A Study on Prepared Copper Zinc Ferrites Nano Powder by Sol-gel Technique

S. Surendran*, E. Sivasenthil, V. Senthil Kumar

Abstract--- The nanoparticle called "Copper zinc ferrite" and its preparation is said to be a very exhausting subject for academics, and the most appreciable thing is that it is treated as an application-oriented research in the field of Nano science. In this preparation, a variety of physical as well as chemical methods can be employed for nanoparticle synthesis. Hence, Sol-gel method is adopted for the preparation of copper zinc ferrite. The adopted method is efficient for fiber and fine powder preparation by permitting the distinct access to various oxides, and it can be processed under low temperature. Hence the preparation of tests is isolated by the X-ray powder diffraction pattern technique. The meticulous metric is calculated by exploiting the Scherer's concept, which involves spinal cubic framework. The second feature called "scanning electron microscope" (SEM) has paid more attention to electron beam scanning above the surface for image creation. The electrons present in the beam cooperate with the model, generating different signals which are employed to acquire data regarding the composition and topology of the surface and help in gathering the resulting electron signals. The third feature is the utilization of Energy Dispersive X-ray Analyzer (EDAX), which is referred to as an x-ray technique utilized to categorize the material composition of the elements. The final method is Fourier Transform infrared spectroscopy (FTIR), which measures the vibrational frequencies by permitting the valuable imminent into the diverse functional groups and the chemical bonds involved in the existing system. The vibrational frequency of the spinal framework is present in the CuZn functional group, and it is recognized with the help of FTIR. The value of coercivity starts decreasing when CuZn is carried out in various annealing temperatures. The energy level band gap of the copper zinc ferrites nano samples can be determined by the FTIR. The projected work is performed for computing the crystalline framework and its chemical composition.

Keywords--- Sol-gel, Nano particle, XRD, EDAX, FTIR

I. INTRODUCTION

Nowadays, the material called as Nanosized ferrite has gained more interest in the recent decades. It displays an abnormal chemical as well as physical properties termed to be dissimilar to those of the aggregate materials due to their acutely small measurement and ample specific apparent surface area. Normally, the features of ferrites are said to be non-conductive ferri magnetic bowl compounds acquired from the oxides of iron like hematite (Fe2O3) or magnetite (Fe3O4) and also the added metal oxides, and are like the best added ceramics, tough and fragile [8]. In conformity with the alluring properties, the diverse ferrites are generally classified as either "elastic" or "rigid", which refers to their low or aerial alluring coercivity. The inorganic compound Zinc oxide is denoted by its formula ZnO. This is impenetrable in water and generally has the appearance of white powder. The powder is broadly acclimated as an accretion into the numerous products and materials involving rubber, glass, ceramic materials and lubricants. Zinc oxide is a vital and imperative material because of its cost effectiveness and ample band gap (3.37 eV), luminescent features and ample excitation binding activity (60 MeV).It is broadly employed in abounding applications like gas sensor, catalyst, filtering properties for UV light, and additionally as retanning and antimicrobial abettor. The black material cupric oxide (CuO) has the melting point above 1200°C, which includes oxygen loss and is utilized as a colorant in adobe glazes. Numerous colors such as blue, red, and green can be acquired from it.

As a mineral, it is accepted as tenorite which has the features of organic solvents, water dissolvent and has the color of red. Copper (II) oxide has appliance as a p-type semiconductor [5]. It is an adapted aggravate to optical equipment brightness for generating dry battery cells as cathode. Cupric oxide (CuO) is an imperative metal oxide transition along with the narrow band gap, and forms the base of several absorbing aerial temperature superconductors and huge magneto resistant materials. Either Iron (III) oxide or Ferric oxide is an inorganic admixture with the chemical formula Fe2O3. It is one of the three imperative iron oxides and the rest is two iron (II) oxide (FeO), which is exceptional and iron (II, III) oxide (Fe3O4), which additionally occurs as the magnetite mineral. The mineral accepted as hematite, Fe2O3, is the center antecedent of iron for the purpose of steel industry. The formula Fe2O3 has dark reappearance and is voluntarily assailed by acids [2]. The term rust is generally iron (III) oxide, and to some measurement this characterization is functional, because rust shares several luminescent properties with the related composition. The rust is treated as the hydrated ferric oxide and an ill-defined material by chemists.

The utilization of the high purity raw materials helps in the preparation of the ferrite sample, because the existence of impurities present in the raw materials may have a great influence on the prepared material properties. Asuitable percentage of the weight of the oxide is required for mixing the diverse composition. The nano powders of ZnO, CuO and Fe2O3 are taken and they are mixed in an equal proportion to attain the uniformity among the components [1]. This nano powder preparation can be executed by the sol-gel method, which is explained in the next section.

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II. SOL–GEL TECHNIQUE

The nano crystalline ferrite synthesis is performed by the sol-gel technique and factors involved are listed below:

- The reaction rate is high
- Temperature required for preparation is low
- Small amount of nano particles can be generated

Therefore, the preparation and synthesis of copper zinc ferrite can be performed by sol-gel method. The stoichiometric quantity of both citric acid as well as nitrates is liquefied individually in refined water to create 0.1 M. Fig. 1 depicts the technique of sol-gel concept for copper zinc ferrite preparation. The ratio considered is 2:1 for the nitrates till citric acid. The pH value is fine tuned to the value of 7 by appending the ammonia solution into the solution in order to alleviate the solution called nitrate-citrate [3].

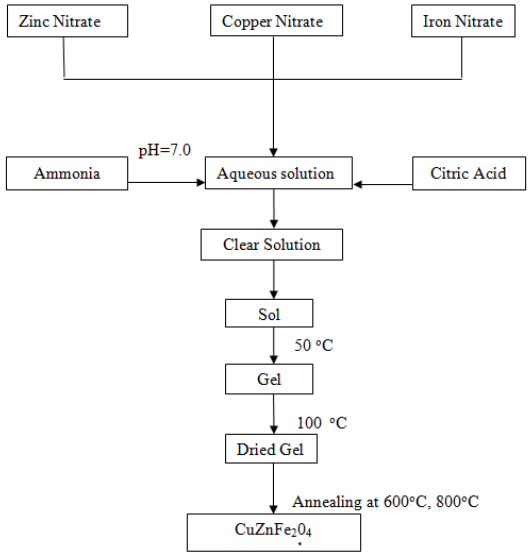

Fig.1: Preparation of Copper Zinc Ferrite

The solution was constantly stimulated by utilizing the magnetic agitator by keeping it at the 50 °C in this technique. This combined solution was transferred to a vessel and it was allowed to be heated to 100 °C slowly and stimulated constantly till it remained glutinous, and the color change happened when the solution became a green absorbent dry gel. This type of dry gel was allowed to burn to become a loose powder [7]. A similar technique is involved in preparing copper zinc ferrite by accumulating the hexa hydrated zinc nitrate. This type of powder preparation can be calcined and maintained at various temperatures i.e. 800 °C and 600 °C for about 5 hrs. The samples can be prepared, characterized and synthesized by various techniques like EDAX, XRD, FTIR and SEM.

III. RESULTS AND DISCUSSION

Sol-gel method is considered to be the simplest and easier method in the preparation of copper zinc ferrite and it can also be prepared at low annealing temperatures. The preparation and characterization of Copper zinc ferrite is performed by sol-gel method and by

- X-ray Diffraction Pattern (XRD)
- Scanning Electron Microscopy (SEM)
- Energy Dispersive Analysis by X-Rays (EDAX)
- Fourier Transform Infrared Spectroscopy (FTIR)

i) XRD Analysis

The nano powder synthesis can be attained by utilizing the Philips PW1800 X-ray diffractometer combined with CuKα radiation, which has the value of λ=1.5406Å and performed at 40 kV and 30 mA in X-ray Diffraction Pattern (XRD). The 2θ range angle is considered for the samples from 20 to 70º angle at an unvarying scanning speed to recognize the stage formation. It depicts the existence of copper zinc ferrite. XRD pattern provides the single stage formation of spinal cubical framework along with the Fd3m space group [4].

The prepared data of nano particle copper zinc ferrite powder calcined at 600 °C and 800 °C for about 5 hrs. are illustrated in table 1 and fig 2. The outcome illustrates that the peak of diffraction level has turned to be sharper and broader and has the highest level of intensity, when there is an increase in the calcined level of temperature, which denotes the crystalline intensification thatbegins from the increasing level of crystalline because of the

magnification of the nuclei size. The growth in the peak intensity can be contributed to the growth of the annealing temperature. The data sets can be annealed at the temperatures 600 ºC and 800ºC and is shown below:

Table 1: XRD pattern Analysis of Copper Zinc Ferrite

Tests	Grain measurement (nm)	Lattice metric (a) Å	Dislocation Density ($\times 10^{14}$ lines/m^2)	Strain ($\times 10^{-3}$ lines^{2}m^{-4})
CZF AS	12.20	8.3268	7.4134	9.56
CZF-600 ºC	26.21	8.4279	9.7244	11.18
CZF-800 ºC	36.31	8.3782	1.9824	5.016

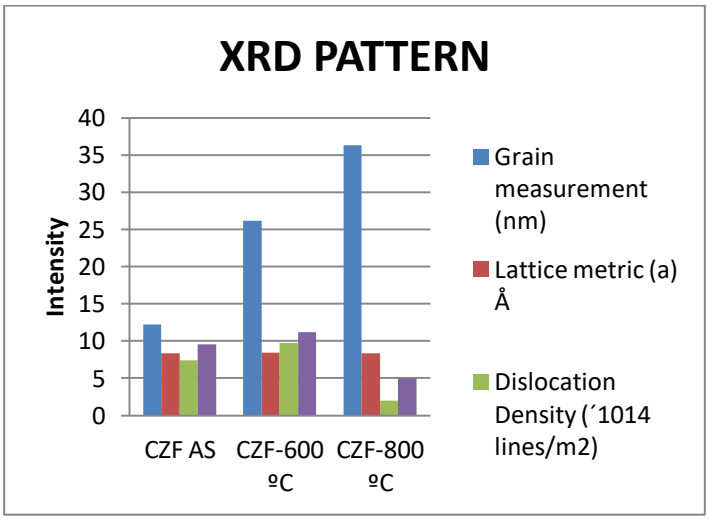

Fig. 2: XRD Pattern of Copper Zinc Ferrite

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ii) Scanning Electron Microscopy (SEM)

The samples are taken and morphology analysis is performed and synthesized by sol-gel concept, and it is illustrated by the technique of scanning electron microscopy (SEM). The images and the synthesis are depicted in Fig.3. It denotes sporadic grain framework of a micro graph. The grain is said to be well-structured with no cracks, and it also contains regular grain framework in the absence of voids [6]. The image morphology is known to be similar, horizontal and less dispersed in its measurement, and it is shown below.

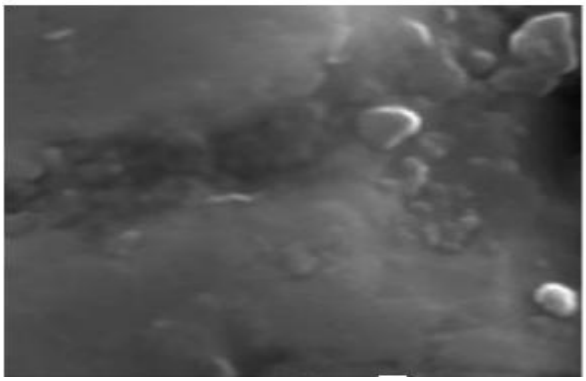

Fig.3: Morphology Analysis

iii) EDAX Analysis

The mixture of chemical composition of the various products was identified and recognized by EDAX spectra theory and shown in table 2 and fig 4. The spectra present in the analysis illustrate the availability of O, Cu, Zn and Fe in the data samples, and this method does not involve impurity of any element. The outcome demonstrates that the impurities existing in the sample cannot be present in the reaction and the ratios of Zn/Fe are computed from the analysis of spectra, and they are displayed below.

Table 2: Composition Analysis

Samples	CZF-AS (Wt %)	CZF-600 ºC (Wt %)	CZF-800 ºC (Wt %)
O	30.62	28.51	28.11
Fe	40.32	41.07	51.52
Cu	14.21	14.62	15.64
Zn	11.21	11.45	10.72

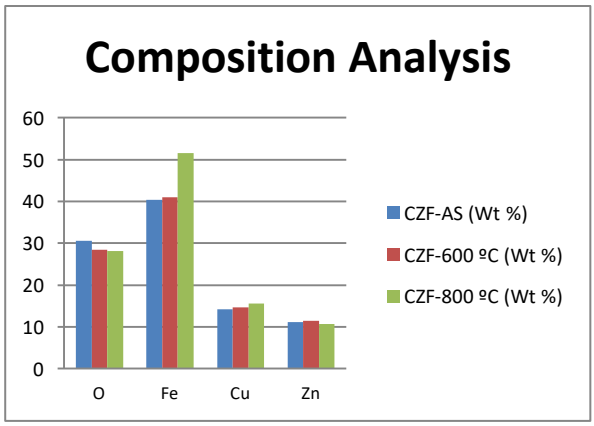

Fig.4: Composition Analysis

iv) FTIR Analysis

The results of the absorption bands of the samples are CuZnFe2O4, and it is shown in fig.5. The highest level of frequency band is denoted as υ1 and it is available in the range among 568 and 536 cm-1 and the lowest frequency band is denoted as υ2 and it is present around 395cm-1.

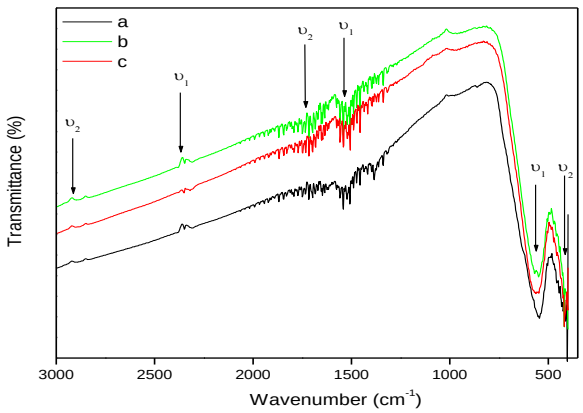

Fig. 5: FTIR Analysis

IV. CONCLUSION

The sol-gel technique is involved in the preparation of Copper zinc ferrite nano powder, because this is the easiest method that can be performed at various annealing temperatures. This also decreases the level of coercivity. The energy level band gap of the copper zinc ferrites nano samples can be determined by the FTIR. A variety of physical as well as chemical methods can be employed for nanoparticle synthesis by XRD pattern.SEM has paid more attention to electron beam scanning above the surface for image creation. The proposed terminology is performed for computing the crystalline framework and its chemical composition.

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