Studying of Structural Properties of $Zn_xNi_{1-x-y}Cu_yFe_2O_4$ Spinel Ferrite Using XRD Powder

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Received in:4 April 2013,Accepted in :19February 2014

Abstract

$Zn_xNi_{1-x-y}Cu_yFe_2O_4$ spinel ferrite were prepared using solid state reaction method with (y=0.1, x=0.2, 0.3, 0.4, 0.5, 0.6) . X-ray diffraction with diffractometer CuKα analysis have been carried out and studied showing single phase spinel cubic with space group $FD\bar{3}m$ for all prepared samples . Lattice parameters and crystallite grain size and x-ray density($\rho_{x\text{-}ray}$) bulk density and porosity ratio's were calculated and showed good agreement with the international data reported in the scientific research's.

Keywords: Spinel ferrite-

Introduction

Ferrite with spinel type structure may be described by the general formula $MeFe_2O_4$ where Me are divalent cations (Cu^{2+} , Ni^{2+} , Cd^{2+} ….) the space group of this ferrite is ($FD\bar{3}m$) and the lattice parameters are typically ~ 5.8 °A. The Oxygen anions are arranged in Face Center Cubic (FCC) lattice . Each unit cell contains 8 formula units with O^{2-} anions in the 32 (e) sites and metal cations reside on 8 of 64 tetrahedral sites (A- sites) and 16 of 32 octahedral sites (B- sites) [1-8].A whole range of possible cation distribution is observed as shown in fig(1).The study of ferrites materials has attracted immense attentions of the scientific community because of their novel properties and technological applications[2]. Due to their various technological applications NiZn ferrite have attracted recently considerable research interests [3].We have been studied the structure of $Zn_xNi_{1-x-y}Cu_yFe2O_4$ ferrite with different dopant concentrations and calculating the lattice parameters ,x-ray densities , grain size for each dopant and the unitcell volume by using the XRD analysis technique in order to study the effects of increasing Zn-Cu on Ni-ferrite.

Experimental procedures

Spinel ferrite with the formula $Zn_xNi_{1-x-y}Cu_yFe_2O_4$ have been prepared by suitable solid state reaction method. The structure of the spinel Me-type in our present work have been studied using powder XRD analysis and carried out using SHIMADZU6000 diffractometer with CuKα radiation. The obtained XRD data was compared with standard patterns of JCPDS-ICDD (International Center for Diffraction Data) card no. 89-8103 for α-Fe_2O_3 and card no. 08-0234. The lattice parameters of the samples was determined using the relation[4,5]

$a_{exp}= d_{hkl}(h^2+k^2+l^2)^{1/2}$ ……..(1)

The average crystallite size was determined from the diffraction peak broadening with use of the Scherrer's equation [2-5].

$D=0.98\lambda/\beta\cos\theta$ ……(2)

Here λ is wavelength of the CuKα radiation (λ=1.54060 A°) , and β is the FWHM in radians. The x-ray density for spinel ferrite structure is :

$\rho_{x\text{-}ray}= Z.M/V.N_A$ ……..(3)

where Z=8 for spinel cubic ferrite , M= molecular atomic mass , V= a^3 the volume , N_A=Avogadro number [2,4].

Porosity ratio for the prepared samples also calculated using the relation;

٪Where ρ_{bulk}=mass/volume of the samples.

Results and Discussion

Fig.2 shows XRD patterns of spinel cubic ferrite samples $Zn_xNi_{1-x-y}Cu_yFe_2O_4$ with different concentrations, comparing with standard pattern(JCPDS file no.08-0234) ,all the XRD patterns have been indexed (hkl) manually and the lattice parameters, crystallite grain size, x-ray density and porosity ratio were calculated using equations (1-4).All the prepared samples showed spinel cubic structures with space group $FD\bar{3}m$,Table.1 summarizes the dependence of lattice parameters determined by XRD analysis. The most intense peaks in all specimens ,indexed as (220), (311), (221), (400), (422), (333), and (440) are found to match well with single phase cubic spinel structure (JCPDS no. 08-0234) no additional phase corresponding to any structures in doped samples was detected. It can be observed that the lattice parameters increases linearly with increasing x-value due to the greater ionic radius of Zinc ion (~0.74 °A) with respect to ionic radius of iron ions (~ 0.55 A°). Fig.3 plots the lattice parameters as a function of x-values for Zn substitutions where y=0.1 for all prepared samples. The porosity ratio for the prepared samples listed in table.1 is between 9 to 14 percentage and

it seems to be reasonable according to situations in our poor lab's equipment's .The results of the present work were totally acceptable and in agreement with the international works reported in M. Sopan etl and M. A. Batal. and the other researchers[1-8].

Conclusions

$Zn_xNi_{1-x-y}Cu_yFe_2O_4$ (y=0.1, x= 0.2, 0.3, 0.4, 0.5, 0.6) were synthesized by solid state reaction method. The x-ray diffraction analysis for all prepared samples revealed existence of single phase cubic spinel structure identified by (JCPDS card no. 08-0234) with space group FD3m in agreement with the data's reported in most scientific research and we showed also that XRD analysis is a very useful tools in materials science and technology research .

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Table No. (1): Lattice parameters, crystallite grain size and x-ray density with porosity ratio for $Zn_xNi_{1-x-y}Cu_yFe_2O_4$ for the prepared samples

sampe	X, y value	Chemical formula	a A°	V °A³	x-ray $\frac{gm}{cm3}$ ρ	Porosity ratio	Dnm
b1	0.2, 0.1	$Zn_{0.2}Ni_{0.7}Cu_{0.1}Fe_2O_4$	8.35	573.83	5.46	14%	34.26
b2	0.3, 0.1	$Zn_{0.3}Ni_{0.6}Cu_{0.1}Fe_2O_4$	8,36	584.9	5.37	9%	24.68
b3	0.4, 0.1	$Zn_{0.4}Ni_{0.5}Cu_{0.1}Fe_2O_4$	8.37	586.37	5.27	10%	42.4
b4	0.5,0.1	$Zn_{0.5}Ni_{0.4}Cu_{0.1}Fe_2O_4$	8.38	588.48	5.59	14%	43.6
b5	0.6, 0.1	$Zn_{0.6}Ni_{0.3}Cu_{0.1}Fe_2O_4$	8.39	590.58	5.36	11.2%	42.24

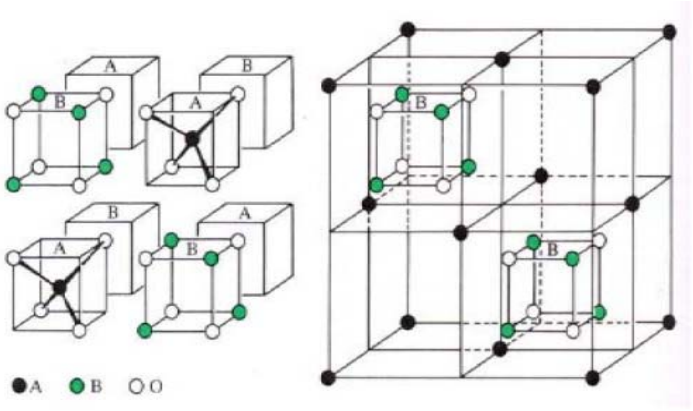

Figure No.(1) Structure representation for spinel cubic ferrite

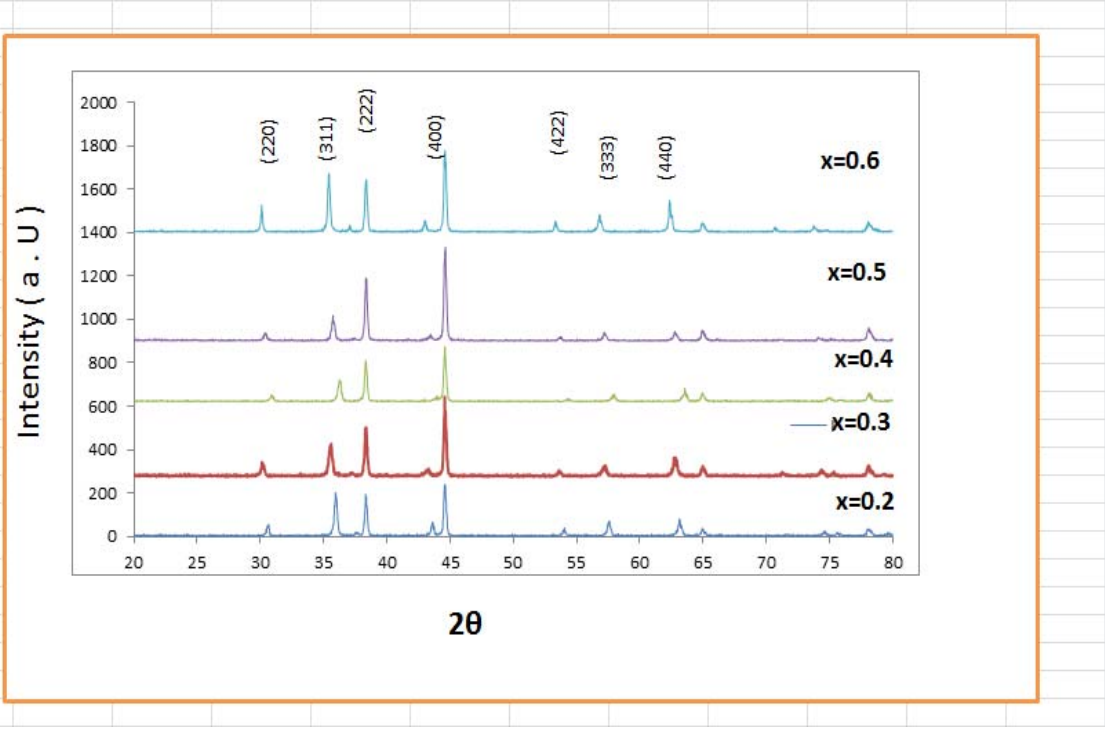

Figure No.(2): XRD patterns of powdered $Zn_xNi_{1-x-y}Cu_yFe_2O_4$ for different substitutions x- value

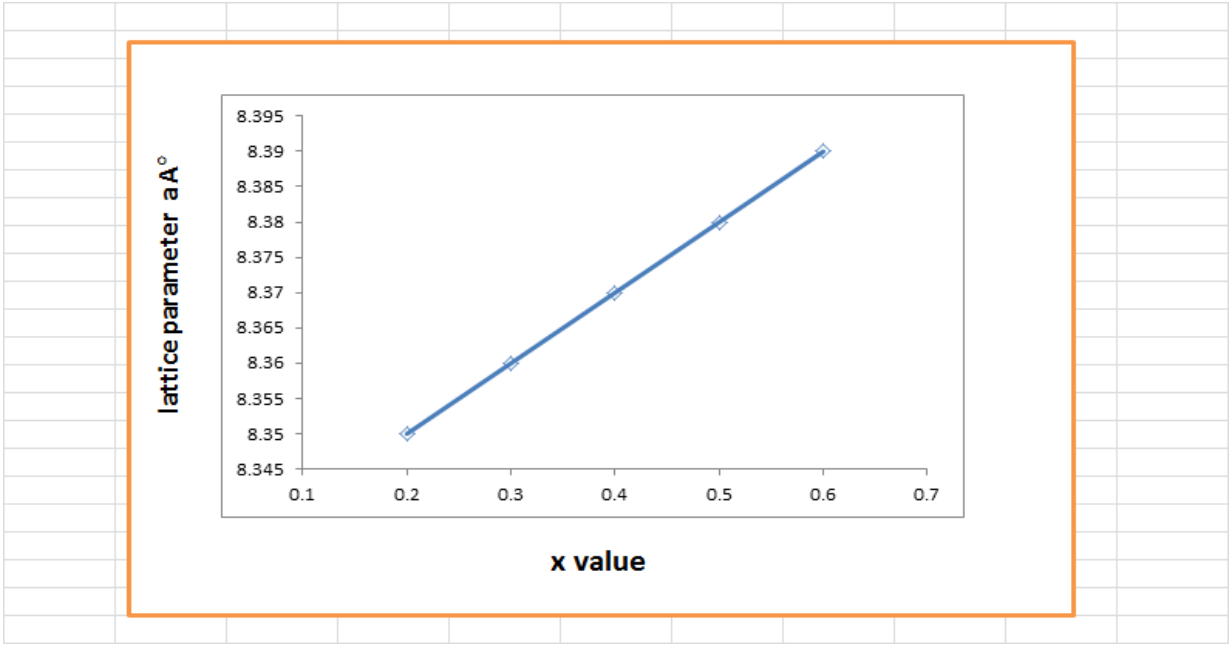

Figure No.(3): Lattice parameters as a functions of Zn x-values Show the increasing of lattice parameters with increasing of x-values

دراسة الخصائص التركيبية للفيرايت ذي الصيغة الكيميائية $Zn_xNi_{1-x-y}Cu_yFe_2O_4$ باستخدام حيود الاشعة السينية للمساحيق XRD

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الخلاصة

حضر الفيرابت المغزلي مكعب التركيب بالصيغة الكيميائية ZnxNi1-x-yCuyFe2O4 باستخدام تقنية تفاعل الحالة الصلبة وبنسب تعويض , (y=0.1, x=0.2, 0.3, 0.4, 0.5, 0.6)وتم اجراء عملية تحليل حيود الاشعة السينية لها وقورنت مع الكارتات العالمية التابعة للمركز الدولي لبيانات الحيود ICDD ورقم الكارت JCPDS 08-0234, واظهرت جميع النماذج المحضرة انها ذو تركيب طوري واحد من نوع المغزلي المكعب ورمز مجموعة التناظر له , $FD\bar{3}m$ وبعد اجراء عمليات التحليل لهذه البيانات وقياس الابعاد البلورية للشبيكة وحجمها وكثافة العينات باستخدام بيانات الحيود وكذلك نسبة المسامات الموجودة في كل عينة ودراسة نسب التعويض x لعنصر الخارصين وتاثيرها في الابعاد البلورية وظهر انها على تطابق تام مع مانشر في البحوث العالمية.

الكلمات المفتاحية:- حيود الاشعة السينية – نيكل خارصين نحاس فيرايت