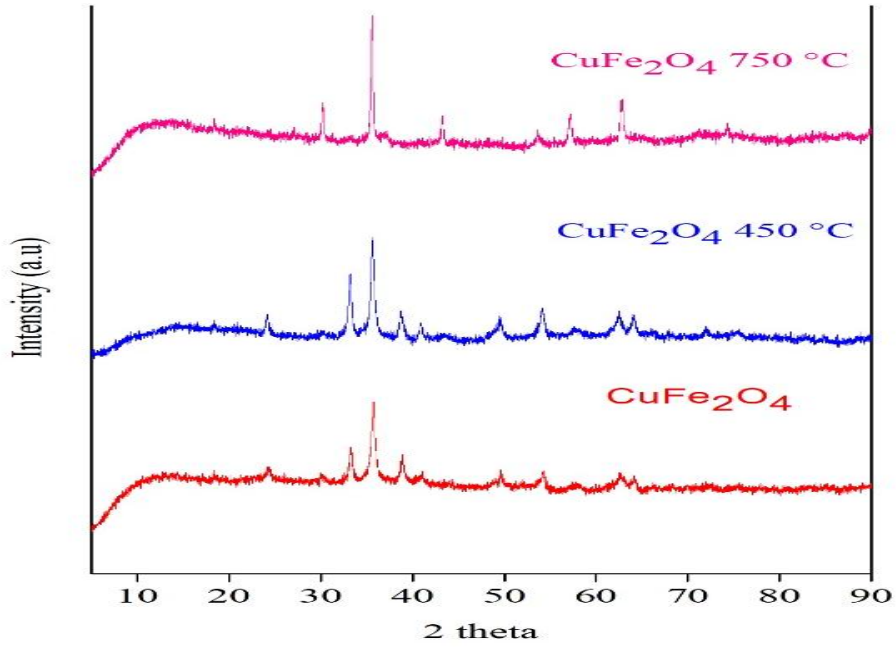

Fig. 1: XRD spectra for copper ferrite nanoparticles.

For multi-component system analysis FT-IR spectroscopy is used. This technique is used to understand the molecular dimension of the samples. It also provides information on the blend composition. The FT-IR spectra of 'as prepared' & annealed samples are shown in (Fig 2). A peak at 3484cm^{-1} corresponds to OH stretching vibrations. This confirms the present of water molecules in the particles. At 1416cm^{-1}, the determined peak was attributed to bending vibrations of hydroxyl. Generally, the metal oxide vibrations occurs below 1000cm^{-1}. A peak at 567cm^{-1} corresponds to bending vibrations of copper oxide. This confirms the presence of copper metal oxide. FT-IR spectra for annealed $CuFe_2O_4$ nanoparticles confirms the absence of organic compounds such as OH derivatives. Hence organic free metal nanoparticles were formed after annealing.

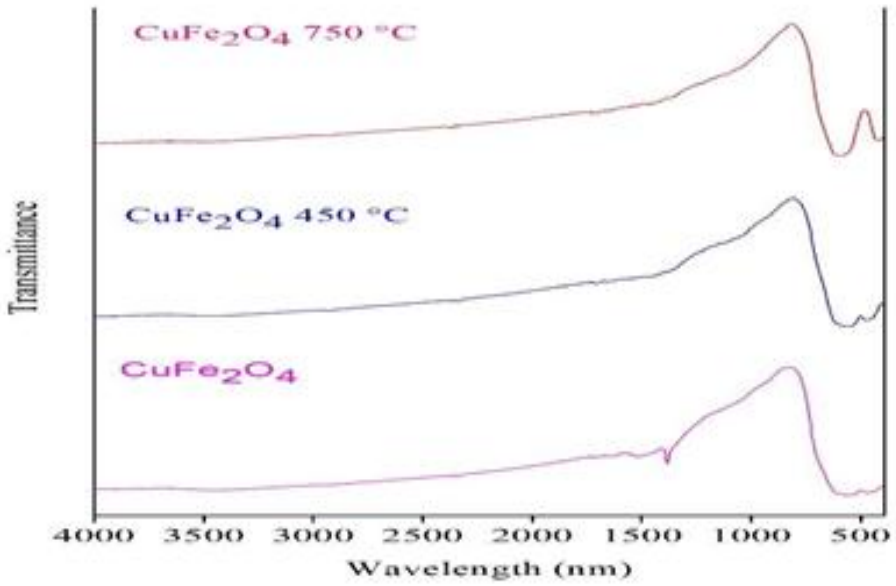

Fig. 2: FT-IR Spectra for Cobalt ferrite nanoparticles.

The UV-VIS spectrums (Fig 3,4,5) for $CuFe_2O_4$ -as prepared, 450℃, 750℃ samples are recorded in the range 200-800nm. The absorbance result demonstrated that the $CuFe_2O_4$-as prepared sample had considerable absorbance in the range of 500nm wavelength. After undergoing annealing at two different temperatures 450℃ and 750℃, the result of absorbance is calculated in the range of 595nm and 610nm respectively.

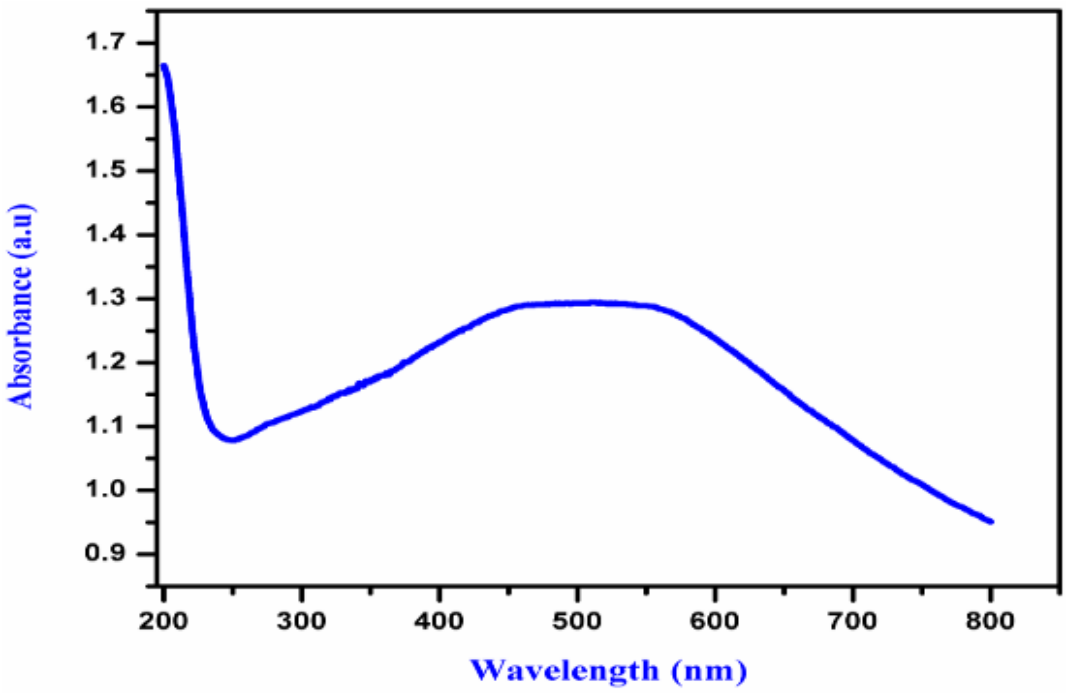

Fig. 3: UV spectra for $CuFe_2O_4$ (as prepared) nano particle.

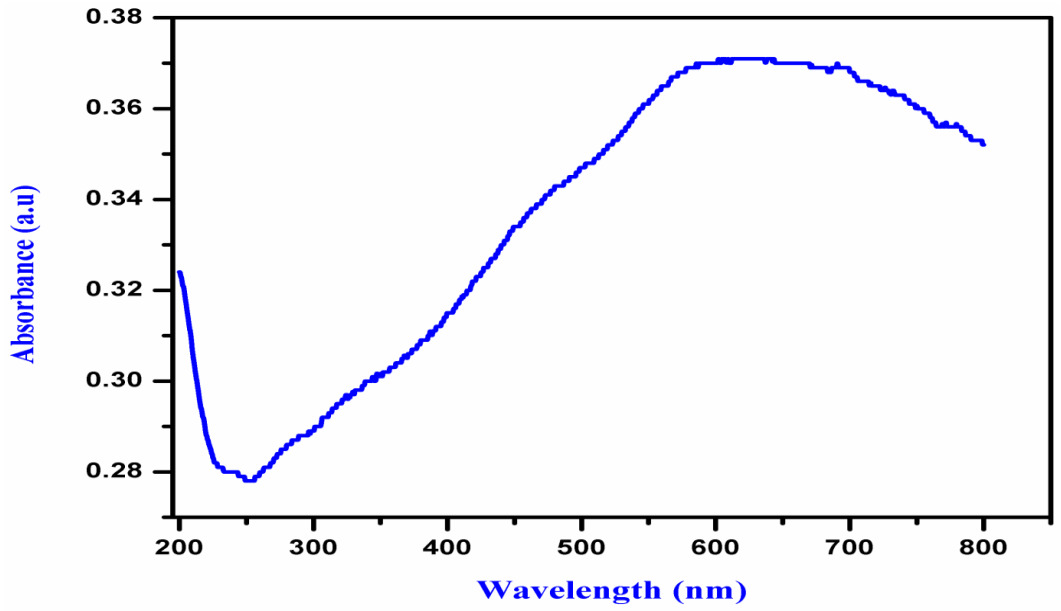

Fig. 4: UV spectra for $CuFe_2O_4$ (as prepared) Nano particle.

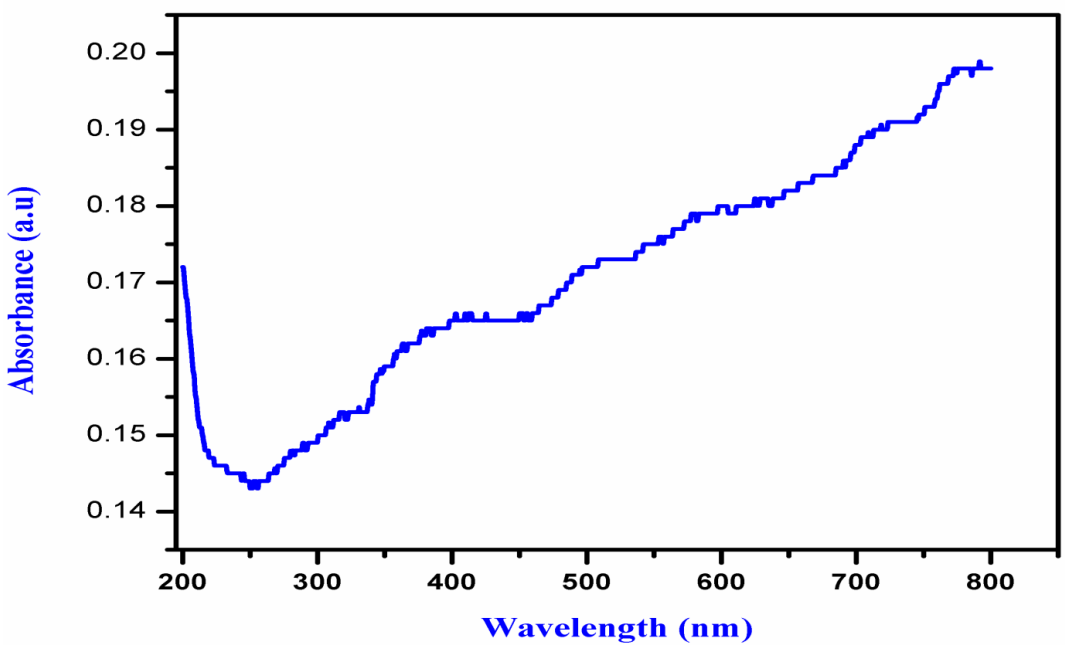

Fig. 5: UV spectra for $CuFe_2O_4$ (as prepared) Nano particles.

The surface morphology photos of the 750^{o}C annealed copper ferrite samples are shown in Fig 6. SEM results show that the 750^{o}C annealed copper ferrite have a crystalline nature with the formation of the copper ferrite. The copper ferrite crystalline sizes are in the range 28-50 nm as revealed by morphological analysis, which is found near to the calculated average particle size from XRD analysis. The obtained rod shape depends on the annealing process, which changes the agglomeration and particle size.

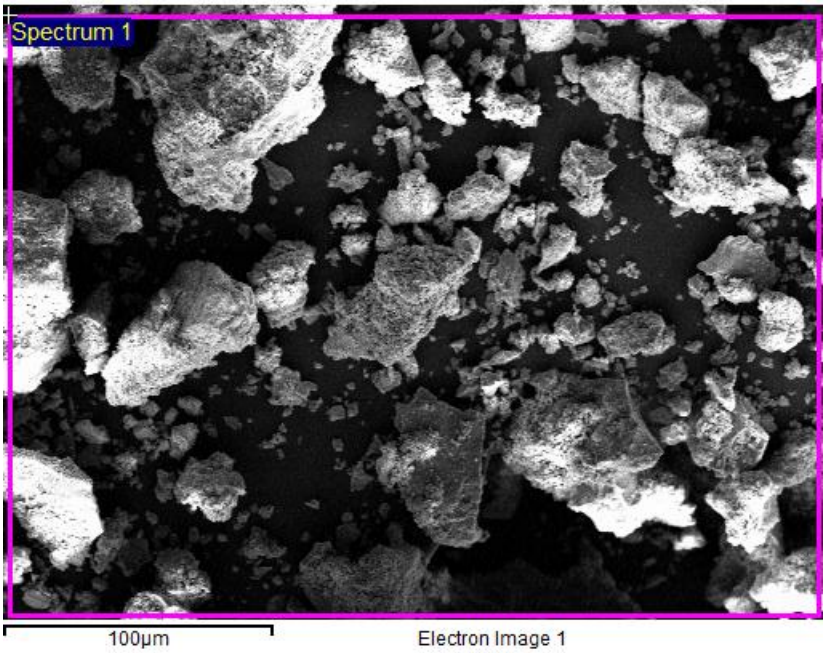

Fig. 6: HRSEM images of as prepared Copper ferrite Nano particle.

The energy dispersive X-ray (EDX) spectrometer was used to investigate the elemental composition of the synthesized compound. The recorded spectra confirmed the presence of Cu, Fe and O elements in the synthesized compound. Fig 7. reports the spectra of as prepared Copper ferrite which indicates the presence of Cu, Fe and O at a measured atomic percentage of elements 13.81% and 24.04%, 62.15 respectively. From the EDX spectra shows presence of Co, Cu, Fe and O atoms.

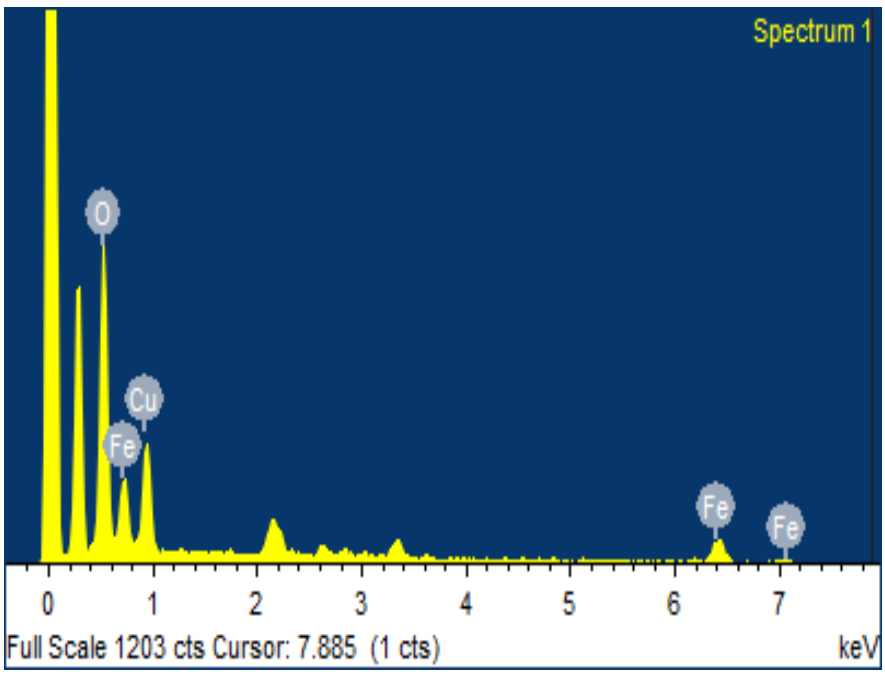

Fig. 7: EDAX image of Copper ferrite Nano particle.

The Saturation magnetization value calculated for Copper ferrite nanoparticles is 1.85, 2.1 and 6.95emu/g for as prepared, 450℃ and 750℃ which is a consequence of super paramagnetic nature of the magnetic nanoparticles. The coercivity value is also found to be null as it decreases in the same curve as show in Fig 8.

This magnetic property plays a major role in biomedical field. Drug delivery, MRI contrast agent and microbial detection are probably the best applications where super paramagnetic nanoparticles engaged with more noteworthy hand. Their mobility could be controlled from outside the body framework for in vivo applications. Hence this unique magnetic property rakes into consideration efficient target capture, enrichment and convenient separation which adds to their promising biomedical applications.

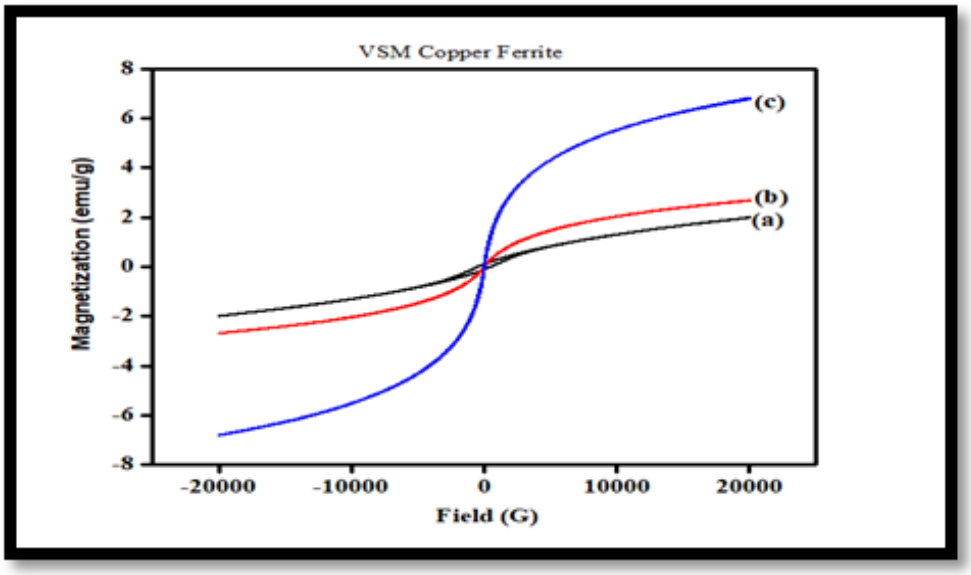

Fig. 8: Hysteresis loop for $CuFe_2O_4$ Nano particles.

CONCLUSION

This study demonstrated the synthesis of copper ferrite nanoparticle by a simple auto-combustion and characterized by structural analysis. The synthetic technique using urea as a reducing agent with 1:2 ratio of salts has not been yet reported so far for auto combustion method and it was proved to be a easy way to synthesize magnetic nanoparticles. The results obtained were well supported the formation of Copper ferrite Nanoparticles (CuF-NP). Structural studies have shown the smooth structure of CuF-NP and demonstrated the crystalline structure under XRD. The grain size calculated by XRD was found near to the SEM image. The major peak was obtained at (311) and the structure was found out to be cubic spinal structure. CuF-NP shows sharp peak at 567 cm^{-1} corresponding to Cu-O group.

The VSM results shows that CuF-NP is Super paramagnetic in nature. This unique magnetic property of the prepared CuF-NP has the potential to be the drug delivery agent and MRI contrast agent. This work may provide an alternative for clinical applications.

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