*JKAU: Sci., **Vol. 33.Number(1)** pp: 25-30 (2023 A.D. / 1444 A.H.)*
DOI:10.4197/Sci.33-1.3

Study the Property of superparamagnetic property of nickel ferrite by Zinc doping as base to use in medical resonance imaging.

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ABSTRACT: This paper add new step information study ability of work on dopant Zink by 0.01% to nano crystal of $NiFe_3O_4$ that has good VSM signal on 33% Ni and 67% Fe to check ability to use it as a base on MRI Contrast Agent. BY using Hydrothermal technique to prepare $\mathbf{NiFe_xO_y}$ this type of preparation results in cubic ferrites structure depending on the purity and condition of preparation. This paper will show some results of this material structure with dopant of Zinck this utility used contrast agent base in a medical physics Magnetisation properties study for super spinel ferrites. Data analyzing by use tow examination X-Ray diffraction Analysis and vibrating Sample Magnetometer.
Keywords: Nickle Ferrite , *XRD,VSM, Contrast agent, MRI,*

I. Introduction

MRI (Magnetic Resonance Imaging) is one of the best 3D imaging machines because it is a non-zing imaging machine that is non-invasive and non-destructive. MRI's highly saved modality doesn't have any medical noon harmful effects. (Sofia Caspani1 Ricardo Magalhaes, : 28 April 2020). To get more information from MR images, One-third of MRI cases need to use contrast agents to clarify the actual situation of illness. Normal tissue did not accept absorbed contrast agents. The Mri with contrast agent cases increases with increasing depending on non-ionising exams by new MRI protocols (Éva Tóth, January 2002).

The last century has had a significant speed jump in technology. One of the reasons for this acceleration in work is the modern technology of materials science (Lashieras, De Mpsausti, & Gil de Muro, 2016)in the last few years. This acceleration makes improvements to reuse the atoms of the material to get new specifications or improve and enhance the known ones (N. Gupta).

Today nanotechnology and nanophysics help scientists create super spinal ferrite by using material mixed with iron atoms (A. Morr and K. Haneda, vol. 52, 1931.). This material structure, followed by information about the specifications of compounds, can be used in making new medical stuff (J. C. Rendón-Angeles, 2012).

Using the hydrothermal technique is the most accessible and most available technique to prepare a good size of nano ferrite materials

that can serve the research purpose (Yoshimura, 2012.). It can use a small amount with different contrast of mixed elements, and dopants can change all specifications (O. Lemine, 2014).

The nickel ferrite was an excellent chance to make a contrasting base of ferrite from the element and easy to connect under hydrothermal technique with high-purity crystal (C. Pereira, 2012).

The work used different contrast rates between iron and nickel through selected rates to make iron dominant and nickel follower material (iron concentration is more than a nickel) to drive magnetic specification (S. Shen, 2012)

Information in this field usually depends on the iron Element, which can consider as the magnetic part that relies on a constant called the Curie constant (Wei, , 2009.). Element interaction with the body has many factors that must note, like toxicity and allergy. But the first step is founding the base of material that we well used (A. Rufus, 2016.) (B. Zou and V. Volkov, 2000.) (J. Huo and M. Wei, Characterization and magnetic properties of, 2009). After that Starting, treatment processing can be used using with pharmaceutical preparation.

The enhancement in the combination improves the magnetic specifications and drives to the new edge of the contrast agent and image. This improvement by nanoparticle science as a field of enhancement of MRI Medical has expectations (F. S. Tohrani, 2012.). The Magnetic resonance imaging so far for modality or image reconstruction will be reread depending on information coming from contrast interaction results in the image.

So the research tray at this work in the nanoparticle space to get some results to analyses super magnetic ferrite specification. This information may lead to a new step in getting a contrast agent.

2. Materials and methods

The work started by using stichometry points for iron (from 70%-60%) and Ni (40%-30%) and using the molar calculation to mix the percentage depending on the chemical formula (Valenzuela, 2005).

$Ni+Fe+H_2o$---Heat+pressore---->$NiFe_2O_4$

For the preparation of nanomaterial ferrite, the methodology needed for the lab has a lot of specific assets. This asset will be collected in our lab, starting with Chemical material using $NiCl_2$ and $FeCl_3$, which is cheap and easy to solute in sist water. Solution mixed by particular concentration to drive the magnetic property by the guidance of iron element mean $FeCl_3$ must have high molar weight.

They were using chemical glasses pol to make mixing because at mixed, they needed to be sure all quantities of $NiCl_2$ and $FeCl_3$ that weighed by a highly calibrated precision scale that can weigh until five digits of a gram are corrected and used. Solute the chloride salts need good shaker tools or machines.

After preparing the solution to fill the autoclave chamber and shore, all the quantities are transferred. Close the autoclave chamber hard and ensure no spoiling or gabs can affect the chamber's pressure or heating.

Start heating and mixing oven until 150^O C before putting the autoclave chamber. Put the autoclave in the stove in stable condition for 6 Hours. Get that autoclave out and let it cool for 60 minutes.

Filtration of the sample using Glasses installation cones and dripped special paper to collect the nano sample on the drip paper surface. Let drip water dry at room condition for approximately 24 hours until it is scorched. hen, collect the sample from its surface ass Nano-powder.

Nano powder needs to treat by heat to get fully dray and get out the rush component. Crush the powder in a special masher to smush the collection. $NiFe_2O_4$ powder was put on a

ceramic plate and dried in an oven for 4 hours at 400°C.

At last, the sample is ready to study its structure and specifications. Nanomaterial exams like XRD, Scanning Electron microscopy, Transmission electron microscopy, and Vibration Sample magnetometer are too coastally. So choosing XRD and VSM was enough to answer nickel ferrite magnetization ability.

Nickle ferrite is dopped by another chloride salt like Zinc chloride $ZnCl_2$ and sharing $NiCl_2$ percentage to check if it is enhanced or compound. By using the same tools and way, calculate the rate of $NiCl_2$ reduced and put $ZnCl_2$.

Calculate 0.01% $ZnCl_2$ Percent from $NiCl_2$ chosen to be the point of comparing with 33%Ni from Nickle ferrite compound.

3. XRD Sample Exam:

X-ray diffraction exam (Cullity, 1978.) gives information about the primary material that constructs the crystal by measuring the angle between incident X-ray and diffract X-ray, an Angle called 2 Θ (theta). From the spectrum between the theta Angle and X-ray diffract from crystal energy found, the fingerprint of material from the characteristic peak (D. A. Wheeler, 2012.).

The equation used to get a solution

$$D = \frac{0.9\,\lambda}{\mathrm{B}\,cos\theta\mathrm{B}}$$

Lattice crystal space D by Brag diffraction calculation depends on $\Theta_{\mathrm{B\ maximum}}$ brag diffraction angle and X-ray λ from the peak.

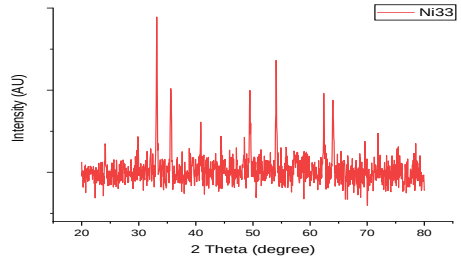

Fig1. XRD for $NiFe_2O_4$ with 33%Ni and 67% Fe

the investigators used many concentrations of $NiFe_2O_4$ and investigated with VSM. They found that the Nickel ferrite with a percentage concentration of 33% of nickel and 67% of iron (III) shows that the XRD that appears in figure 1 has a good VSM, as in figure 3 on this paper.

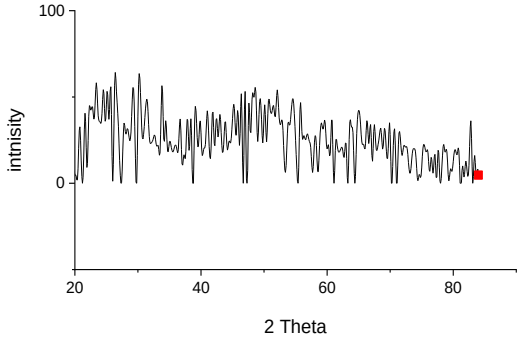

Fig2. XRD for pure 0.01 Zn dopant for $ZnNiFe_2O_4$ crystal

From X-ray diffraction analysis, investigators Can see the main peaks of $NiFe_2O_4$ still appear in the same places but also appear a lot of extra noisy peaks that need analysis. it can change the physical And chemical properties of the crystal this notice but not from the main paper target, so the target is to check magnetic properties and use XRD as guidance.

4. Vibration Sample magnetization exam

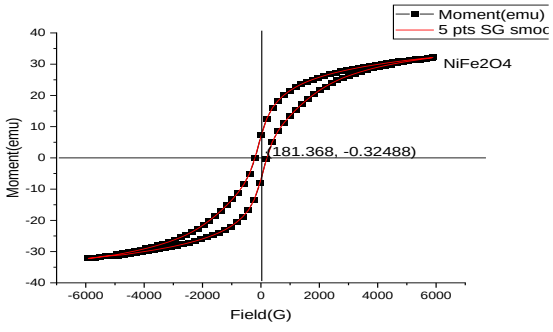

Fig3. $NiFe_2O_4$ Magnetic field response (VSM)

The Vibration sample magnetization for $NiFe_2O_4$ 33% shows that the lattice has a high and organizer shape with a small hysteresis

loop space. This specification signals the heightened ability to use this magnetic base to start an MRI exam. It is approximately Variation from -30 to 30 momentum power without any divergent at excitation.

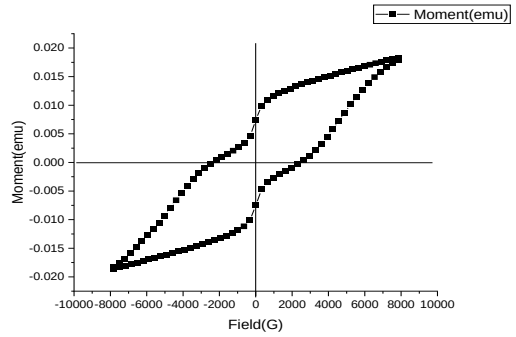

Figure 4 VSM for $ZnNiFe_2O_4$ dopant crystal

This dopant with zinc devreas VSM from 30 Gause to -30 Gause for Nickleferrite to from -20 Gause to 20 Gause for that doped with 0,01 % of Zn. Also, it gives a big hole to hysteresis. Magnetization change appears from increasing the width of the VSM loop and does not go back to relaxation for a long time because it saves a lot of energy inside the crystal that is not good for MRI Medical use.

4.Result and Discussion

From the XRD exam and analysis, the Nickle ferrite crystal with high purity and lesser hydroxide based is the concentration of 33% Ni mixed with 67% Fe that appears just one hydroxide based, and all other peaks are for $NiFe_2O_4$ peaks.

Nano ferrite concludes that Zn is a superior technique to synthesize single-phase tetragonal $NiFe_2O_4$ nanoparticles. $ZnFe_2O_4$ also has a suitable magnetization property, so the doping between the two elements in ferrite preparation looks like a good idea.

For that, the Doping of $NiFe_2O_4$ By Zn element was held. But unfortunately, it did not improve the magnetization as the researcher supposed. This step gave more noise and decreased the response with magnetization change, as shown in figure 4.

3. References

1. A. Morr and K. Haneda. (vol. 52, 1931.). "Magnetic structure of small nife204 particals. *Applied Physics*, , pp. 2196-2108.

2. A. Rufus, N. S. (2016.). *R$C*, 94206-9421.

3. B. Zou and V. Volkov. (2000.). Surface modification on time-resolved Auorescences of fe203 manocrystals. *f Physics and Chemistry of*, 757-764,.

4. C. Pereira, A. M.-G.-M. (2012). *Chemistry of Materials*, 1496-1504.

5. Cullity, B. (1978.). *Elements of xrd diffraction, addition-wesley,".* Reading MA.

6. D. A. Wheeler, G. W. (2012.). *Energy 8 Environmental Sci* .

7. Éva Tóth, L. H. (January 2002, jan). *Relaxivity of MRI Contrast Agents*. Retrieved from research gate : https://www.researchgate.net/publication/226328464_Relaxivity_of_MRI_Contrast_Agents

8. F. S. Tohrani, Y. D. (2012.). pp. 2443-2455.

9. J. C. Rendón-Angeles, Z. M.-V. (2012). *Crystallization-Science and*.

10.J. Huo and M. Wei. (2009). Characterization and magnetic properties of. *Materials Letters*, . 1183-1184,.

11.J. Huo and M. Wei. (2009). Characterization and magnetic properties of nanocrystalline nickel ferrite synthesized by hydrothermal method,". *Materials Letters,*, . 1183-1184,.

12.Lashieras, X., De Mpsausti, 1., & Gil de Muro, B. C. (2016, vol. 120, no. 6). chemical synthesis and magnetic properties of monodisperse nickel ferrite. pp. pp. 3492-3500.

13.N. Gupta, P. J. (n.d.). Current development in synthesis and characterization of nickel ferrite nanoparticle,". *Materials Today*, pp. , 2017.

14.O. Lemine, I. G. (2014). Nanocrystalline ni doped a-fe203 for adsorption of metals from aqueous solution,and A. Hassan,. *Journal of Alloys and Compounds*, 592-595.

15.S. Shen, C. X. (2012). Surface tuning for promoted charge transfer in hematite nanorod arrays as water-splitting photoanodes. *Nano Research,*.

16.Sofia Caspani1 Ricardo Magalhaes, J. P. (: 28 April 2020). Magnetic nanomaterials as contrast agents for MRI. *NOT PEER-REVIEWED((www.preprints.org)* |, doi: 10.20944/preprints202004.0490.v1.

17.Valenzuela, R. (2005). *Magnetic ceramics.* Cambridge university press.

18.Wei, J. H. (, 2009.). Characterization and magnetic properties of nanocrystalline nickel ferrite synthesized by hydrothermal method. *Materials Letters*, 1183-1184.

19.Yoshimura, K. B. (2012.). *Handbook of hydrothermal technology.* William Andrew.

دراسة خصائص للنيكل الفائق المغناطيسية المطعم بالزنك وذلك للتعرف على إمكانية استخدامها في التصوير الطبي بجهاز الرنين المغناطيسي

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مستخلص. تضيف هذه الورقة معلومات عن خطوة جديدة وذلك من خلال دراسة العمل على الزنك الفائق المغناطيسية المطعم بنسبة ٠,٠١٪ إلى بلورات النانو من نيكل رابع أوكسيدات الحديد(NiFe2O4) التي تحتوي على إشارة عينة اهتزاز مغناطيسي جيدة الاستجابة عند تركيز ٣٣٪ Ni و ٦٧٪ Fe للتحقق من القدرة على استخدامها كأساس لصبغة تباين التصوير بالرنين المغناطيسي. باستخدام تقنية الهيدروثيرمال(التسخين المائي) لتحضير NiFexOy ، ينتج عن هذا النوع من التحضير بنية حديدية مكعبة اعتمادًا على نقاء وظروف التحضير. ستعرض هذه الورقة بعض نتائج هذه البنية المادية بعد تطعيمها بذرات الزنك . تستخدم هذه الوسيلة لاستكشاف قاعدة جديدة لعامل التباين في دراسة خصائصه مغناطيسية من بمعرفة للفيزياء الطبية للمواد فائقة اللف المغناطيسي . تحليل البيانات باستخدام تحليل حيود الأشعة السينية المتشتتة و مقياس عينة المغناطيسية المهتزة.

كلمات مفتاحيه: النيكل فائق المغناطيسية، الحليل بتشتت الأشعة السينية، التحليل بالاهتزاز المغناطيسي للعينة، صبغة تباين للتصوير بالرنين، التصوير بالرنين.

JKAU: Sci., ***Vol. 33.Number(1)*** *pp: 25-30 (2023 A.D. / 1444 A.H.)*
DOI:10.4197/Sci.33-1.3