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Structural properties of the composites ($BaFe_{12}O_{19}/Ni_{0.3}Cu_{0.2}Zn_{0.5}Al_{0.5}Fe_{1.5}O_4$) prepared by sol-gel auto combustion

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ABSTRACT

The nanocomposites ferrites ($BaFe_{12}O_{19}/Ni_{0.3}Cu_{0.2}Zn_{0.5}Al_{0.5}Fe_{1.5}O_4$) with (x=10,25,50,75,90%) were prepared by sol-gel auto combustion. The micro-structural features of the samples were studied using X-ray diffraction (XRD) and scanning electron microscopy (SEM) techniques. The results were compared which show that the grain size of the nano composites which prepared by sol-gel auto combustion about (25-46) nm.

Introduction

Ferrites are materials that used in many important technological applications where found to be used as model materials which gives a better understanding of magnetic interactions in nano-criterion [1]. Since the discovery of substitute pairing in 1989 by Coehoorn and his group from experiments on nanostructured Nd-Fe-B/Fe-B electromagnet[2]. Magnetism has been widely studied on both thin films and magnetic particles [3,4]. The magnetically hard and soft must be exchanged coupling in order to obtain best magnetic with electrical properties[5,6]. Therefore, it is necessary to use the effective characterization way to determine the existence of replacement coupling between hard and soft phases[7,8]. Researchers are experimented to output hard and soft ferrites by using commoner methods. In this view, studies have focused on new systems, such as $CoFe_2O_4/ZnFe_2O_4$[9]. It turns out that the exchange coupling between magnetically soft and hard phases get better magnetic properties as well as microwave absorption of nano-composites.

Experimental Methods

To prepare the ($BaFe_{12}O_{19}$) and ($Ni_{0.3}Cu_{0.2}Zn_{0.5}Al_{0.5}Fe_{1.5}O_4$) ferrites by sol-gel auto combustion used ($Ba(NO_3)_2$), ($Fe(NO_3)_3.9H_2O$), ($Ni(NO_3)_2.6H_2O$),($Zn(NO_3)_2.6H_2O$),($Cu(NO_3)_2.3H_2O$, ($Al(NO_3)_3.9H_2O$), (NH_3) and ($C_6H_8O_7$) as raw materials. The ferrite powders were synthesized as follows; appropriate amount of metal nitrates were dissolved in deionized water. Citric acid was then added into the prepared aqueous solution .The mixed solution was neutralized to pH 7 by adding ammonia and then stirred continuously at 80˚C until a viscose gel was obtained. The obtained gel was ignited to form a loose powder. Finally, powder was calcined at 1250˚C for two hours with a heating rate of (5˚Cmin^{-1}) to obtain barium hexaferrite and NiCuZnAl ferrite. Then mix the two ferrites powder rates (x=10,25,50,75,90%). The properties of their synthetic should be studied by using the X-ray diffraction (XRD) device with Cu K_α radiation and observed the microstructure of sintered ferrite by scanning electron microscope (SEM) .

Results

1. XRD Patterns

The fig 1 shows that the XRD patterns of the [$BaFe_{12}O_{19}/Ni_{0.3}Cu_{0.2}Zn_{0.5}Al_{0.5}Fe_{1.5}O_4$]nanocomposites which prepared by sol-gel auto combustion method. The diffraction peaks appeared in the XRD patterns can be indexed with the standard patterns for $BaFe_{12}O_{19}$ (JCPD 051-1867) and $Ni_{0.3}Cu_{0.2}Zn_{0.5}Al_{0.5}Fe_{1.5}O_4$ (JCPD 054-0964), which

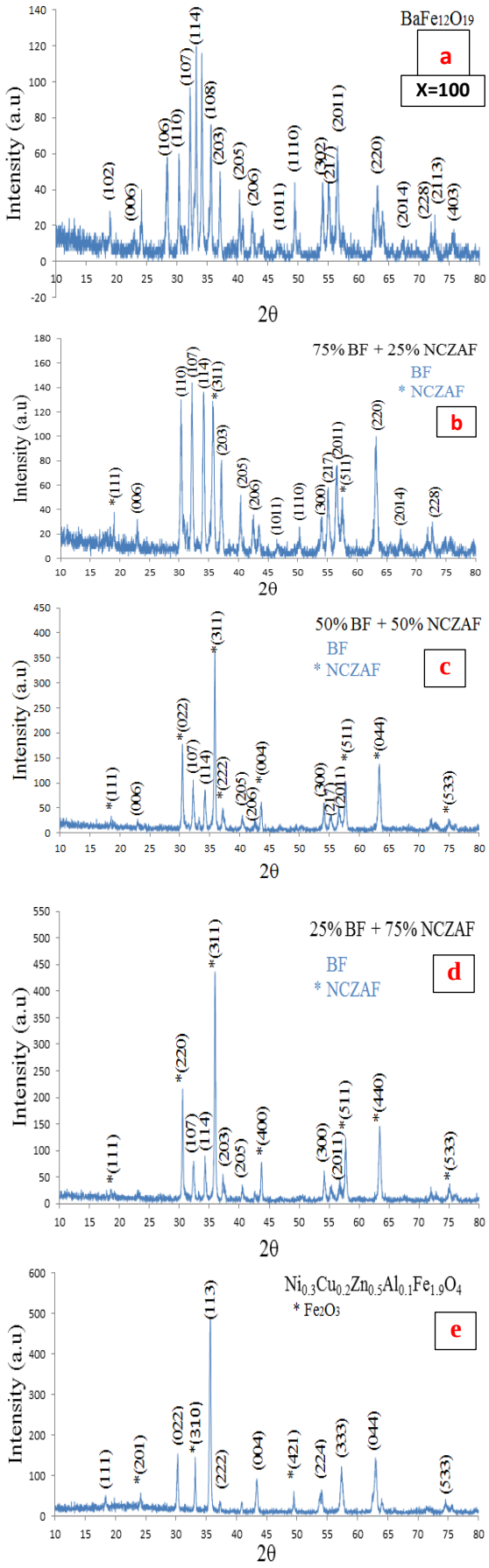
depict hexagonal structure of $BaFe_{12}O_{19}$ and cubic structure of $Ni_{0.3}Cu_{0.2}Zn_{0.5}Al_{0.5}Fe_{1.5}O_4$. Well-defined sharp peaks in the XRD pattern of sample which was treated by sol-gel auto-combustion method indicates the good crystalline quality and confirm the formation of nanocomposite. Also all these peaks have shifted. So, this is approxmittly due to the presence of internal strain. The average crystallite size (D) obtained from the most obvious angle (θ=30.4498^o) as estimated by Debye Scherrer's and Williamson-Hall equations as follows [10]:

$$D = \frac{K\lambda}{\beta cos\theta} \dots\dots\dots\dots\dots (1)$$

$$\beta cos\theta = \frac{k\lambda}{D_{w-H}} + 4\varepsilon sin\theta \dots\dots\dots\dots (2)$$

θ : diffraction angle.
β : full width at half maximum (FWHM).
K : constant and equal to 0.9.
λ : X-ray wavelength and equal to 1.5406A^o.
ε : the micro strain.

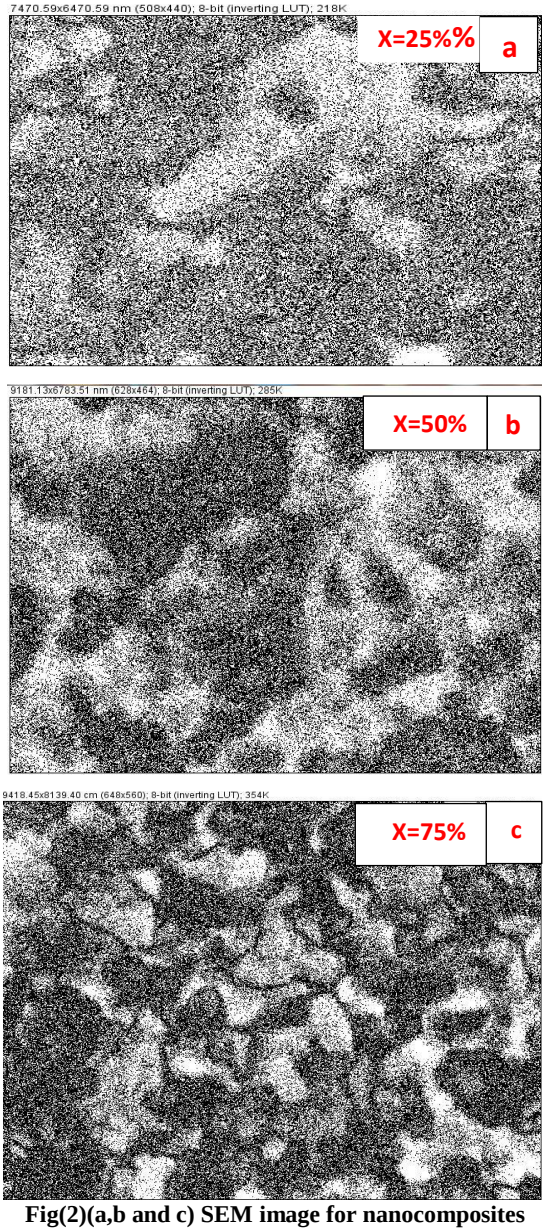
The grain sizes begin fom (25-46nm) and (28-49nm) respectively. The value of lattices are constant which are a=5.0847A^o and c=23.116A^o for the hexagonal structure while a=b=c=8.3775A^o is for cubic structure, this result was compared with (JCPD 051-1867).



Fig(1) (a,b,c,d and e) : Show x-ray diffraction pattern of $BaFe_{12}O_{19}/Ni_{0.3}Cu_{0.2}Zn_{0.5}Al_{0.5}Fe_{1.5}O_4$ nano composites at (x=0,25,50,75,100)%

2. Scanning electron microscope image (SEM)

As the result, obtained from the scanner electronic microscope (SEM) technique, there are samples with a spherical shape and agglomeration of grains on the sample surface this is because of the high surface energy of the grain. These results of grain size obtained by (XRD) technique compared with the results of (SEM) technique which find results that are close to each other as shown in fig 2, and get the information about the spread of grain in the samples.



Fig(2)(a,b and c) SEM image for nanocomposites $BaFe_{12}O_{19}$/ $Ni_{0.3}Cu_{0.2}Zn_{0.5}Al_{0.5}Fe_{1.5}O_4$ at (x= 25,50,75)% after analysis by image-J program

3. Energy Dispersive X-Ray Spectroscopy (EDX)

The EDX technique is important device used to detect the chemical elements in the samples and the chemical analysis of samples. It is based on the principle of X-ray, where a reaction between the sample material and electrons the emission from the device, then some electrons are reflected differently. The reason of this difference is because of the sample components.

The fig 3 shows at the ratio 50% the component elements of the nanocomposites ($BaFe_{12}O_{19}$ /$Ni_{0.3}Cu_{0.2}Zn_{0.5}Al_{0.5}Fe_{1.5}O_4$) which (Ba , Fe , Ni , Cu , Zn , Al and O) the carbon existence is the result of the incomplete combustion in the electric oven.

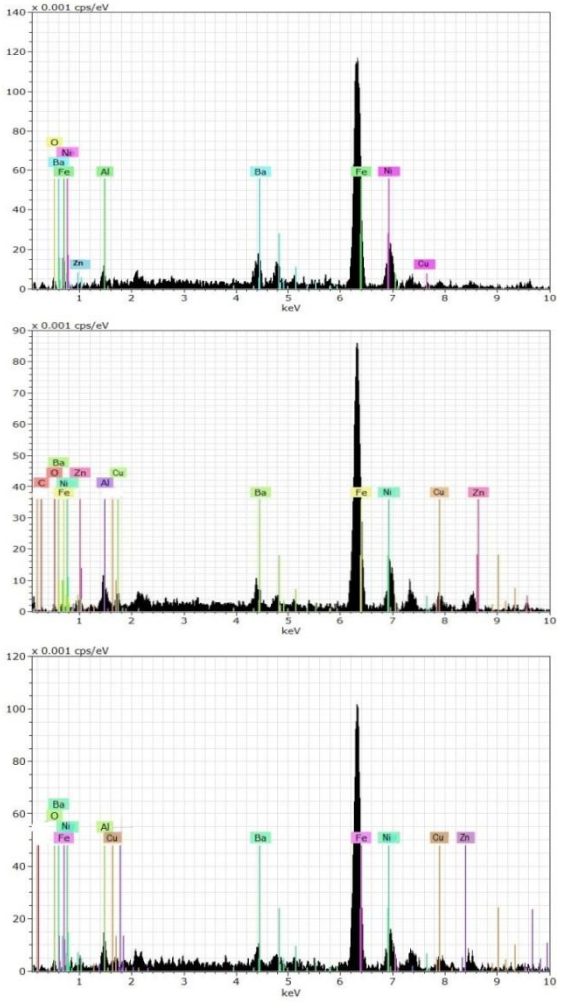


Fig (3)(a,b and c) EDX image of the nanocomposites $BaFe_{12}O_{19}$/ $Ni_{0.3}Cu_{0.2}Zn_{0.5}Al_{0.5}Fe_{1.5}O_4$ at (x= 25,50,75)%

Conclusion

$BaFe_{12}O_{19}/Ni_{0.3}Cu_{0.2}Zn_{0.5}Al_{0.5}Fe_{1.5}O_4$ ferrites nanocomposites were synthesized by using sol-gel auto combustion method. XRD patterns reveal that the hexaferrite $BaFe_{12}O_{19}$ and spinel $Ni_{0.3}Cu_{0.2}Zn_{0.5}Al_{0.5}Fe_{1.5}O_4$ were formed. The grain size is average between (25-49)nm that measured by the Debye Scherrer's and Williamson-Hall equations. Obviously. The scanning electron microscope shows that the shape of the powders surface is a spherical shape and agglomeration of grains on the sample surface this is because of the high surface energy of the grain. At the ratio 50% the component elements of the nano composites ($BaFe_{12}O_{19}$ /$Ni_{0.3}Cu_{0.2}Zn_{0.5}Al_{0.5}Fe_{1.5}O_4$) which (Ba , Fe , Ni , Cu , Zn , Al and O) the carbon existence is the result of the incomplete combustion in the electric oven.

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الخصائص التركيبية للمتراكبات ($BaFe_{12}O_{19}/Ni_{0.3}Cu_{0.2}Zn_{0.5}Al_{0.5}Fe_{1.5}O_4$) المحضرة بطريقة سول–جل للاحتراق التلقائي

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الملخص

تم تحضير المتراكب ($BaFe_{12}O_{19}/Ni_{0.3}Cu_{0.2}Zn_{0.5}Al_{0.5}Fe_{1.5}O_4$) باستخدام طريقة سول–جل للاحتراق التلقائي وبنسبة تراكب (x=10,25,50,75,90%)، وتم دراسة الخصائص التركيبية لها باستخدام تقنية حيود الاشعة السينية (XRD) و تقنية المجهر الالكتروني الماسح (SEM) عند مقارنة النتائج وجد أن النتائج متقاربة من بعضها وأن الحجم الحبيبي للمتراكب يتراوح بين (25-46) نانومتر.