JOURNAL OF KUFA–PHYSICS
www.uokufa.edu.iq/journals/index.php/jkp | ISSN: 2077–5830

X-band Region Characterization of Neoprene Rubber Reinforced Cd-Zn Ferrite Composite Material

Firas A'aid Najim ***Wissam Adel Hussien**

Department of Physics, College of Education, University of Al- Qadisiyah, Iraq.

*Corresponding Author E-mail: wissam.adeal@outlook.com

ARTICLE INFO.:

Article history:
Received: 7 FEB, 2019
Accepted: 18 MAR, 2019
Available Online: 22 JUL, 2019

Keywords:
Co-Precipitation Method
cadmium- zinc ferrites
Chloroprene rubber (CR)
VNA

ABSTRACT:

The compound was prepared from ($ZnFe_2O_4$) and ($CdFe_2O_4$) The process of mixing the ferrite compounds was done according to the formula ($Cd_xZn_{1-x}Fe_2O_4$), The resulted compound was ($Cd_{0.7}Zn_{0.3}Fe_2O_4$). The compounds ($ZnFe_2O_4$) and ($CdFe_2O_4$) were prepared by Co-Precipitation method because this method gives a good homogeneity to the powder particles. XRD and FE-SEM were performed, the results showed that ferrites had a phase-shaped cube and an increase in the concentration of cadmium in the ($Cd_xZn_{1-x}Fe_2O_4$) compound .This result showed an increase in the lattice constant, the rate of crystalline size and the distance between the crystalline surfaces, due to the fact that the ionic radius of the cadmium is greater than the ionic diameter of the zinc, which is (0.83 A°).The images of the electron microscope (FE-SEM) showed an increase in particle size with an increase of concentration of cadmium ferrite in relation to the compound ($CdxZn_{1-x}Fe_2O_4$),The components of the ferrite structures prepared by EDS technique were verified, where the ferrite compound ($Cd_{0.7}Zn_{0.3}Fe_2O_4$) mixed with the Neoprene (Chloroprene Rubber) (CR) according to weight ratio of (3,6 g) of ferrite, after the process of forming rubber paste. The VNA was investigated for (8-12 GHz). It was observed that the reflection coefficient was reduced by increasing the fraction of ferrite to (6g) and obtain highly absorbent materials .Where the material behavior varies according to the frequency, as well as the concentration ratio in the ferrite and the quantity of the ferrite with Chloroprene rubber (CR).The Permeability of ($Cd_{0.7}Zn_{0.3}Fe_2O_4$) was calculated as a function of frequency.The real part of the amplitude showed the amount of energy from the external electric field stored in the material.

DOI.: http://dx.doi.org/10.31257/2018/JKP/2019/110116

توصيف حزمة (X) لمطاط النيوبرين المدعم بمواد متراكبة من كادميوم- زنك فرايت

فراس عائد نجم **وسام عادل حسين**

قسم الفيزياء ،كلية التربية، جامعة القادسية ،العراق

الـــخُـــلاصـــة:

تم تحضير الفرايت ذو التركيب ($Zn\ Fe_2O_4$) و($Cd\ Fe_2O_4$) ومن ثم تمت عملية

الكلمات المفتاحية:

الترسيب الكيميائي المشترك

خلط المركبات الفرايت حسب الصيغة ($Cd_xZn_{1-x}Fe_2O_4$) والحصول على المركب ($Cd_{0.7}Zn_{0.3}Fe_2O_4$) حيث تم تحضير المركبات الفرايتية ($Zn\ Fe_2O_4$)و($Cd\ Fe_2O_4$) بطريقة (Co-Precipitation Method) لأنها تعطي تجانسا لجزيئات المسحوق. تم دراسة الخواص التركيبية للنماذج المحظرة حيث أظهرت النتائج ان الفرايت من نوع (الطري) وان زيادة تركيز الكادميوم في المركب ($Cd_xZn_{1-x}\ Fe_2O_4$) أدى الى زيادة كل من ثابت الشبيكة و معدل الحجم البلوري والمسافة بين السطوح البلورية كلما ازداد فرايت الكادميوم ويرجع سبب ذلك لان نصف القطر الايوني للكادميوم اكبر من نصف القطر الايوني للخارصين الذي يبلغ (٠.٨٣°A) واظهرت صور المجهر الالكتروني (FE-SEM) تزايد حجم الجسيمات مع زيادة تركيز فرايت الكادميوم بلنسبة للمركب ($Cd_xZn_{1-x}\ Fe_2O_4$) وتم التحقق من العناصر المكونة للتراكيب الفرايتية المحضرة بواسطة تقنية (EDS) تمت عملية مزج المركب ($Cd_{0.7}Zn_{0.3}Fe_2O_4$) مع (Neoprene Chloroprene Rubber) (GRT) بإضافة (٣,٦) غم من الفرايت ،بعد عملية تكوين العجينة المطاط تم اجراء فحص(VNA) للعينات ضمن حزمة X من الموجات الميكروية (٨-١٢) GHz . لوحظ أن معامل الانعكاس قد انخفض عن طريق زيادة جزء الفريت إلى (6 g) والحصول على مواد شديدة الامتصاص .حيث يختلف سلوك المادة باختلاف التردد ، وكذلك نسبة التركيز في الفريت وكمية الفريت مع المطاط النيوبرين (CR). حيث تم احتساب نفاذية للمركب ($Cd_{0.7}Zn_{0.3}Fe_2O_4$) كدالة للتردد. تم حساب الجزء الحقيقي والجزء الخيالي من ثابت العزل كدالة للتردد في النطاق X . أظهر الجزء الحقيقي من السعة مقدار الطاقة من الحقل الكهربائي الخارجي المخزن في المادة.

كادميوم-زنك فرايت
مطاط النيوبرين
فحص معاملات الاستطارة

1. INTRODUCTION

(Ferrites) are materials of magnetic ceramics [1].with chemical compositions and various semi-conductive crystalline structures, all of which have ferromagnetic material. It possesses high resistivity (10^9) [2]. high and stable permeability dielectric constant which is between (10 to15) as these quantities changed by electric and magnetic fields [3]. The ferrite is divided into two types, hard and soft ferrites. The soft ferrite which had the fractions of a general formula ($MoFe_2O_4$) where M represents one of the two bivalent elements (Co^{+2},Mg^{+2},Fe^{+2}.Cd^{+2},Mn^{+2}, ,Cu^{+2})[4]. the first uses for many electronic and magnetic devices due to its magnetic permeability low magnetic properties and high temperature tolerance[5]. The properties of these materials depend on the granules and their size, on the method of preparation, sintering temperature, the type of elements and their constituent quantities of the material. The second is the hard ferrite. The fractions of hard ferrite which characterized by very complex compositions, consisting of spindle shape that somehow correlate to hexagonal crystalline structures. The general formula for the hard ferrite is ($M^{+2}Fe_{12}O_{19}$) where (M) a divalent metal ion such as barium (Ba) and strontium (Sr) [6,7].The preparation process of material is conducted in a ceramic at a temperature of 1000-1100 ^oC [8]. and one of the most important properties of the ferrite which led to its widespread uses is as a magnetic materials [9]. It also operates with a wide frequency range ,low losses ,thermal stability and low cost . Polymers, such as rubber, together with ferrite, improve material properties. It include plastic and rubber materials, many of which are organic compounds. Carbon and hydrogen are essential elements in their composition. These materials are usually with low density and may be very flexible[١٠,١١]. An important feature when blending the ferrite with the rubber is to obtain an overlay that acts as a wave attenuation and it highly susceptible to wave absorption[١٢,١٣] .

2. MATERIALS AND METHODS

2.1 Rubber Ferrite composite

The main materials in this research were ($ZnFe_2O_4$) and ($CdFe_2O_4$) mixed with Neoprene chloroprene (CR) rubber type-GRT. The process of composition of our composite using chemical Co-precipitation method in the addition of ammonia to those solutions that were containing metal ions in the composition of the ferrite as the hydroxides of these metals or chlorides and the process was a mixing these

materials in specific weight ratios and mix them by adding distilled water to the ionic process of chemical solution and mixed together to One solution is applied to a temperature (50 ^{o}C) for a period of time. Ammonia was added to the solution until the ph factor reaching to the range between (12-8) using the ph meter. Then, the first sintering process begins by burning the material reaching to (400-600 ^{o}C) for a period of time of (6) hours after-that it left to cool until it reaches to room temperature and then grinded it. The process of sintering gets a shortage in the weight of the material because of the disappearance of impurities from the water. the final burning is then done for (6) hours at a temperature (800-1100 ^{o}C).then mixed the compound of ($ZnFe_2O_4$) with ($CdFe_2O_4$) where the ratio (X=0.7) and will obtain the compound ($Cd_{0.7}Zn0._3Fe_2O_4$). The X-ray diffraction (XRD) and Scanning Electron Microscope (SEM) and Energy Dispersive X-ray Spectrometry (EDS) were investigated. The mixing process for rubber was done by using (Comerio Ercole Busto Avsizo) instrument, The materials were added according to the table (1). The rubber was moved between the two rollers in several times with the distance between the two rollers were reduced and the material was added with continuous mixing. The rubber molds were then ready to prepare a layer of GRT rubber. The elastic samples were measured within dimensions (L = 20 cm, W = 20 cm, h = 2 mm) and the microwave attenuation was measured using the Vector Network Analyzer type (Anritsu-MS4642A) (8-12 GHz).

Table 1: The components ratios of rubber and ferrite.

Material	parts per hundred of Rubber (PPHR)	Weight of embryos (100g)
Rubber GRT	100	63.37
6PPD	1	0.62
HAF326	40	25.37
Stearic acid	1	0.62
Zinc oxide	5	3.12
MBTS	0.5	0.31
Aromatic oil	10	6.37
$Cd_{0.7}Zn_{0.3}Fe_2O_4$	3 , 6	3 , 6

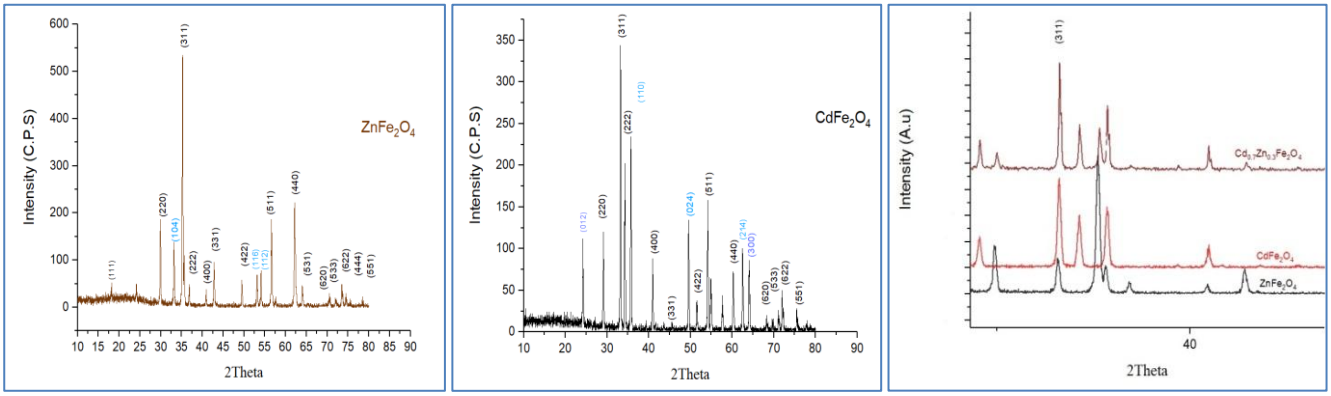
3. RESULTS AND DISCUSSION

3.1 Structural and morphological properties (XRD)

The composite ferrite of ($ZnFe_2O_4$) and ($CdFe_2O_4$) was characterized by using (XRD) after the sintering at (900 ^{o}C) figures(1 a,b) The ($ZnFe_2O_4$) was found to be identical to the standard card (00-022-1012 icdd) and for ($CdFe_2O_4$) with the standard card (icdd 00-022-1063) were showing that the diffraction peaks at the crystalline levels (111, 220, 311, 222, 400, 331, 422, 511, 440, and 531). which confirm the formation of phase shaped cubic of the FCC structure. which shows that the preparation method ensures the incorporation of positive ions in the structure of the spinel ferrite and after mixing the two compounds to form the compound ($Cd_{0.7}Zn_{0.3}Fe_2O_4$). The distance was calculated for (d_{hkl}).crystal size for (311) as shown in table(2) compiles of the calculations found that the x-ray diffraction showing lattice constant of the compound ($Cd_{0.0}Zn_{1.0}Fe_2O_4$) will be (8.425887647). and for ($Cd_{1.0}Zn_{0.0}Fe_2O_4$) will be (8.916407702) after mixing the composite fracture compounds by formula ($Cd_XZn_{1-X}Fe_2O_4$). Notice that when the concentration of cadmium ferrite at (x=0.7) increases the lattice constant and it becomes at value (8.916407702) the crystalline surfaces (D) also increased by increasing the concentration of cadmium ferrite at ($Cd_{1.0}Zn_{0.0}Fe_2O_4$), The increasing values could be due to the difference in ionic diameters of both cadmium and zinc. The ionic radius of zinc (0.83 A$^{\circ}$) and cadmium (0.99 A$^{\circ}$) where figurer (1 c) illustrates the effect of increasing of cadmium for the ferrite compound ($Cd_{0,7}Zn_{0,3}Fe_2O_4$).

Table (2) :shows the information extracted values for XRD examination.

X	$Cd_XZn_{1-X}Fe_2O_4$	$d=n\lambda/2\sin\theta$	$a=d_{hal}\times\sqrt{h^2+k^2+l^2}$	$D=K.\lambda/B\cos\theta$	$=B\cos\Theta/4\varepsilon$	$S=1/D^2$ (A°)
0.0	$Cd_{0.0}Zn_{1.0}Fe_2O_4$	2.540501319	8.425887647	364.2269352	0.000951676	7.538E-06
1.0	$Cd_{1.0}Zn_{0.0}Fe_2O_4$	2.688398716	8.916407702	453.8272308	0.000763784	4.85533E-06
0.7	$Cd_{0.7}Zn_{0.3}Fe_2O_4$	2.693098385	8.931994737	944.7224519	0.000366908	1.12045E-06



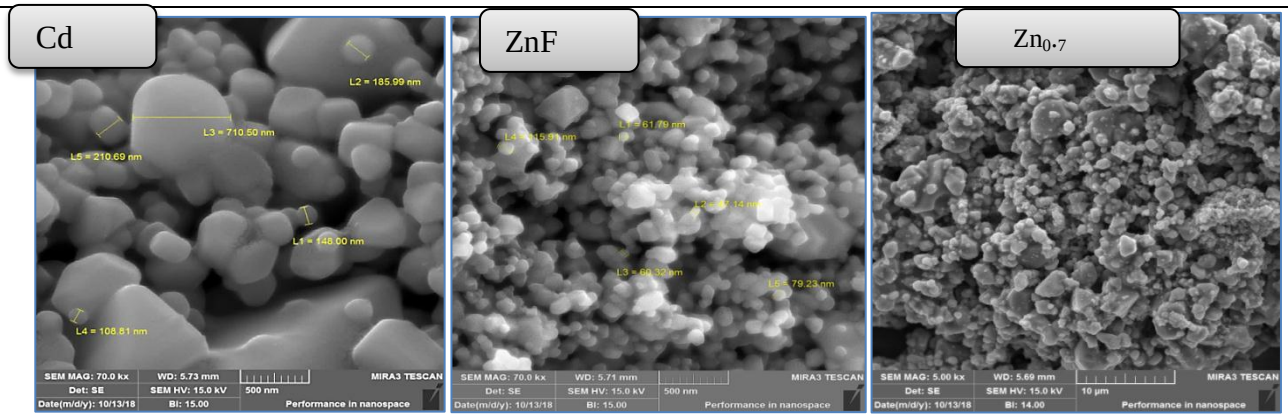
Figures 1: X-ray diffraction pattern of the compound a- ($CdFe_2O_4$) b- ($ZnFe_2O_4$) & c-($Cd_{0.7}Zn_{0.3}Fe_2O_4$).

3.2 FE-SEM and EDS

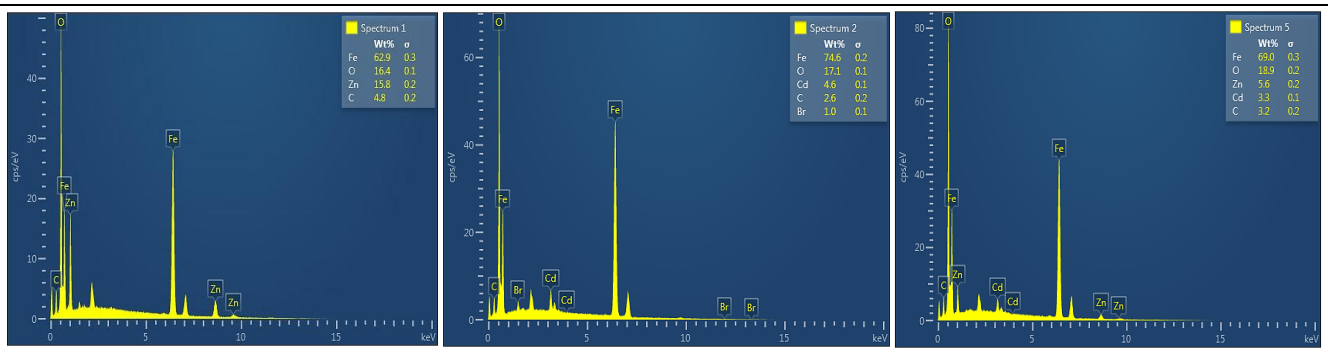
The FE-SEM of the compound ($Cd_XZn_{1-X}Fe_2O_4$), can give information on the crystalline size and shape of the crystals. was tested using the ratio (X=0.0 ,0.1) for the compound ($Cd_{0.0}Zn_{1.0}Fe_2O_4$) and ($Cd_{1.0}Zn_{0.0}Fe_2O_4$) as shown in figures (2 a,b) These figures gives a clear picture for prepared samples with crystal size determination where it is observed that the crystal size of cadmium ferrite ($Cd_{1.0}Zn_{0.0}Fe_2O_4$) ranged between (210 to 108.8 nm) and the crystal size of the zinc ferrite ($Cd_{0.0}Zn_{1.0}Fe_2O_4$) is ranging from (79.2 to 47.14 nm) . The FE-SEM test showed that the crystal size of the cadmium ferrite is greater than the zinc fraction because the ionic diameter of the cadmium is greater than the ionic diameter of zinc (0.83 A°). After the addition of (x=0.7) of the cadmium ferrite with ratio compound ($Cd_{0.7}Zn_{0.3}Fe_2O_4$) that illustrated in figure (2 c). was observed increasing in crystalline size, as the particles differ in size from each other. The size of the nanoparticles increases when the Zn^{+2} is replaced with Cd^{+2} in the crystalline lattice, EDS was used for chemical structures and elements .At the ratio of (X = 0.0) of the compound ($Cd_{0.0}$ $Zn_{0.1}$ Fe_2O_4),the spectra showed the presence of the following elements only (iron, zinc, carbon and oxygen). And, when ratio (X=0.7) for compound ($Cd_{0.7}Zn_{0.3}Fe_2O_4$). the EDS spectra shows only the following elements of (iron, cadmium, carbon, oxygen, and zinc)and these were presented in table (3). The atomic ratio of oxygen ranged from (16.4 to 18.9 %), iron range between (62.9 to 69.0 %) and carbon (3.2 to 4.8 %), while zinc decreases while increasing cadmium by replacing cadmium with zinc as shown in figures (3 a,b,c).

Table 3: Percentage of constituent elements of rheumatic compounds.

X	$Cd_XZn_{1-X}Fe_2O_4$	O	σ	Fe	σ	Zn	σ	Cd	σ	C	σ	Total
0.0	$Cd_{0.0}Zn_{1.0}Fe_2O_4$	16.4	0.1	62.9	0.3	15.8	0.2	-	-	4.8	0.2	100
1.0	$Cd_{1.0}Zn_{0.0}Fe_2O_4$	17.1	0.1	74.6	0.2	-	-	4.6	0.1	2.6	0.2	100
0.7	$Cd_{0.7}Zn_{0.3}Fe_2O_4$	18.9	0.2	69.0	0.3	5.6	0.2	3.3	0.1	3.2	0.2	100



Figures 2: FE-SEM images of the a- ($CdFe_2o_4$) b-($ZnFe_2o_4$) & c-($Zn_{0.7}Cd_{0.3}Fe_2o_4$).



Figures 3: Examination (EDS) of the compound a- ($Cd_{0.0}Zn_{1.0}Fe_2O_4$) b- ($Cd_{1.0}Zn_{0.0}Fe_2O_4$)& c- ($Cd_{0.7}Zn_{0.3}Fe_2O_4$)

3.3 Reflection Coefficient & loss of reflection & Attenuation & complex permittivity

The coefficient of reflection was calculated as a function of the frequency (f) for the prepared samples. The figure (4 ,a) shows the change in the reflection coefficient of the compounds (CR) Rubber with ratio of (3g) of ferrite compound ($Cd_{0.7}Zn_{0.3}Fe_2O_4$). The reflectivity reached to points (0.065) and (0.041) at frequency(8.14-8.40) GHz. When adding (6 g) of ferrite compound to (CR), the rubber will be observed at its lowest value of the reflection coefficient to be at points (0.092),(0.037) at the frequency range (8.84 to 9.30GHz) was obtained with less reflectivity when adding (6g) and (3g) of ferrite to (CR) rubber showing a decrease in the reflection coefficient, but when we increase the ferrite. when observe a greater reduction in the reflection coefficient by increasing the fraction of the elasticity of rubber, The frequency range (8.84 to 9.307 GHz), which achieved the lowest value of the reflection coefficient. Which achieved the lowest value of the reflection coefficient. The lower value of reflection

coefficient due to absorbance of the material, the loss of reflection shows higher value of loss in reflectivity in the negative value, that means we obtaining high absorbent materials. Where the loss calculations showed the reflection spectrum when adding (3g) of compound ferrite to the (CR) rubber. The loss of the reflection spectrum reached at (-33.3) with the frequency range (8.38-9.01GHz), When adding(6gm) from the ferrite compound to (CR) rubber, the value will be at (-19.5) with frequency range (8.38 to 9.01GHz). figure (4, b) shows the loss of reflection energy. The reason of these changes in coefficients of loss of reflectivity. The results showed that the highest attenuation value was (19.34 dB) in the band (8.38-8.81GHz). Figure (4,c) shows the attenuation at the addition of (6 g) of ferrite compound to (CR) rubber. It was observed that the highest attenuation value in the band (8.38 to 8.87 GHz) was (19.75 dB). The composite permittivity of the prepared samples was calculated as a function of the frequency with a weight of(3g) of the ferrite for (CR) Rubber. The permittivity value (12.02 At 8.075 GHz) is shown in figure(° a). The real part of dielectric constant and the imaginary part of dielectric constant as a function of the frequency at the X beam within the microwave region indicates the true portion of the amplitude to the amount of energy from the external electric field stored in the material where the constant value The isolation at (3g) will be at ($8.53*10^{-11}$) and for (6g) will be ($8.02*10^{-11}$) as shown in figure(5 b). The imaginary part refers to the energy dissipated or loss of energy. It is a measure of loss of the material for the real external electric field when adding (3g) from ferrite to the (CR) rubber will observed a highest value at ($6.47*10^{-11}$ to $2.45*10^{-11}$), and when adding (6g) of ferrite became ($6.001*10^{-11}$ to $-2.33*10^{-11}$) which refers to loss of energy as shown in figure (5 c).

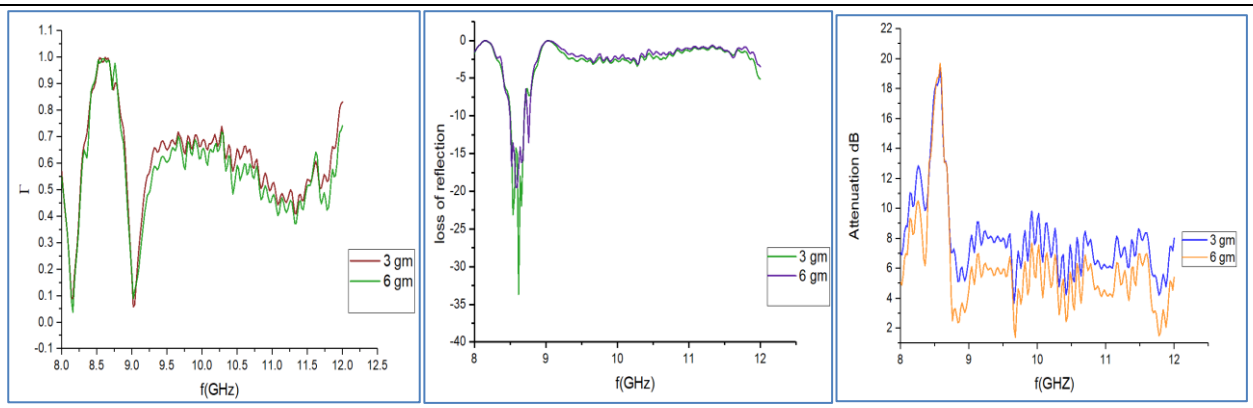


Figure 4: Illustrates both of a- Reflection coefficient , b- Loss of reflection & c- The attenuation.

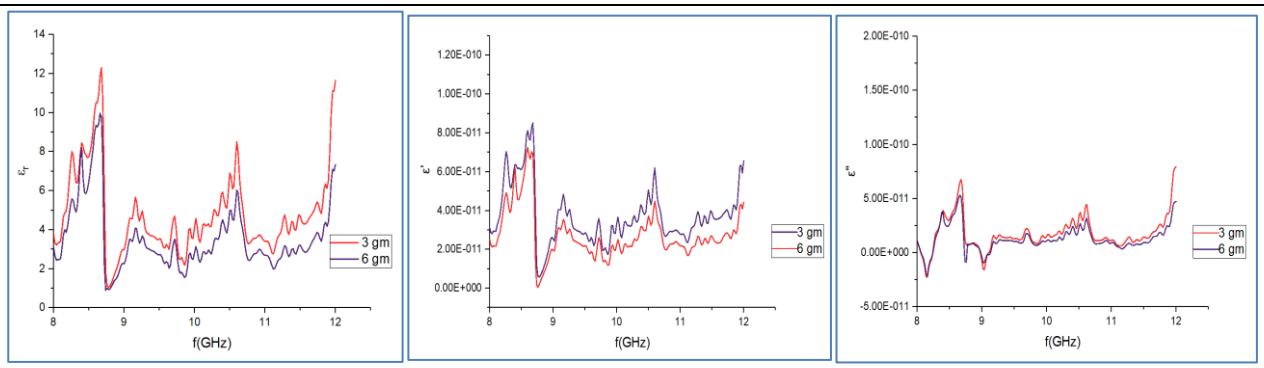


Figure 5: Illustrates both of a- The permittivity , b- The real dielectric constant & c- The imaginary dielectric constant.

3.4 Conclusion

can conclude that when increasing the fraction of cadmium ferrite to the fraction of zinc ferrite for the compound of ($Cd_XZn_{1-X}Fe_2O_4$), this leads to increasing the crystalline volume. When the compound of ($Cd_XZn_{1-X}Fe_2O_4$) is combined with (CR) rubber by adding (3g) and (6g) of the ferrite to rubber, when notice that the reflection coefficient decreases to (0.037) .Where a highly absorbent material was obtained for microwave ranges with high attenuation. The higher amount of ferrite to (CR) rubber increase the absorption of the material, Therefore, it is observed that the increase of ferrite in cadmium -zinc to the (CR) rubber, this would improves the properties of the material and increasing the materials absorption of the waves within the microwave ranges.

4. REFERENCES

[1] S. Nakashima, K. Fujita, K. Tanaka, K. Hirao, T. Yamamoto, and I. Tanaka, "Thermal annealing effect on magnetism and cation distribution in disordered ZnFe2O4 thin films deposited on glass substrates," J. Magn. Magn. Mater., vol. 310, no. 2 SUPPL. PART 3, pp. 2543–2545, 2007.

[2] D. S. Mathew and R. S. Juang, "An overview of the structure and magnetism of spinel ferrite nanoparticles and their synthesis in microemulsions," Chem. Eng. J., vol. 129, no. 1–3, pp. 51–65, 2007.

[3] N. A. Spaldin, "Magnetic materials: Fundamentals and applications," Magnetic Materials: Fundamentals and Applications, vol. 9780521886. pp. 1–274, 2010.

[4] A. R. Gainsford, M. J. Sisley, and T. W. Swaddle, "Hydrothermal Formation of Ferrite Spinels," Can. J. Chem, vol. 53, no. May, pp. 12–19, 1974.

[5] Y. Wang, F. Xu, L. Li, H. Liu, H. Qiu, and J. Jiang, "Magnetic properties of La-substituted Ni-Zn-Cr ferrites via rheological phase synthesis," Materials Chemistry and Physics, vol. 112, no. 3. pp. 769–773, 2008.

[6] F. N. T. Gonzalez, A. M. B. Miró, F. S. De Jesús, C. A. C. Escobedo, and S. Ammar, "Journal of Magnetism and Magnetic Materials Mechanism and microstructural evolution of polyol mediated synthesis of nanostructured M-type SrFe 12 O 19," J. Magn. Magn. Mater., vol. 407, pp. 188–194, 2016.

[7] R. Sohn, "Magnetic and dielectric properties of the M-type barium strontium hexaferrite (Ba x Sr 1 − x Fe 12 O 19) in the RF and microwave (MW) frequency range Magnetic and dielectric properties of the M-type barium strontium hexaferrite (Ba x Sr 1 - x Fe 12 O," no. May, 2009.

[8] S. Edition, Modern Ferrite Technology. 2006.

[9] M. A. Gabal, "Structural and magnetic properties of nano-sized Cu-Cr ferrites prepared through a simple method using egg white," Materials Letters, vol. 64, no. 17. pp. 1887–1890, 2010.

[10] N. Dadkar, B. S. Tomar, and B. K. Satapathy, "Evaluation of flyash-filled and aramid fibre reinforced hybrid polymer matrix composites (PMC) for friction braking applications," Mater. Des., vol. 30, no. 10, pp. 4369–4376, 2009.

[11] B. N. Chawla and Y. Shen, "Mechanical Behavior of Particle

Reinforced Metal Matrix Composites," no. 6, pp. 357–370, 2001.

[12] Y. Hwang, "Microwave absorbing properties of NiZn-ferrite synthesized from waste iron oxide catalyst," Mater. Lett., vol. 60, no. 27, pp. 3277–3280, 2006.

[13] B. R. Mahafza, RADAR SYSTEMS ANALYSIS AND. New Yor k, 2013.