Synthesis and Characterization of $BaFe_{12}O_{19}$ /$LiFe_5O_8$ Nano Composite Materials.

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Abstract

The composite powders of barium- lithium ferrite were prepared using sol-gel auto-combustion method. The X-ray diffraction (XRD) and Vibrating Sample Magnetometer (VSM) were used to investigate the structural and magnetic properties of composite samples. The X-ray diffraction characterization showed the formation of hexagonal structure related to $BaFe_{12}O_{19}$, cubic structure related to $LiFe_5O_8$ and little percent of α-Fe_2O_3phases.The best corocive force was obtained for 50% LiM& 50% BaM.

Keywords: Composite ,Ferrites , Sol- Gel method.

الخلاصة:

حضرت مساحيق متراكبه من الفرايت ليثيوم _ باريوم بأستخدام طريقة الهلام_السائل ذاتية الاحتراق. أستخدمت حيود الاشعه السينيه (XRD) والاهتزاز المغناطيسي (VSM) للتحقيق في الخصائص المتراكبة والمغناطيسية للعينات المتراكبة. أظهر حيود الاشعة السينية تكوين اطوار من الفرايت السداسي العائد لفرايت الباريوم ، الفرايت الشوكي العائد لفرايت الليثيوم و كمية صغيره من $\alpha-Fe_2O_3$. أفضل قوة قسرية تم الحصول عليها عند النسبه LiM%50 و BaM%50.

الكلمات المفتاحية: متراكب ، فرايت ، طريقة الهلام _ السائل.

1. Introduction

Ferrites are materials that have huge imoprtance in view of the substantial number of mechanical applications they find and additionally on the grounds that they can be utilized as model materials and in this way give a chance to better comprehension of the magnetic cooperation in nanoscale(Silvaa *et.al*., 2004). Ferrites are unrivaled magnetic materials which generally utilized as a part of microwave and electrical ventures. They show high electrical resistivity consolidated with helpful ferromagnetic conduct. Their applications run from straightforward capacity gadget, for example, little lasting magnets to complex gadgets for the electronic business. Some fascinating utilizations of these materials are magnetic media utilized as a part of PCs, recording gadgets, and magnetic cards, among others (Nalbandian *et.al*., 2008 - Nalwa *et.al*., 2002)one of the appealing properties of ferrites is the likelihood to get ready diverse structures and along these lines change the magnetic properties. Recently, one of the difficulties is to enhance the magnetic properties of soft ferrites, for example, immersion polarization, magnetic hysteresis, demagnetizing power and anisotropic vitality. Scientists are trying to make hard and soft ferrites by utilizing basic techniques. In this view, many reviews have concentrated on new frameworks, for example, $CoFe_2O_4$/$ZnFe_2O_4$(Masala *et.al*., 2006),earth-iron-boron (Maeda *et.al*.,2004) and Fe/Z-type ferrite (Liu *et.al*, 2006).The results propose that coupling interchange occurs between the nanoparticles and the interaction remarkably effects magnetization and coercivity of the composite powders.

Between these materials, joining between hexagonal ferrite and spinel ferrite are intensively inspected by many researchers. (Chen *et.al*., 2007)inferred that the retention execution of $SrFe_{12}O_{19}$/$ZnFe_2O_4$ composite powders which were created by sol-gel method might be ascribed to trade coupling cooperation amongst hard and soft stages.(Shen *et.al*.)examined the magnetic properties of $SrFe_{12}O_{19}$/$Ni_{0.5}Zn_{0.5}Fe_2O_4$ nanocomposite in their exploration. They have indicated this string the nanocomposite magnets consolidating a high immersion polarization of the soft stage and high coercivity of the hard stage will be perceived as the up and coming era of permanents.

As per studies, we went onto examine the auxiliary and magnetic properties of $BaFe_{12}O_{19}/LiFe_5O_8$ as hard/soft composite powder. $BaFe_{12}O_{19}$, is notable for its elite lasting magnetic and great mechanical hardness which has pulled in impressive consideration as of late attributable to its high coercivity , high Curie temperature, generally huge charge, and the predominant substance strength and consumption resistivity. $BaFe_{12}O_{19}$ has been utilized as microwave retaining operator as a part of 2–18 GHz to dispose of undesirable electromagnetic signs, which may meddle with electronically controlled frameworks and be harmful to health (Wang *et.al*, 2008 – Gomez *et.al*., 2006).

Lithium ferrite ($LiFe_5O_8$) has drawn consideration from quite a while because of its one of a kind superb properties, for example, high saturation magnetization, low dielectric losses, magnificent square state of hysteresis bend, fantastic dielectric properties, high Curie temperature (620^{o}C), high chemical inertness, thermal stability , high resistivity, low eddy current losses, low cost and safety. Due to these eligible properties, it is broadly utilized as a part of delayed innovative applications, for example, lithium particle batteries, high-thickness magnetic recording, magnetic liquids, magneto-caloric refrigeration , magnetic reverberation imaging upgrade and magnetically guided medication conveyance and is extremely appealing as a substitute for costly Yttrium Iron Garnet (YIG) in mass-scale microwave gadgets, for example, circulators, tage shifters, isolators, influence change in hardware, memory center, reception apparatuses and fast computerized tapes (Mazen *et.al*.,2015).

In this work, the powders were synthesized by using sol- gel auto combustion method. The crystal structure and magnetic properties of the composite materials were also studied.

2. Experimental procedure

2.1 Starting materials

The raw materials used to prepare barium and lithium ferrites by sol-gel method were barium nitrate (sarbia), lithium chloride (spain), ferric chloride (india), citric acid(india), ammonia (india) and distilled water was used for the preparation of all samples.

2.2 Synthesis of Nanoferrite by Sol-Gel Auto-Combustion Method

Barium nitrite, lithium chloride and ferric chloride were dissolved in distilled water. The barium solution is mixed with iron solution, where the ratio of iron to barium solution was selected according to a definite chemical stoichiometric ratio as (Fe: Ba =9:1) by using hot plate magnetic stirrer. Also the lithium solution is mixed with iron solution, where the ratio of iron solution to lithium solution was selected according to a definite chemical stoichiometric ratio as (Fe: Li=5:1) by using hot plate magnetic stirrer. After two hours drops of ammonium hydroxide was added to the mixed solution until the gel bed was formed. PH of the solution was measured, where the gel formation begins at PH=6 addition of citric acid that leads to hear notifying the combustion after few minutes which indicate reducing the particle size of produced gel, to get out the gel solution was filtrate with filter papers.

The filtered gel was then dried at temperature 80°C for 1 hours in a programmed electrical oven. The gel was then calcined at temperature 700°C at heating rate 5°C/min for 2 hour and then cooled by switching off the furnace to room temperature. The powder were finally crushed to obtain barium hexaferrite and lithium ferrite phases, and then tested to check the size of particle in nano range.

2.3 Fabrication of $BaFe_{12}O_{19}/LiFe_5O_8$ Nanocomposite.

The raw material used to prepare nano composite samples were nano barium ferrite and nano lithium ferrite, are weighted in the proportions as shown in table (1).

Different percentages are used in each sample, after that compacting practice were done under 20KN load pressure. Each sample was subjected to sintering under temperature of 1100°C for 2 hrs. The sintering heating cycle including a slow heating rate with 5 °C⁄ min, (see figure 1). All sintering practices were carried out by using electric furnace.

Table (1): Nano composite profile.

Composite sample	Weight of LiM(g)	Weight of BaM(g)
100% LiM	0.4	0
80% LiM& 20%BaM	0.32	0.08
75% LiM+25% BaM	0.3	0.1
65%LiM+35%BaM	0.26	0.14
50%LiM+50%Bam	0.2	0.2
35%LiM+65%BaM	0.14	0.26
25%LiM+75%BaM	0.1	0.3
100% BaM	0	0.4

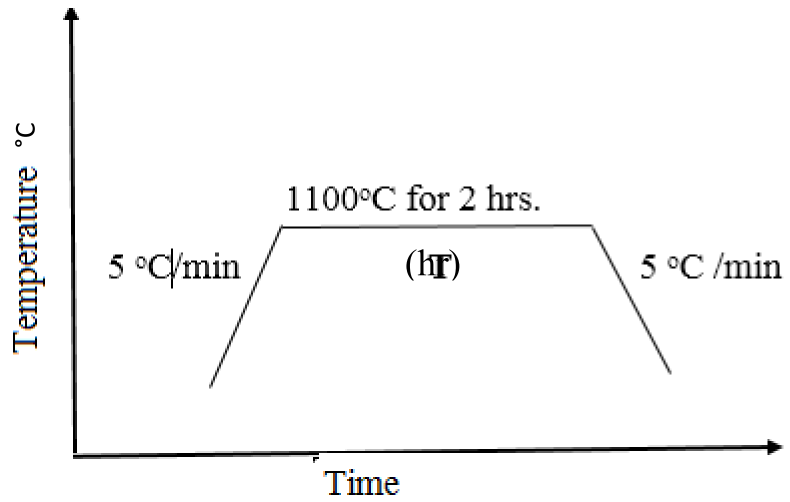


Figure (1): Single heating cycle of the applied sintering process.

3. Results and Discussion

3.1 Particle Size Distribution

The size distribution of the powders at calcination temperature 700°C with Fe/Ba of 9/1 and Fe/Li of 5/1 characterized by laser particle size analyzer and Atomic force microscope are shown in Figs. (2) and (3) respectively. The result suggests that the particle size is relative uniform and almost all of them are varied from 75.23nm (Barium ferrite) to about 89 nm (lithium ferrite).

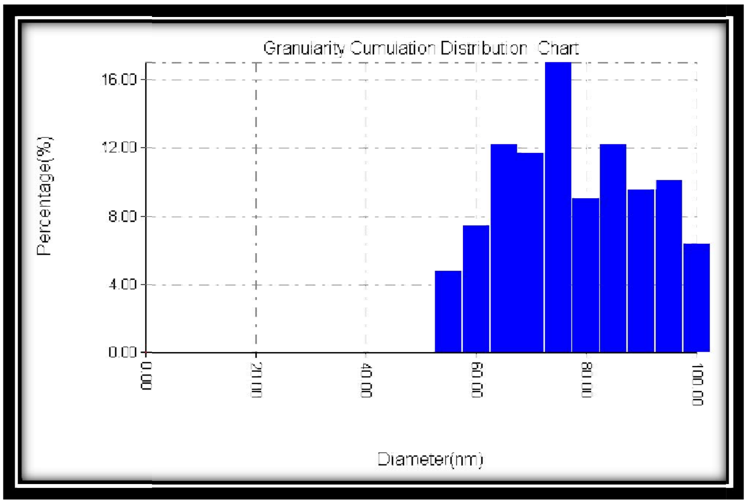


Figure (2): The size distribution of barium ferrite.

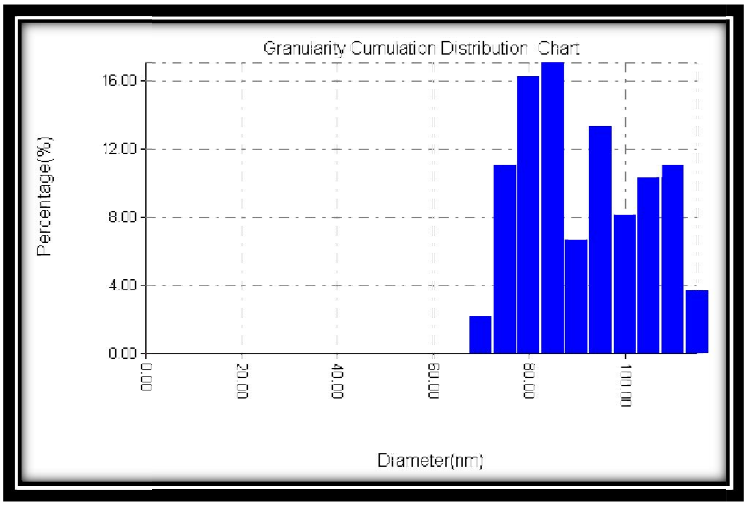
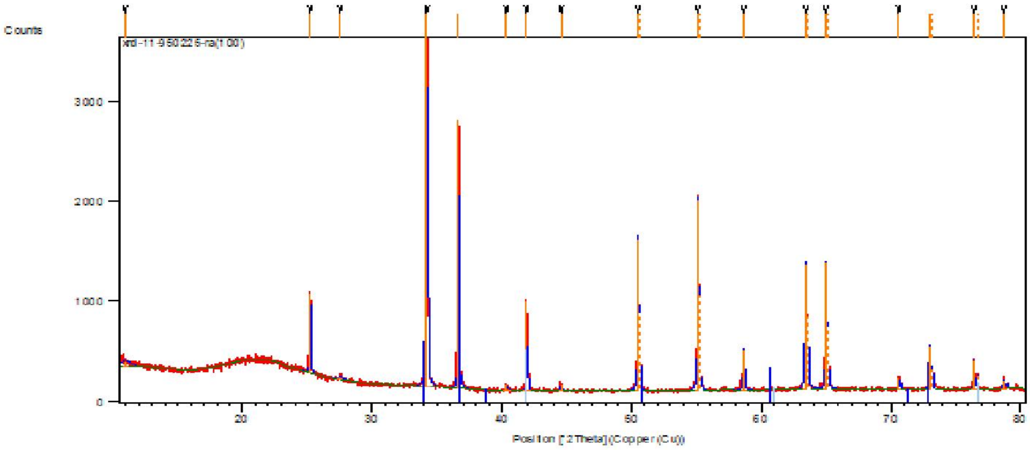


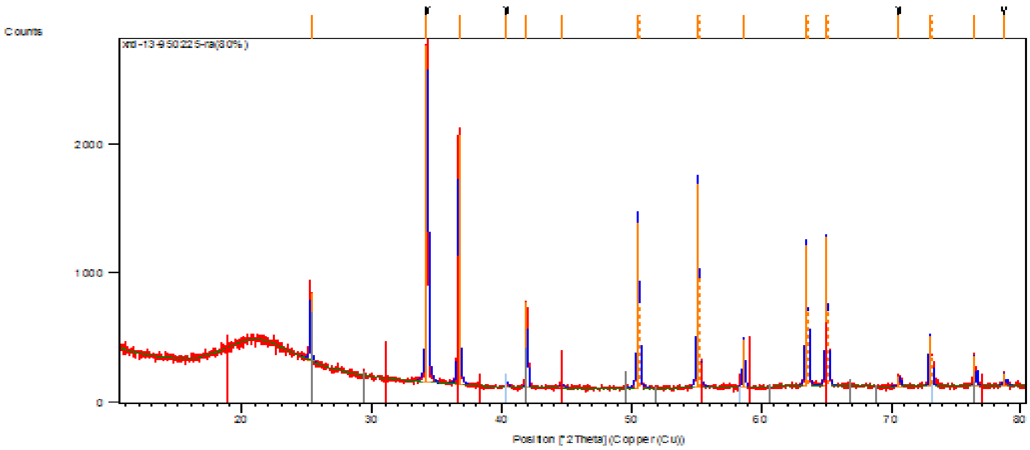
Figure (3): The size distribution of lithium ferrite.

3.2 XRD Patterns

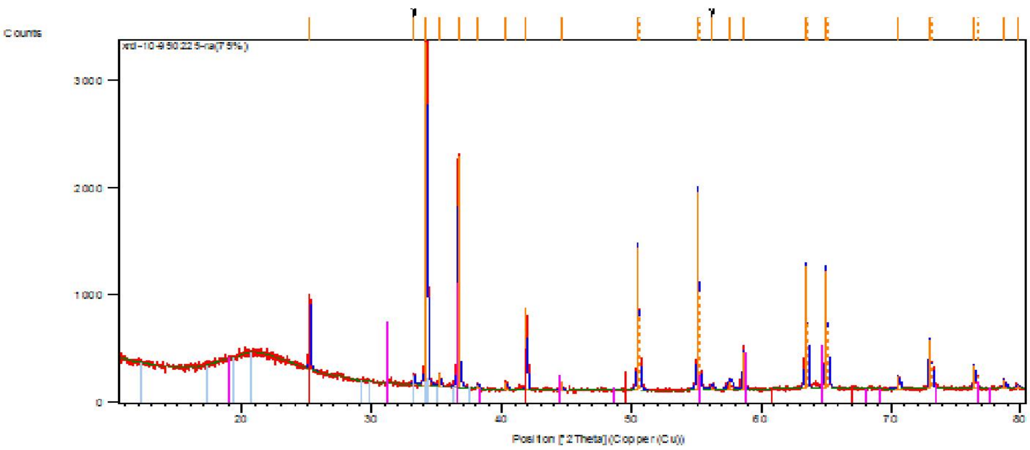
The XRD patterns in Fig. (4) (a,b,c,d,e,f,g and h) represent the $BaFe_{12}O_{19}/LiFe_5O_8$ nano composites. The diffraction peaks can be indexed with the standard patterns for Barium ferrite and Lithium ferrite. It is obvious from the figures when the percentage of barium ferrite (hexagonal structure) increased above the percentage of lithium ferrite (cubic structure), The XRD pattern showed partial amorphous structure, amorphous hump and also present of sharp peaks of hard-soft ferrite. Also all the peaks have shifted, so, this is may be due to the presence of internal strain.



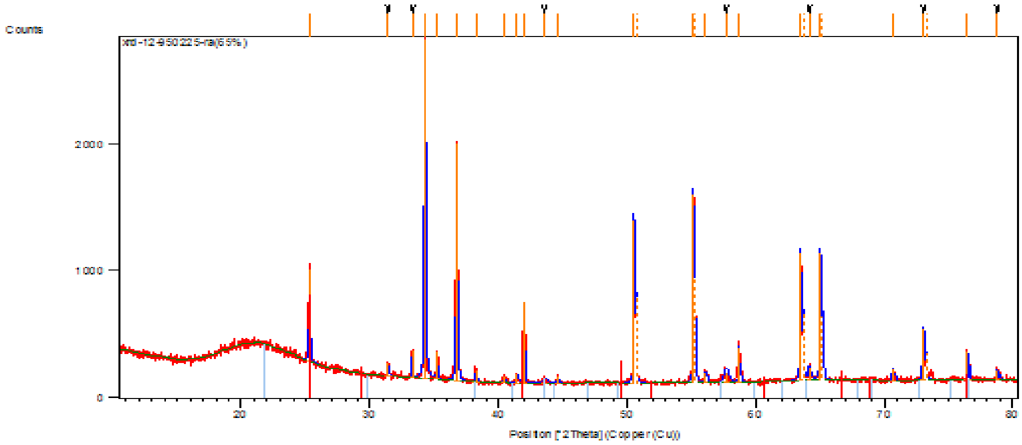
a)100% LiM & 0% BaM



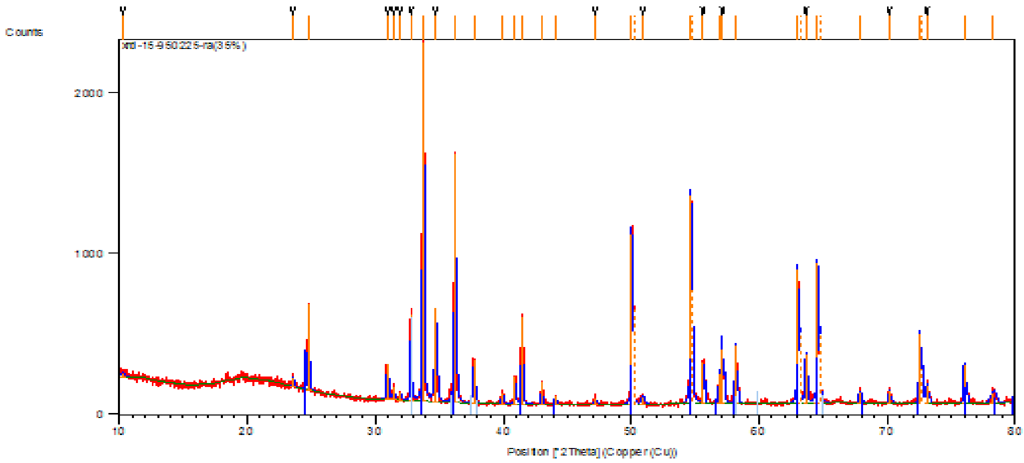
b) 80% LiM & 20% BaM



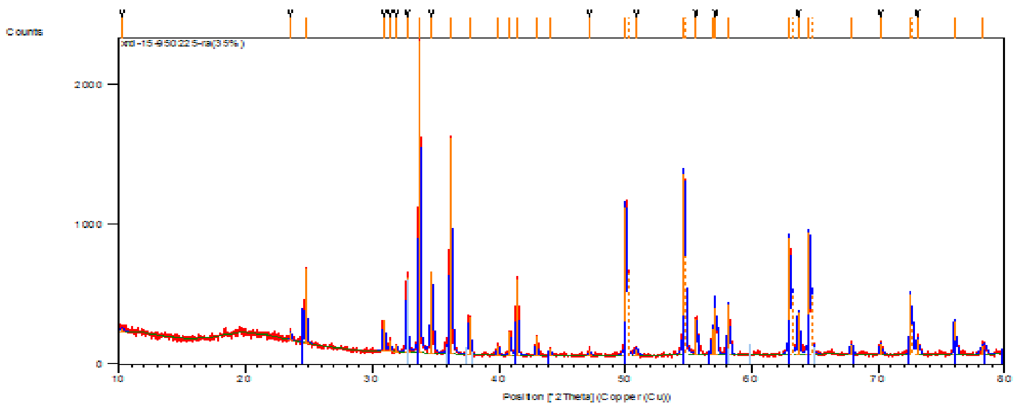
c) 75% LiM& 25 % BaM.



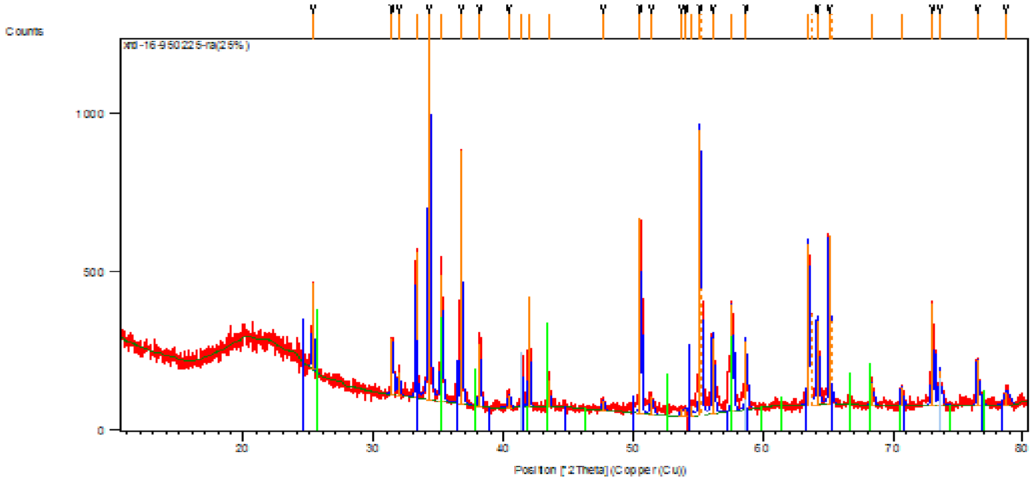
d) 65% LiM& 35% BaM



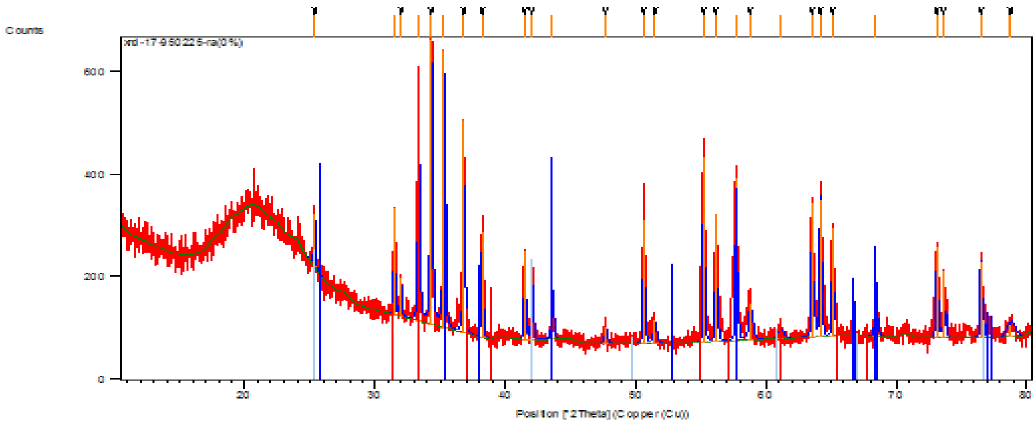
e) 50% LiM & 50% BaM**.**



f) 35% LiM & 65% BaM.



g) 25% LiM & 75% BaM

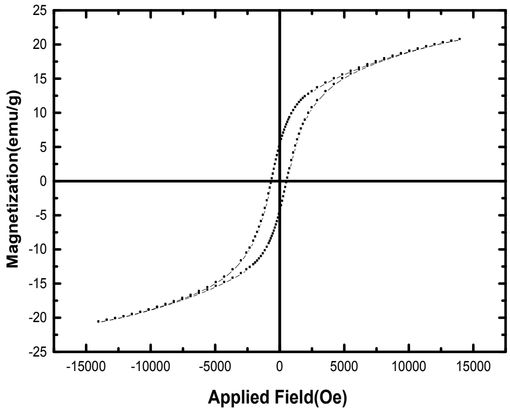


h)0% LiM & 100% BaM

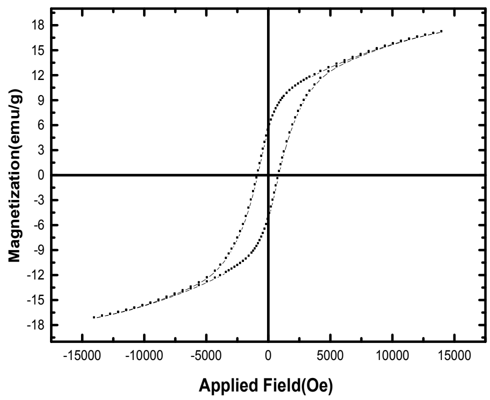
Figure(4)(a,b,c,d,e,f,g and h): X-ray diffraction patterns $BaFe_{12}O_{19}$ /$LiFe_5O_8$ Nano composites

3.3 Vibrating sample magnometer (VSM) measurement

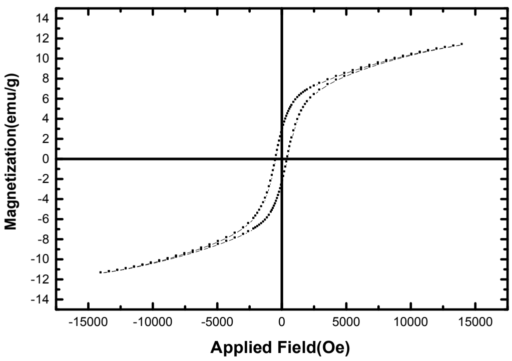
Magnetic measurement of the samples is performed by VSM at room temperature (25^{o}C) with a maximum applied field of 15 kOe**.** Figure(5) (a,b,c,d,e,f,g and H) shows typical hysteresis loops of lithium ferrite and barium ferrite compact with various percentages and sintered at 1100^{o}C for 2 hours, It is observed that the saturation magnetization, remenance magnetization and corecivity were improved in hard-soft nano composite. The variation may be attributed to the interphase interacting at the surface of two phase ferrites. The interaction between the hexagonal (barium ferrite) and spinel (lithium ferrite) could be form the nano composite with good magnetic saturation and coercive force (Bakhtiari *et.al.*,2013), the coercivity (*H*c) variation in nano composite sample can be explained on the basis of the size of the particles and domain structure. The saturation magnetization, remenance magnetization and corecivity were determined from the hysteresis graphs and listed in table (2).



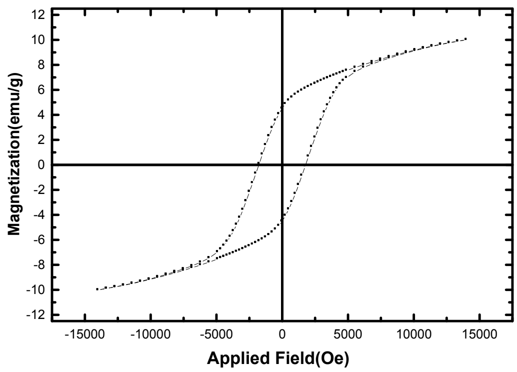
*a)*100%BaM



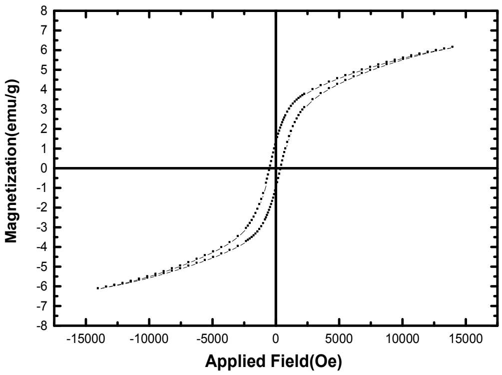
b) 25% LiM&75% BaM.



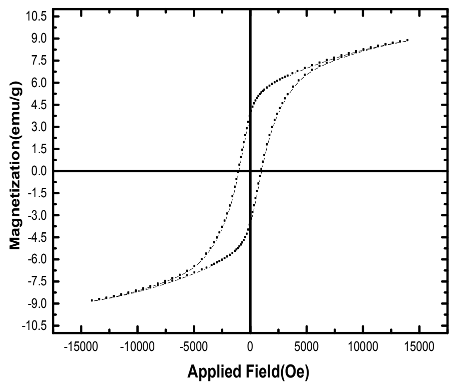
c)35% LiM&65% BaM.



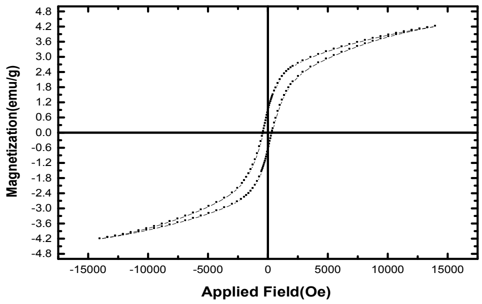
d) 50% LiM&50% BaM



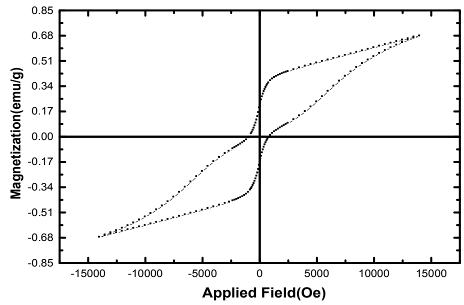
e) 65% LiM& 35% BaM



f) 75% LiM&25% BaM.



g)20% BaM&80%LiM.



H) 100% LiM.

Figure(5)(a,b,c,d,e,f,g&g): hysteresis curve of Nano-composite LiM&BaM sintered at 1100^{o}C.

Table (2):- Magnetic properties of Nano-composite samples.

Structure	Ms (emu/g)	Mr(emu/g)	Hc(Oe)
0% LiM& 100% BaM	20.679	6.04	560.28
25% LiM&75%BaM	17.18	6.019	909.2
35%LiM&65%BaM	11.37	3.33	480.9
50%LiM&50%BaM	10.01	4.52	1749.5
65%LiM&35%BaM	6.13	1.74	398
75%LiM&25%BaM	8.84	4.05	1042.5
80%LiM&20%BaM	4.208	1.145	349.26
100% LiM&0%BaM	0.677	0.246	968

4. Conclusions

$BaFe_{12}O_{19}/LiFe_5O_8$ ferrite nanocomposites were synthesized by using sol-gel auto-combustion method. The XRD patterns reveal that the hexaferrite $BaFe_{12}O_{19}$ and spinel Li Fe_5O_8 were formed. The results showed that the interaction between the hexagonal and spinel ferrite could be form the nanocomposite with good magnetic saturation and coercive force. The sample with 50% lithium ferrite and 50% barium ferrite showed the higher saturation magnetization 10.01 emu/g and corocive force 1749.5 *Hc*, as compared with other samples.

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