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Synthesis and characterization of Co Doped in Lead Ferrite Nanopowder Using Sol-Gel Method

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ABSTRACT

Co_x Pb_{1-x} Fe2O4 (where x=0.2, 0.4, 0.6) Nano ferrite powders were synthesized by sol-gel method at cost effective low temperatures. The synthesized powders were sintered at740^{0}C.The prepared samples were characterized by X-ray diffraction and VSM. From XRD characterization the structure of the material is found to be spinel ferrite. The lattice constants and average particle size were studied by X-ray diffraction. The substitution of Co in Pb Ferrite shows the remarkable changes in particle size and magnetic property. The average particle size is in range of 17 to 30 nm. The magnetic properties were studied by VSM.

Keywords: Pb-Co Nano ferrite, sol-gel, XRD, VSM etc

INTRODUCTION

Recent studies have shown that the physical properties of nanoparticles are enhanced significantly by various processing technique and with different composition.This method is used to obtain improved properties, more homogeneity and narrow particle distribution, thereby influencing structural, electrical and magnetic properties of ferrite. It is interesting and important to develop techniques by which the size and structure of the particles can be well controlled. In the present work we have successfully synthesized and studied the effect of Co on the structural properties of $PbFe_2O_4$ samples. $PbCoFe_2O_4$ Nano-particles were successfully prepared by Sol-gel auto-combustion method.

METHODOLOGY

The high purity AR grade ferric nitrate ($Fe_2(NO_3)_2.9H_2O$), Lead nitrate ($Pb(NO_3)_2.6H_2O$), Cobalt nitrate ($Co(NO_3)_2.6H_2O$), citric acid ($C_6H_8O_7$), ammonium hydroxide solution (NH_4OH) were used to prepare Pb_{1-x} Co_x Fe_2O_4(x=0.2,0.4,0.6) nanoparticles by sol-gel auto combustion synthesis technique. In this chemical process Citric acid was used as a Fuel. These nitrates and citric acid were weighed accurately to have proper stoichiometric proportion required in the final product. The mixed solutions of all the chemicals were stirred until the homogeneous solution is obtained. During the stirring process ammonium hydroxide solution was added drop by drop to obtain pH of 7. The mixed solution was simultaneously stirred at 100˚C for 3 to 4 hours to form a gel after that it takes auto-combustion. The prepared powder was sintered at 740˚C for 6hours.

RESULTS AND DISCUSSION

XRD Analysis:

From figure 1 the XRD pattern is used to estimate the average size of very small crystallites, from the measured width of the peaks in the different pattern.

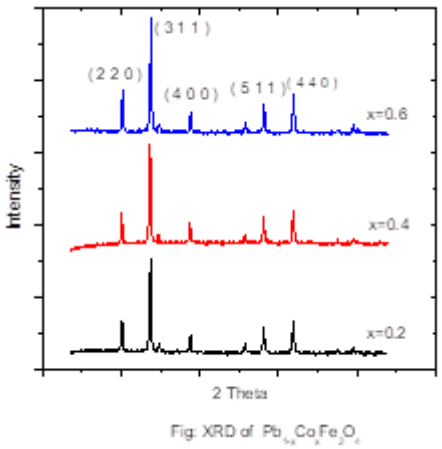

Fig: XRD of $Pb_{1-x}Co_xFe_2O_4$

Figure 1: shows the XRD pattern of $Pb_{1-x}Co_xFe_2O_4$

Composition	Average particle size "t" (nm)	Interplanar distance "d" (nm)	Lattice constant "a" (A^0)
$Pb_{1.8}Co_{0.2}Fe_2O_4$	17.3360	2.5311	8.5841
$Pb_{1.6}Co_{0.4}Fe_2O_4$	23.3625	2.5277	8.4712
$Pb_{1.4}Co_{0.6}Fe_2O_4$	30.1255	2.1423	8.3715

Composition	Hc in Oe	Mr emu/gm	Ms emu/gm
$Pb_{1.8}Co_{0.2}Fe_2O_4$	1657.5926	5.6996	5.8912
$Pb_{1.6}Co_{0.4}Fe_2O_4$	1090.7407	7.94	9.0851
$Pb_{1.4}Co_{0.6}Fe_2O_4$	833.5802	12.6901	27.4317

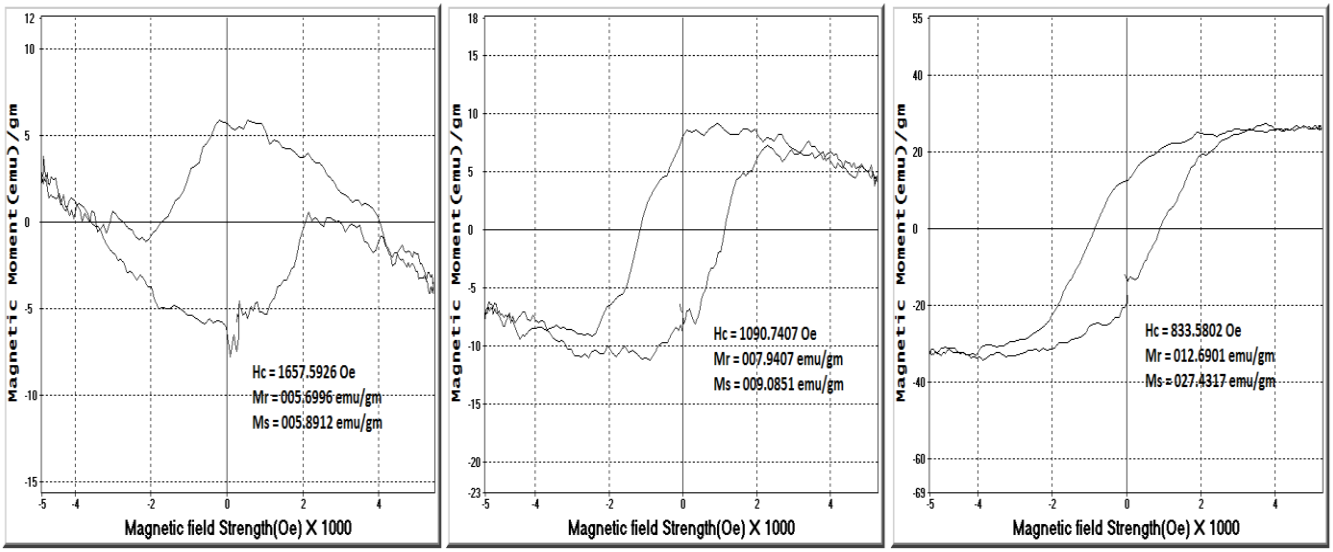

Figure 2: (a) VSM of $Pb_{1.8}Co_{0.2}Fe_2O_4$Fig3: (b) VSM of $Pb_{1.6}Co_{0.4}Fe_2O_4$ (c) : VSM of $Pb_{1.4}Co_{0.6}Fe_2O_4$

The particle size were calculated using Scherer's formula:

$$t = \frac{0.9\lambda}{\beta\cos\theta}$$

Where,
λ =wavelength of X-ray used,
β = Full Width Half Maxima (FWHM) in radians,
θ = peak position.

Lattice parameter (a) of the sample was calculated by using the formula

$$a = d \times \sqrt{h^2 + k^2 + l^2}$$

Where,
a = Lattice Constant,
(hkl) are the Miller Indices

VSM Characteristics (Hysteresis Loop):
The Figure 2 shows that the magnetic properties of the synthesized material from the hysteresis loop it clear that the figure 2 (a) to Figure 2 (c) it increasing the Pb concentration in Cobalt the property of the material changes from hard to soft ferrite.

CONCLUSION

$Pb_{(1-x)}Co_{(x)}Fe_2O_4$ Nano sized ferrite powder were synthesized successfully by sol gel- auto combustion method. From XRD calculation it is conclude that average grain size goes on increasing as concentration of cobalt increases this influence is occur due to ionic radii and exchangeability of ions and it is in the nanostructure range and spinel ferrite. Form, the magnetic properties were studied by hysteresis loop and it is found that the magnetic saturation goes on decreasing as percentage of Co goes on increasing also it convert hard ferrite to soft ferrite.

Conflicts of interest: The authors stated that no conflicts of interest.

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