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Studi of the Effect of Alternating Magnetic Field on Zinc Ferrite at Low Temperature

Edie Sasito Sarwodidoyo[a] and Imbang Rahmad Tritjahjono[b]
[a]Jurusan Refrigerasi dan Tata Udara.
[b] Jurusan Tehnik Mesin, Politehnik Negeri Bandung, Bandung Indonesia.

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ABSTRACT
Zinc Ferrite (ZF) is a material that is paramagnetic. Its presence in the universe has a magnetic force that is different depending on the structure and composition of materials. In some cases look almost the same, especially on substances ZF reacted at temperatures between 60 0C to 90 0C. ZF 70 have weaknesses at a temperature of 70, which is where most low coercivity alternating magnetism.

I. Introduction

Zinc Ferrite (ZF) is a compound based on zinc ferrite and pasted material. These compounds are found among the ruins of compound based on zinc ferrite and pasted material. These compounds are found among the ruins of the compound Fe3O4 and Fe2O3. ZF white can stand alone and are not attracted by the magnetic field.[1]. ZF is also the magnetic nanoparticles, nanopowder magnetic, magnetic nanocrystals, magnetic nanostructures, super paramagnetic, bulk magnetic nanomaterials, Fe, Ni, Co, Fe, ferrite magnets, magnetic alloys, magnetic oxides and magnetic nitride. Applications Nanoparticles Magnetic among other things; the data storage nanostructures (magnetic nanocrystal arrays), biomedical applications, optoelectronic, imaging probes intelligent, fluid nanostructured biomedical ferrofluid, biodegradable microspheres, drug and delivery system genes, separation biomagnetic, nanocomposites magnetic seal magnetic fluids , cancer treatment hyperthermic, synthesis magnet.[2,3] In stochiometri ideal expressed by equation ZnFe2 O4, a ferrimagnetic material with ;Spinnel structure M1 2 + 23 + .O4 .M2. Space group: Fd 3 m Unit cell: cubic consist of 56 atoms, ions O2- 32, 24 cations M23 + M12 + and octahedral lattice dispersed in 16 pieces and in a tetrahedral lattice 8 pieces.

Interstitials ion atomic number 96, 64 atom in a lattice formation tetra hedral, and 32 atoms in the lattice formation of oxygen ions O2 oktahedral.Posisi are in a face-centered cubic close packing [4,5]

The general formula AB_2O_4 spinel oxide, the two kinds of spinel, yalni; normal and inverse spinel spinel. In normal spinel A2 + ions are in the tetrahedral lattice and every atom A coordinated with four oxygen atoms while B2 + ions coordinated with six oxygen atoms in the lattice octahedral. In the inverse spinel ion A2 + and half of B2 + ions in octahedral lattice and a half of B2 + ions are in the lattice tetrahedral.contoh compound; Fe_3O_4, $FeTiFeO_4$, $FeMgFeO_4$, $FeNiFeO_4$.[5,6]

Tele:
E-mail address: edie.s.didoyo@gmail.com

Noting the nature of normal and inverse equation A and B on AB2O4 defined by the equation; A = [M (1-λ) Feλ]; B = [M λFe (1-λ)]; O_4 [], λ stated degree of inversion, which states that for; 0 <λ <1 inverse spinel structure compound partially. λ = 0 normal spinel structure. λ = 1 inverse spinel, λ =2/3 random structure.[6,7]

Alternating current magnetic apply to ZnFerrite sample is placed in an overlay that is free from goods or other equipment. After that the sample is processed as usual.

II. Experiment

The Raw material use Chemicals Pro Analyst production Merc, like
a) FeCl3.6H2O b) FeCl2.4H2O c) ZnCl2. d) NaOH. e) Aqua demineralization [5-8]. Material Preparation, the sample were prepared by co-precipitation method of the metal chloride salt. The materials are weighed according to the required stoichiometric ratio and dissolved of salt in distillated water as a mix solution. Mixing, drying, have done it since the material was apply,). With the chemical equation

$$2(1\text{-}x)FeCl_2.4H_2O + 4\ FeCl_3.6H_2O + 2x.ZnCl_2 + 16\ NaOH \rightarrow 2\ Zn_xFe_{(3\text{-}x)}O_4 + 16\ NaCl + (40\text{-}8x)\ H_2 \quad [9]$$

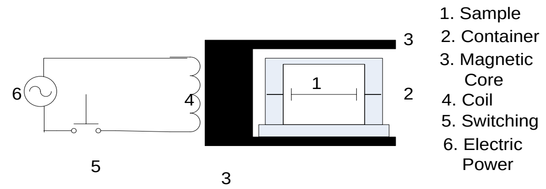


Figure 1. TEST equipment with coil 220 Volt Alternating Current

After the yield generated ZF70 be included in the measurement tool. The laying of the sample into the magnetic cage done after making sure the magnetic cage activem The time duration of treatment of approximately 10 minutes. Electric alternating current will generates alternating magnetic

But careful use is only a short time (10 minutes), prolonged use can burn. due to the open coil will generate heat.

Area 1 and 2 are air gap alternating magnetic flux with intensity not high,and tend to higher temperatur.

Subsequently the samples is checked using x ray machine. For each reaction at a temperature of 60 0C, 70 0C and 80 0C. In each of each process is done deposition, several times washing, draining, and drying.until pH to approximately = 7. Grinding process is then performed with a degree of fineness of about 100 mesh, and printed by the printer cylindrical and pressed at a pressure of 6 tons. Yield of preprinted further tested by XRD machine and magnetic testing machine.

Three ingredients yield expressed as Konet, Fisnet and Fisac. The results of data processing Video Data Logger coprecipitation process zinc material Ferrite ZF60, ZF70 and ZF80 generate graphical form as follows; ZF60. ZF 70 and ZF80 From the sigmoidal graph data logger ZF60, ZF70 and ZF80 which give a Lamer models and Dinegar is ZF70. Illustrated three stage process of co-precipitation that is supersaturated in the 10th to 38 seconds, self nucleation at second to 38 to 50 and the growth occurring after the second 50.

III. Result and Discussion

Parameter Value Table kinetic Syntesa Co-precipitasi To Environmental Conditions Different pH Alkaline Solution.From the graph sigmoidal data logger ZF60, ZF70 and ZF80 which give a Lamer models and Dinegar is ZF70. Illustrated three stage process of co-precipitation that is supersaturated in the 10th to 38 seconds, self nucleation at second to 38 to 50 and the growth occurring after the second 50.

The dynamics of the formation of the yield of the reaction is determined by the value copresipitasi kinetic parameters Parameter Value .

Table kinetic Syntesa Co-precipitasi.To Environmental Conditions Different pH Alkaline Solution.[9].

Kinetic parameters (k, n) depending on the temperature and the initial pH and the half-life t0.5

Table kinetic value of the yield ZnFerrite

Temperature [^{0}C]	K .Constant	N .Avrami Constant	T [K]	$t_{0.5}$	1/T	Ln t 0.5
60	0.17035	0.1306	333	18.58	0.003003	-5.808142
70	23.1	1.403	343	23.1	0.0029155	-5.83773
80	0.5743	0.042	353	24.42	0.0028329	-5.866468

The reaction temperature between 60 ^{0}C and 80^0 Cshows the linear nature of the temperature. The more towards the longer the Half-life of 800.Coprecipitation process energy is obtained from the slope of the graph Ln t0.5 versus 1 / T. Retrieved Qe / R = 342.31, so the energy of formation of the three materials ZnFerrite (ZF60, ZF70 and ZF80) is Qe = 342.31 x 8314 = 2845 joules / mol = 0.68 kcal / mol. (NB; joules = 0.7376 ft-lb = 0.239 cal =107 ergs). Entropy at a temperature of 333K = 2:04 [cal.mol-1 K-1]. [9,11].

As an illustration of the validity of calculation of enthalpy levels ZF illustrated graph entropy simple spinel formation of A.Navrotsky, 1967 [10] as material for comparison, as follows GSAS Refinement.

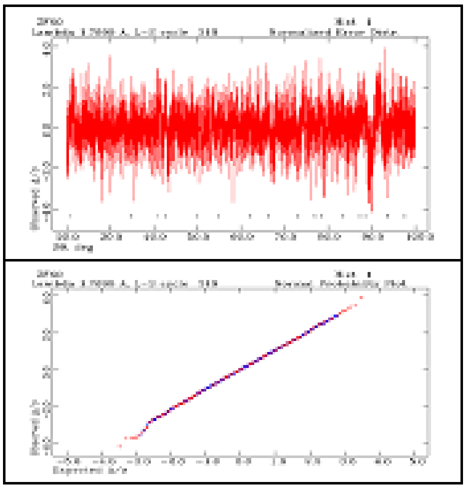
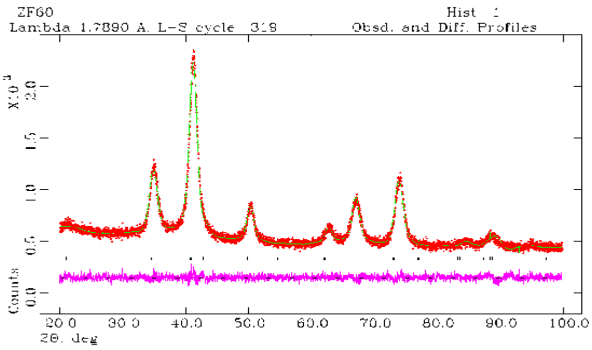


Figure 2. GSAS Refinement of x-ray diffraction profile sample ZF60



$ZnFe_2O_4$ Phase
space group : F d -3 m (227) Crystal System : Cubic Latic Parameter: a = 8.5092(1) Å, b = 8.5092(1) Å and c = 8.5092(1) Å, $\alpha = \beta = \gamma = 90^o$, V = 616.1(3) Å^3 dan ρ= 3.221 gr.cm^{-3} R Factor (wRp=4.32, Rp=3.40, χ^2 (chi-squared) = 1.134)

Cationic distribution of $ZnFe_2O_4$

	Zn	Fe
Content (at %)	0.4091	2.5909
Composition	$Zn_{0.409}Fe_{2.591}O_4$	

Avrami parameter behavior formation yield fraction f (t), k and n of the Avrami equation f (t) = 1- exp (-ktn), acquired in the expectation of a linear trend graphs the relationship Ln {-Ln (1-f (t)) } VS Ln t as shown below.

Slope states intercept parameter n = 0.1306 stated

Ln k = -1.7699, so k = 0.17035.

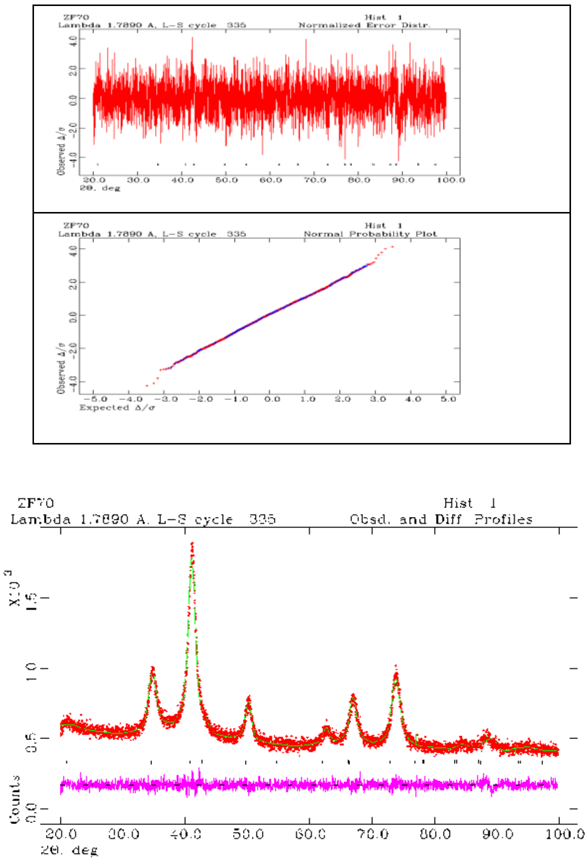
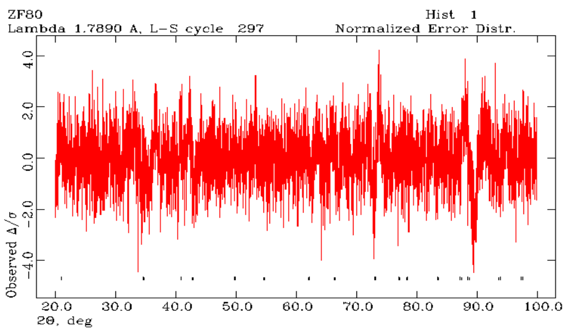


Figure 3. GSAS Refinement of x-ray diffraction profile of sample ZF70 ^{0}C

Sample ZF70		
$ZnFe_2O_4$ Phase		
space group : F d -3 m (227) Crystal Sistem : Cubic ,Lattice Parameter : *a* = 8.5096(1) Å, *b* = 8.5096(1) Å and *c* = 8.5096(1) Å, α= β = γ= 90^{o}, V = 616.2(3) Å^{3} dan ρ = 3.020 gr.cm^{-3} R Factor (wRp=4.54 Rp=3.58, χ^2 (chi-squared) = 1.155)		
	Zn	Fe
Content (at %)	0.4157	2.5843
Composition	$Zn_{0.416}Fe_{2.584}O_4$	



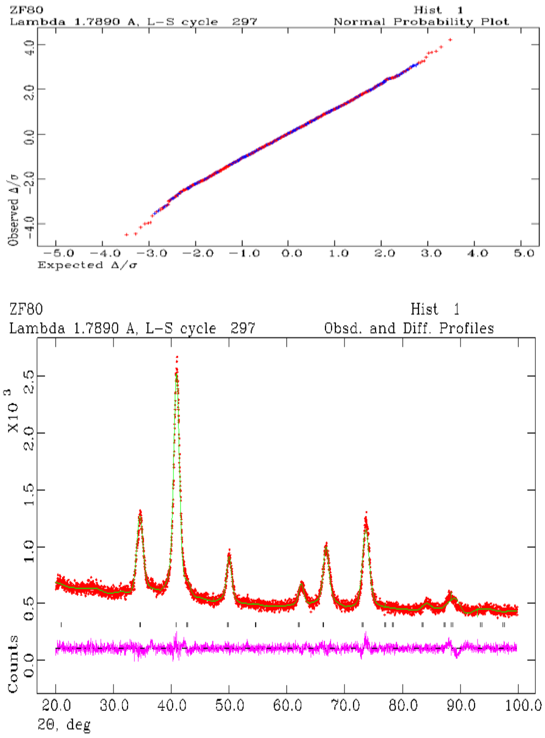


Figure 4. GSAs Refinement x-ray diffraction profile of sample ZF80 .

Sample ZF80
Fasa $ZnFe_2O_4$
space group : F d -3 m (227) l : Cubic Parameter kisi : *a* = 8.5062(1) Å, *b* = 8.5062(1) Å dan *c* = 8.5062(1) Å, α = β = = 90^{o}, V = 615.4(2) Å^{3} dan ρ = 3.191 gr.cm^{-3} R Factor (wRp =4.58 , Rp = 3.6 χ^2 (chi-squared) = 1.267)

Cationic distribution of $ZnFe_2O_4$

Comparison between the conventional method and the co-precipitation yield the following ;

Reaction Methods Label name Chemical formula Lattice Parameter Description Konet Zn0.245Fe2.755O4 lattice parameters: a = 8,589 (4) Å, b = 8589 (4) Å and c = 8589 (4) Å, α = β = γ = 90 °, V = 615.4 (2) A3 and ρ = 5,582 gr.cm-3 reactor in the form of flash with 3 nek, equipped with a mechanical stirrer, pH electrode meters, electrodes thermometer .

Fisnet $Zn_{0.428}Fe_{2.572O4}$ lattice parameters: a = 8524 (4) Å, b = 8524 (4) Å and c = 8524 (4) Å, α = β = γ = 90 °, V = 619.3 (1) A3 and ρ = 5,084 gr.cm-3 reactors in the form of a coil hose equipped injector,

Fisac $Zn_{0.739}$ $Fe_{2.261}$ O_4 a = 8,572 (7) Å, b = 8,572 (7) Å and c = 8,572 (7) Å, α = β = γ = 90 °, V = 629.9 (1) A3 and ρ = 4,918 gr.cm-3 reactors in the form of a coil hose equipped with injector, the yield of container, equipped with magnetic coil AC 50Hz. Reaction Kinetics Analysis of Results-Based Record Defraktog

The enthalpy of the product depends on stoichiometric obtained from XRD analysis as follows;

a. ZF60= $Zn_{0.409}Fe_{2.591}O_4$

$$\Delta H_{ZF60} = 0.409x\Delta H^0{}_{ZNO} + 0.591xH^0{}_{FeO} + 2xH^0_{Fe2O3}$$

$$= (0.409x3.504 + 0.591x2.720 + 8.24 =$$

$$11.283 \quad [kJoule / mole] = 2.696 \text{ kcal/mole}$$

b. ZF70= $Zn_{0.416}Fe_{2.584}O_4$

$$\Delta H_{ZF60} = 0.416xH^0{}_{ZNO} + 0.584xH^0{}_{FeO} + 2xH^0_{Fe2O3}$$

$$= (0.409x3.504 + 0.564x2.720 + 8.24 =$$

$$11.496\,[kJoule/mole] = 2.747\ kcal/mole$$

c. ZF80= $Zn_{0.412}Fe_{2.588}O_4$

$$\Delta H_{ZF60} = 0.412xH^0{}_{ZNO} + 0.584xH^0{}_{FeO} + 2xH^0_{Fe2O3}$$

$$= (0.412x3.504 + 0.584x2.720 + 8.24 =$$

$$11.272\quad [kJoule/mole] = 2.694\ kcal/mole$$

The results of XRD formation defraktogram ZF60, ZF70 and ZF80 have compatibility with graphics 2-3 spinel formation.

The enthalpy change during co-precipitation reaction at 2,845 joules / mol it can predict the energy levels of the reactants is;

a. enthalpy of reactants ZF60 = (11. 283-2845)
= 8,438 kJoule / mole.

b. enthalpy of reactants ZF70 = (11.496-2.845)
= 8,651 kJoule / mole.

c. enthalpy of reactants ZF80 = (11.272-2.845)
= 8,427 kJoule / mole.

In the defraktograf material has a number of Zn, where atoms ZF70 more than ZF60 and ZF80. If the terms of the parameters in which the reaction temperature ranged ZF60 at temperatures 650-700, and ZF 80 at temperatures ranging from 850-900 looks strong correlation that increased temperature synthesis Zink Zn ferrite adding a portion of the atoms are included in ZnF spinel structure.

But it turns out that correlation does not occur in ZnF70 which has a portion of Zn atoms which enter into the structure spinnel ZnF70 greater than Zn60 and Zn80.

Alternating Magnetic Test

From this fact seen any indication that the alternating magnetic treatment on material synthesis process provides process yields the interstitial atom in the zinc ferrite material is higher than the effect of changes in temperature synthesis.

Crystal size is calculated by the formula Debey Sherrer d = B. λ/β.Cos θ, [9]

λ is the wave length of X-ray beam used, β is the full-with half maximum (FWHM) of diffraction and θ is the Bragg's angle. [9] d Debey = (0.9 x λ) / FWHM [rad] θ xCos θ ,With λ = wavelength of X-rays = 1.790300 Å
Data obtained from the peak of XRD (Match and Bella as follow;

Data angle Peak ZF60; 29.46, 41.22, 50.30, 67.08, 73.94 FWHM 1.7600

Data angle Peak ZF70; 34.79, 41.10, 50.2, 66.96, 73.82, FWHM 2.0800

Data angle Peak ZF80 ; 34.62, 40.9, 50 882, 66.76, 73.66, FWHM 1.4000

Table Debey

Kode Bhn	2θ 311	Cosθ 311	FWHM	FWHM[rad]	D (debey)[nm]
ZF60	50.3	0.905293	1.76	0.0307022	5.797081875
ZF70	50.2	0.905663	2.08	0.0362844	4.903218248
ZF80	50.882	0.903125	1.4	0.0244222	7.305254902

It is seen that the influence of the alternating field ZF70 provide significant crystal size that is 4.9 nm, Effect of temperature rise resulting in an increased size of the crystals look significantly different in ZF60 to ZF80. In ZF70 despite the increase in temperature but it is compensated by the influence of the alternating field causes the crystal size dropped precipitously

Noting the nature of normal and inverse equation A and B on AB2O4 defined by the equation;

A= [$M_{(1-\lambda)}Fe\lambda$]; B= [M $_{\lambda}Fe_{(1-\lambda)}$];$O_4$ [10]

λ stated degree of inversion, which states that for; 0 <λ <1 inverse spinel structure compound partially.
λ = 0 normal spinel structure.
λ = 1 inverse spinel sructure
λ = 2/3 random structure

Refinement of the XRD results, obtained that;
a. ZF60 = Zn0.409Fe2.591O4, inversion index λ = 0591,
b. ZF70 = Zn0.416Fe2.584O4, inversion index λ = 0584,
c. ZF80 = Zn0.412Fe2.588O4, inversion index λ = 0588 , means ZF60, ZF70, ZF80 including as a partial inverse s.

The pattern of the magnetic moment of spinel inversion normal to inverse spinel. To the degree inversion i, then the magnetic moment M obtained = MB-MA = {3i + 5 (2-i)} - {5i + 3 (1-i)} μB = {7-4i} μB. Thus obtained magnetic moment ZF60 = MZF60 7-4x0.591} = {μB = 4.636 μB 7-4x0.584 MZF70 = {} μB = 4,664 μB 7-4x0.588 MZF80 = {4648} μB = μB

If in this case the magnetic moment μB is Bohr = The spin magnetic moment is a constant called the Bohr magneton with asumsion

$$\mu_B = \frac{q_e \hbar}{2.m_e},$$

μ_B= 9.27400915×10^{-24} Joule/Tesla
= 9.27400915×10^{-21}Erg/Gause
Or μ_B= 5.7883817555(79)×10^{-5} eV/Tesla = 9.27 x 10^{-27} A.m^2
= $\mu_B = \frac{e\hbar}{2m_e} = 9.27 \times 10^{-24}$ J/T

Magnetic moment of ZF 60 = 6.02x 10^{23} x 9.27 x 10^{-24} [J/T.Mole] = 5.580 [J/T.Mole]

From the graph B-H diagram (Hysteresis Diagram) that both ZF60, ZF70 and ZF80 is paramagnetic, but BH diagrams thinnest is ZF70, it states Hysteresis loss of energy in the system. The energy loss is proportional to the loop area , therefore more ZF70 are more paramagnetic than the ZF60 and ZF80.

In connection with the treatment at the time of synthesis, the effect of alternating magnetic field it produces an increase in the paramagnetic properties Yield. So when the ferrimagnetic material particles are formed, alternating magnetic field from the outside would try to move the particles towards the external field. But the material is not able to follow the movement of the terrain, so the alternating field energy is not converted into a back and forth motion. Energy field besides excess will be converted into heat but also move the atoms of materials. to occupy the vacancy position corresponds to the atomic se owned atomic energy level/s.Reaction Methods Label name Chemical formula Lattice Parameter Description,

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Reaction Kinetics Analysis of Results-Based Record Defraktogram XRD. The enthalpy of the product depends on stochiometri obtained from XRD analysis as follows;

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b. ZF70 = $Zn_{0.416}Fe_{2.584}O_4$, inversion index λ = 05
c. ZF80 = $Zn_{0.412}Fe_{2.588}O_4$, inversion index λ = 0588
means ZF60, ZF70, ZF80 including as a partial inverse spinel.

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Saturation occurs when μH / kT is very large, it means that a large H or T is low will tend to produce moments rectification process or address the effects of thermal interference irregularity, so if μH / kT is small, the magnetization M to be linear with respect to H

Table Comparison ZF60, ZF70 and ZF80.

Material	Magnetisation Process	Zn:Fe	Magnetic Field	saturation magnetizatio [kA/m]	Coerciviy magnetizatio [kA/m]
ZF60	No	0.409 / 2.591	Paramagnetik	16.67	4.97
ZF70	Yess	0.416 / 2.584	Paramagnetik	8.91	1.89
ZF80	No	0.412 / 2.588	Paramagnetik	28.5	8.1

In connection with the treatment at the time of synthesis, the effect of alternating magnetic field it produces an increase in the paramagnetic properties yield., so when the ferrimagnetic material particles are formed [16], alternating magnetic field from the outside would try to move the particles towards the external field. But the material is not able to follow the movement of the terrain, so the alternating field energy is not converted into a back and forth motion. Energy field besides excess will be converted into heat but also move the atoms of materials. atoms to occupy the vacancy position corresponds to the atomic se owned atomic energy levels.

ZF crystal structure that has been synthesized in the above-mentioned each have a degree of inversion λ and magnetization as follows:
a) ZF60, λ = 0591 and the magnetization M = (7- 4. 0591) μB = 4.636 μB
b) ZF70, λ = 0584 and the magnetization M = (7- 4. 0584) μB = 4,664 μB
c) ZF80, λ = 0588 and the magnetization M = (7- 4. 0588) μB = 4648 μB

Magnetic parameters obtained from the test results with permagraf tabulated as Paramagnetic have an odd number of electrons (spin total is not equal to zero), for example in the NO gas, organic free radicals. Under the influence of the external field moments of atoms located at random so they can cancel each other and the total magnetic moment is equal to zero.. Thermal disturbance atoms will inhibit the tendency of alignment and tends to maintain moments of atoms in a state of random, and there is little alignment moments in the direction of the field.

IV. CONCLUSION

GSAS Refinement gave a vivid description of ingredients, so that we can compare one with the other compounds, but not enough to compare other physical properties. Need to examine the physical properties of other materials, example properties of magnetism.

Time synthesizing process as the core of zinc Ferrite successfully recorded and graphed each of each sigmoidal process temperature in order to obtain specific energy formation process Zn Ferrite with specifications Zn / Fe = 0:15 by Qe = 342.31 x 8,314 = 2,845 joules / mol. Effect of temperature on the synthesis of zinc Ferrite to the limit below 900C does not provide a significant difference to the formation phase.

The alternating magnetic field has significant impact on the process of the interstitial metal atoms occupy the vacancy Zn 2+ to Fe 2+ metal atom. Seen properties that the number of Zn atoms on more than ZF60 ZF70 and ZF80. This has an impact on the particle size ZF70 larger and smaller density.

. As a result ZF70 has a number of Zn atoms, permagraf noted that ZF70 has paramagnetic properties that are much stronger than ZF60 and ZF80. This is reinforced by the data korsifitas ZF70 magnetism smaller than ZF60 and ZF80. .Of profile defraktogram seen that ZF70 more harshly than others, it can indicate that the particle ZF70 has not yet rounded shape (spherical) or the particle size is not perfect..

The presence of an alternating magnet, tends to increase paramagnetic properties of the material,

the paramagnetic properties of the material larger than after the treated magnetic material alternating.

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