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Hexagonal Ferrite with their Structural Studies

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ABSTRACT

The calcium ferrite nano-particle Ca Al1.5Fe10.5O19 were synthesized using a ceramic method to investigate its properties. Ferrite are large class of oxides with astonishing magnetic proparties. Which have been investigated and applied for the past 50 yaers. The application of ferrite are based on very basic properties of ferrites; such as significant saturation magnetisation high electrical resistivity, low electoral losses, and good chemical stability. ferrite can be obtained in different crystal systems by many methods. The prepared power was characterized by using X-ray diffraction (XRD), Scanning Electronic microscope (SEM). XRD shows hexagonal Magnetoplumbite (M) type structure having unit cell dimension 'a' and 'b' varies betweem and . The Sem imager of the sample prepare appear irregular in shape but nearly vertically and seemed to be hexagonal plate like structure.

Keyword : Hexagonal ferrite (Hexaferrite), X-ray Diffraction (XRD), Scanning Electrons Microscope (SEM), Magnetoplumbite (M-type), Calcium oxide and Iron Oxide

I. INTRODUCTION

Ferromagnetic material are usually Known as Ferrites. With the discovery of hexagonal ferrite[1] . there has been an extensive study of ferromagnetism of such compound because of their applications in the field of material science as a permanent magnetoplumbite with general formula M (Fe12O19) where M is usually barium, strontium, Calcium or Lead, are interesting and attracting researchers due to their specific magnetic behavior. The basic structure consists of 38 oxygen ions occupying the interstitial sites forming a close packed hexagonal structure. 24 ferric ions occupy five different locations in the unit cell [2].

To prepared Hexagonal ferrite nanoparticles, various synthesis methods such as chemical co-precipitation [3], Hydrothermal[4], Sol-gel [5],Solution combustion method [6], ceramic method etc. have been developed.In the present work, Calcium hexaferrites substituted with trivalent Al ions synthesized in ceramic method.Their structural properties are studied and reported.

Experiment:

Synthesis:- The preparation of compounds with chemical formula $CaAl_xFe_{12-x}O_{19}$ (with x=1.5) is perform by standard ceramic method. The molecular concentration x is substituted cation in the chemical formula. The oxides Cao,Al_2O_3, Fe_2O_3 of merck grade (with 99.90%) were used as starting materials for the synthesis of present series of compounds. The stoichmetric proportion of weight oxides were mixed thoroughly by grinding for 3days in agate morter with help of acetone ultra-fine homogeneous powder

of sample. the resulting powder pre-sintered at 200°c for half hours to moisture free homogeneous, calcination. The calcination powder were pressed into the pallet machine to form pallet at 7.5kg/cm^2 and then sintered at 1130°c in air atmosphere for about 74 hours and slowly cooled to room temperature at the rate of 200^{0}c/half hours using a microprocessor controlled furnace [10]. The synthesized pallet were broken with hydraulic pressure of pallet machine at 1.20 tone kg/cm^2. Then grinding in agate mortar to get ultra-fine powder of sample. The synthesized powder of sample. The synthesized powder of sample again heated at 300^{0}C for 30minute to remove impurity[11].

Characterization:

- X-ray Diffraction Pattern of $CaAl_{1.5}Fe_{10.5}O_{19}$ hexagonal ferrite under investigation were obtained using X-ray Diffractometer.
- Determination of grain size and Aspect Factor Form SEM data.

II. RESULT AND DISCUSSION:

Structural analysis: The XRD pattern of Ca $Al_{1.5}Fe_{10.5}O_{19}$ powder (fig 1) investigated ferrite sample synthesized by ceramic method correnspond to M-type calcium hexaferrite structure fig1 JCPDS pattern file no. 27-1029. The hexagonal M-type structure with space group (SG:$P6_3/mmc$) (NO.194), which confirms that phase belonges to magnetoplumbite, indicating that the crystal structure were single phase hexagonal magnetoplumbite after substitution with Al^{+3} ions respectively. The lattice constant a and c of hexagonal calcium ferrite were calculated using equation (1).

$$\frac{1}{d^2}=\frac{4(h^2+k^2+hk)}{3a^2}+\frac{l^2}{c^2} \text{----------(1)}$$

Where h, k, l are miller indices, d is interplanar distance. The lattice parameter a and c found to be 5.6463 A^0 and 22.7163 A^o respectively. The crystallite size measurements of were also carried out using the XRD data and using scherrer equation.

$$D=\frac{k\lambda}{\beta cos\theta} \text{----------(2)}$$

Where β is width of the observed diffraction peak at its half maximum intensity, K is the space factor which take value of about 0.9 & λ is the wavelength (Cuk radiation equation to 1.54 A^0) And the average particle size was found to be about nm.

Table 1

Sample	A (Å)	C (Å)	Particle size D)nm	Volume (A^3)
Ca $Al_{1.5}$ $Fe_{10.5}O_{19}$	5.6463	22.7162	48.87	627.614

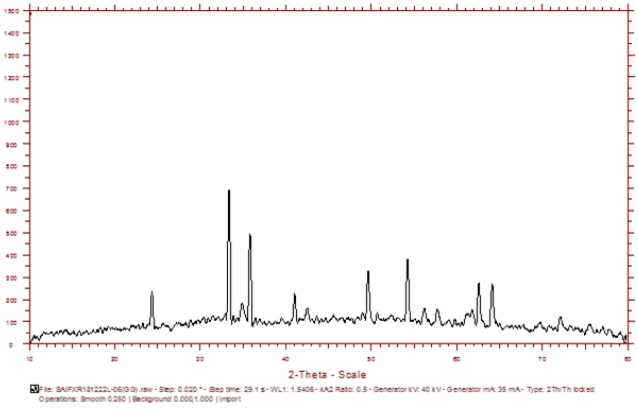


Figure 1. X- ray Diffraction of Ca $Al_{1.5}$ $Fe_{10.5}$ O_{19}

Table 2. Observation table for X-R-D result

Sr. No	2θ	D value (A)	Observe Intensity count	Intensity in %	(h,k,l)
1	24.276	3.6635	234	337	(1 1 2)
2	33.318	2.68705	694	100	(1 1 3)
3	35.771	2.50817	494	712	(2 2 2)

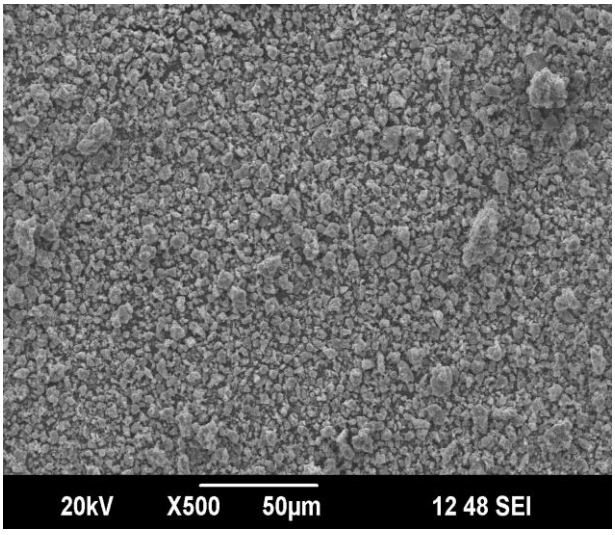
4	41.018	2.19874	102	146	(0 1 4)
5	49.606	1.83825	326	47	(2 2 4)
6	62.578	1.483319	274	39.5	(0 1 6)
7	64.153	1.45052	267	38.4	(1 1 6)

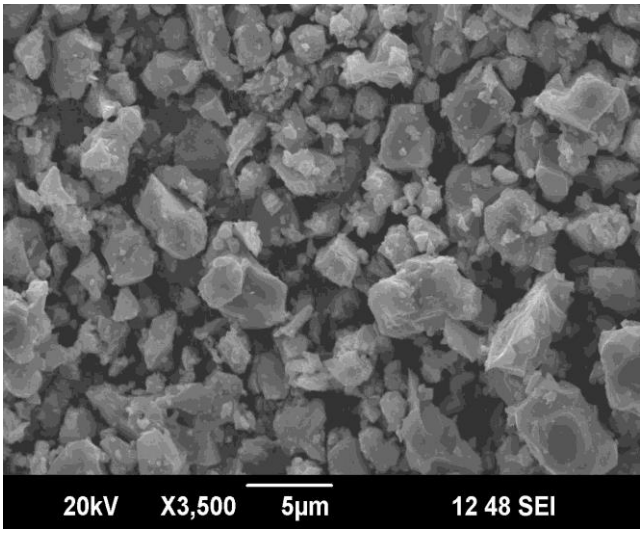
SEM Studies:

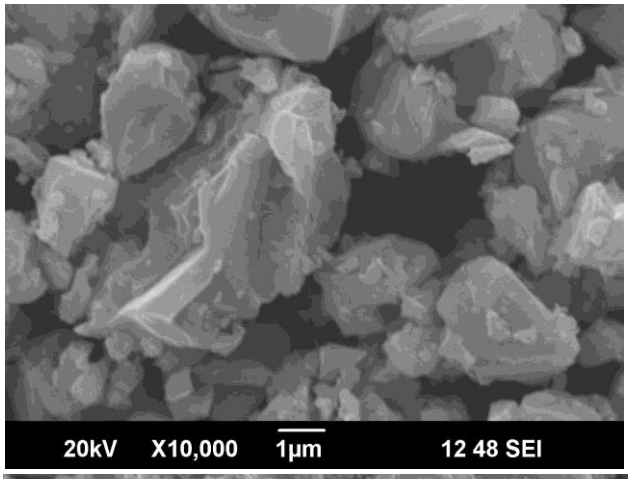
The Scanning Electronmicroscopy (SEM) Fig. shows the morphological information of the hexagonal ferrite containing irregular grain, but nearly vertically arranged shape flakes. The particles seemed to be hexagonal plate like mould which spreed out homogeneously were examined by [8-9] ceramic method.

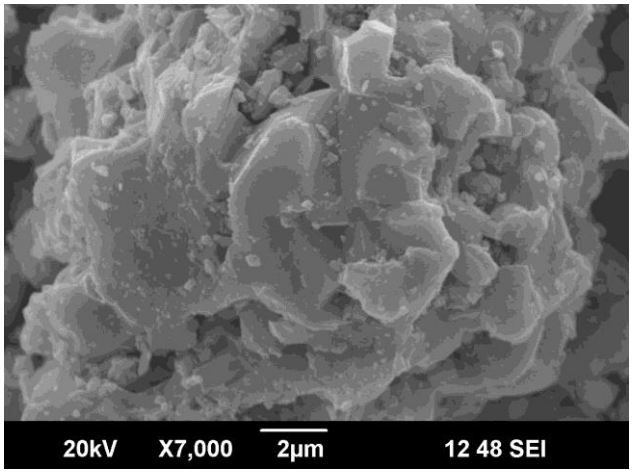
Figure 2 shows the representative SEM micrographs of fractured surface of Al- Substituted sintered CaM the micrograph Shows that Al-substitution reduce the particle size. Al Substituted Calcium Hexaferrite. Aspect Factor calculated from following reaction.

Aspect Factor = $\frac{lenght}{diameter}$









Figuer 2. SEM images of $CaAl_{1.5}Fe_{10.5}O_{19}$

Table 3

sample	particle size	Aspect Factor
$CaAl_{1.5}Fe_{10.5}O_{19}$	865.6	2.5312

III. CONCLUSION

Al Substituted $CaAl_xFe_{12-x}O_{19}$ (with x=1.5) Calcium hexaferrite have been prepared by standard ceramic method. The XRD confirms that Calcium hexaferrite have hexagonal Structure and single phase. the cystallite size is reduce due to less ionic radius of Aluminum. Lattice constant also found to decreases with substitution. Particle size is determined by shcerrer formula. Substitution of Aluminum increase with increasing particle size.

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