Attenuation and Absorption of Electromagnetic Waves of Nanocomposites ($ZnFe_2O_3$ / Graphene: UPE) by Wave Guide Technical

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Abstract

In this article, composites with a polymeric basis were prepared and developed with a $ZnFe_2O_3$ material dyed with graphene that has the ability to absorb and attenuate by a weight ratio of (1-4) % of the base. The samples were formed by chemical blending and ultrasound technology to homogenize the mixture. The waveguide technique was used at the microwave frequencies in the range of 8- 12 kHz and within the X-band range - the results showed a significant improvement in the absorbance and attenuation by increasing the percentage of the deformed material compared to the blank material, and the best value was obtained at 3%. The compositional examinations of the Nano powder were performed using a scanning electron microscope technology equipped with an EDX scan.

Key Words: Attenuation and Absorption, Nanocomposites, $ZnFe_2O_3$/ Graphene: UPE, and Wave Guide.

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Introduction

In daily life applications, broadcasting, satellites, radar, cell phones and wireless networks all operate in the microwave frequency range from 1 to 18 kHz, and the efficiency of these systems can be severely affected by unwanted reflections or emissions, as well as associated health risks. In this context, ferrites play a dominant role in suppressing reflection or damping electromagnetic waves in free space (Petrov VM, 2001) (Lee SE, 2006) (Pande S, 2009). Microwaves are part of the electromagnetic spectrum with wavelengths from 1 to 100 cm and are located between the radio frequencies of RF and infrared rays (IR). Microwaves contain many areas that are divided in two ways: The Institute of Electrical and Electronics Engineers method and the other by the US Army method. Each region has its own specific applications, such as monitoring, detection and surveillance in the long or short term (Duan G, 2008) (Cao J, 2009) (Micheli D, 2011). The most important is the X-band beam because its applications are widely used in radar systems. Ferrites in general are homogeneous dark gray or black ceramic materials composed of mixing different types of iron oxides, which are very hard (Folgueras LC, 2010). Ferrites have different crystal structures and are in the form of weak soft or hard ferrites. The soft ferrites are the essence for magnetic materials in electrical devices (Stergiou CA, 2016). The magnetic properties of ferrites come from the interactions occurring between metal ions which occupy precise and distinct sites in proportion to the oxygen ions within the crystalline structure of the oxide. And that the crystalline structures of the manufactured ferrites take a fusiform shape and its general rule is (MFe_2O_3) as M symbolizes one of the bivalent elements such as:

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(Zn, Cd, Cu, Ni, Fe, Mn) And that some magnetic oxides represented by ferrites possess a crystalline structure that gives one position to the positive ions (cations), and the magnetic moments of metal ions that are located on the same site are parallel to each other and also parallel to the ions of the other site, but oppose it in direction, and in this pattern, the ferrites show the ferromagnetic phenomenon, and this term was invented by the scientist (Neel) (Veley VF, 1987). Many researchers interested in the field of electromagnetic waves and their attenuation, including: The researcher [***Setter A, A, and et al 2005***] (Zhao L, 2006). Studied the effect of adding aluminum on the physical properties of the ferric-magnesium and zinc compound, which was prepared using the traditional ceramic method, where he obtained promising results in the field of attenuation of electromagnetic waves. The researchers also studied [***Muhammad and et al 2015*** (Daham MH, 2015). By preparing a ferric zinc-copper compound with weight ratios and mixing it with rubber (silicon). The reflection coefficient of the prepared samples was studied and found to be higher than 10 dB, which indicates that the absorbance of the prepared materials is greater than 90%. This research aims to form polymer-based nanostructures that have the ability to attenuate and absorb radio waves within the X-band.

Preparation of Polymeric Composites

In this paper, ferric zinc nanoparticles ($ZnFe_2O_3$) were prepared using powder technology and denatured with 3% graphene Nano powder. The Nanocomposites were prepared using liquid mixing and ultrasound technology, where the unsaturated polyester resin (UPE) was mixed, which is a polymer that has a dense texture and a transparent color and fits within the thermally hardened material (thermostatic) where it is mixed with the prepared compound ($ZnFe_2O_3$/ Graphene) at a ratio of (1 - 4%) as a weight percentage. The attenuation of electromagnetic waves was carried out using microwave analysis technology confined between (8 - 12) GHz and within the X-beam range - based on the waveguide technique of rectangular shape.

Results and Discussion

Examination of the scanning electron microscope fig. (1) and examination of the X-ray power dispersion spectrometer accompanying the examination of the electron microscope for zinc metal Nano powder showed a clear image and values of the components as shown in Table (1). And as concerns the nanostructures of samples where EDX examination is, the analyses (2) show the presence of clusters after dispersion in the carbon nanotube resin and zinc Nano ferrites of sample.

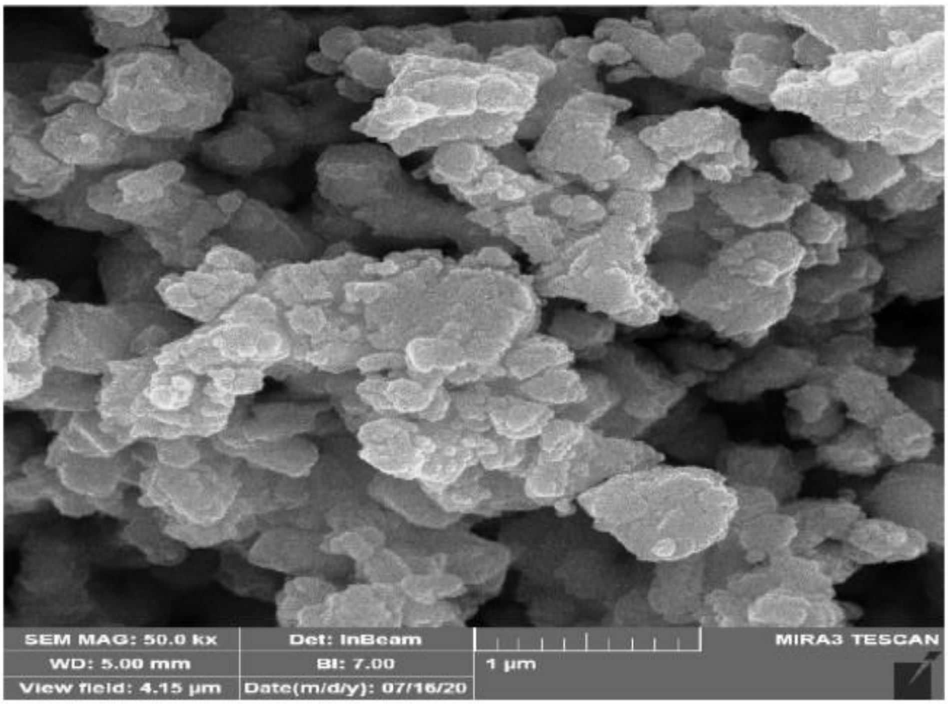


Fig. 1. Image of the scanning electron microscope of $ZnFe_2O_3$/G powder

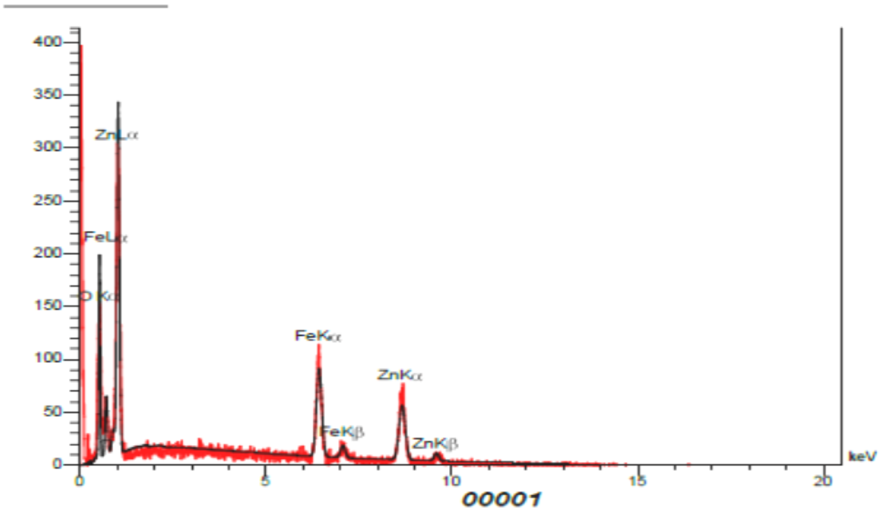


Fig. 2. EDX – A spectrum for $ZnFe_2O_3$/G Nano powder

Table 1 shows the results of the EDX technology examination accompanying the examination of the scanning electron microscope, as it was proved that the weight ratios of the materials entering the reaction are identical to the method of preparing the ferric zinc nanocomposite. The images obtained by SEM. It can be seen in Fig. that the nanotubes and zinc ferrites were homogeneously distributed and there were no clusters in the superposition's sample. We can see in Fig 5 that the nanotubes were badly distributed and there were clusters of the reinforcing materials (carbon nanotube and zinc Nano ferrite) due to the high percentage of reinforcement which conduced to this clustering and heterogeneity.

Table 1. Summary of Weight and Percentages of $ZnFe_2O_3$ Nanopowder

Quantitative Results

Elt	Line	Int	Error	K	Kr	W%	A%	ZAF	Formula	Ox%	Pk/Bg
O	Ka	58.5	8.0925	0.1182	0.1028	19.06	47.75	0.5396		0.00	14.84
Fe	Ka	84.0	0.7438	0.2952	0.2569	25.22	18.09	1.0187		0.00	12.23
Zn	Ka	61.2	0.7913	0.5866	0.5104	55.72	34.16	0.9159		0.00	12.38
				1.0000	0.8701	100.00	100.00			0.00	

Table 2 and fig. (3) shows the results for examining the X-ray diffraction and shows from the table the values of miller coefficients and the grain size of the ferric zinc nanocomposite as the table shows the values of the lattice constant and its dimensions.

Table 2. X-ray results summery

Phase	a(Å)	hkl	G.S. (nm)	d_{hkl}.(Å)	FWHM (Deg.)	2θ (Deg.)
Cub. Fe_2O_3	**8.35385**	**-220**	**15**	**2.9552**	**0.549**	**30.2186**
Cub. Fe_2O_3	**8.33268**	**-311**	**13.7**	**2.5124**	**0.61**	**35.7092**
Hex. Zn	4.9392	-2	15.2	2.4696	0.5491	36.3498
Hex. Zn	2.3022	-100	30.7	2.3022	0.2746	39.0951
Hex. Zn	2.9443	-101	28	2.0891	0.305	43.274
Cub. Fe_2O_3	**4.89897**	**-422**	**29.2**	**1.6982**	**0.305**	**53.9502**
Hex. Zn	3.77157	-102	22.5	1.6867	0.3966	54.3467
Cub. Fe_2O_3	**8.3351**	**-333**	**11**	**1.6041**	**0.8236**	**57.3971**
Cub. Fe_2O_3	**5.8988**	**-440**	**13.3**	**1.4747**	**0.7016**	**62.9792**
Hex. Zn	4.2374	-103	35.4	1.34	0.2745	70.1779
Hex. Zn	1.88288	-110	29	1.3314	0.3355	70.6965

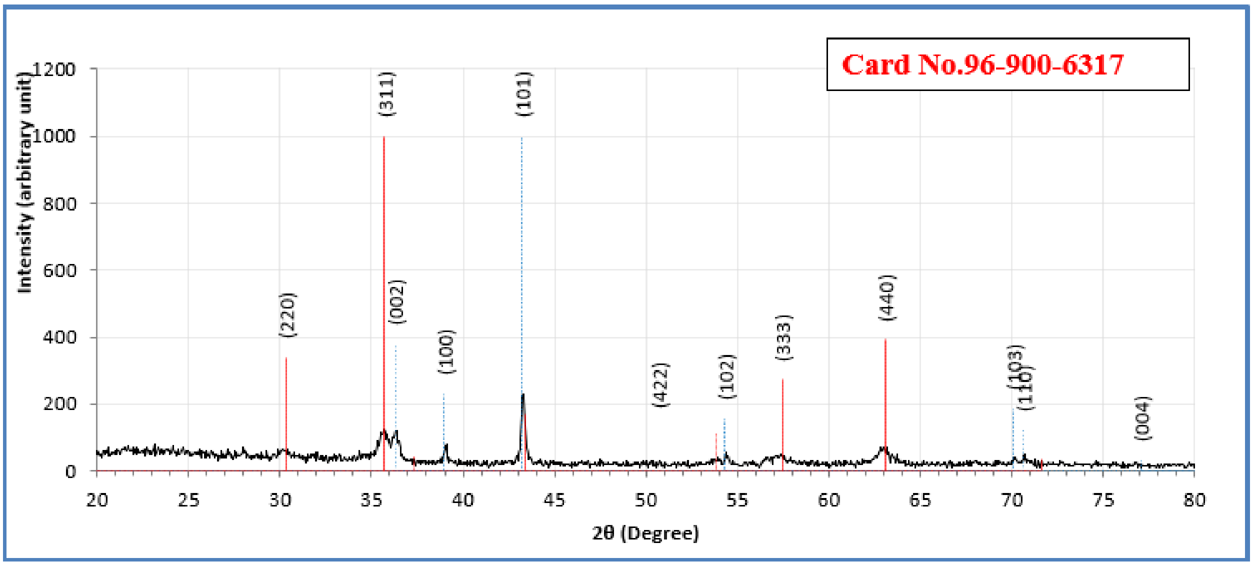
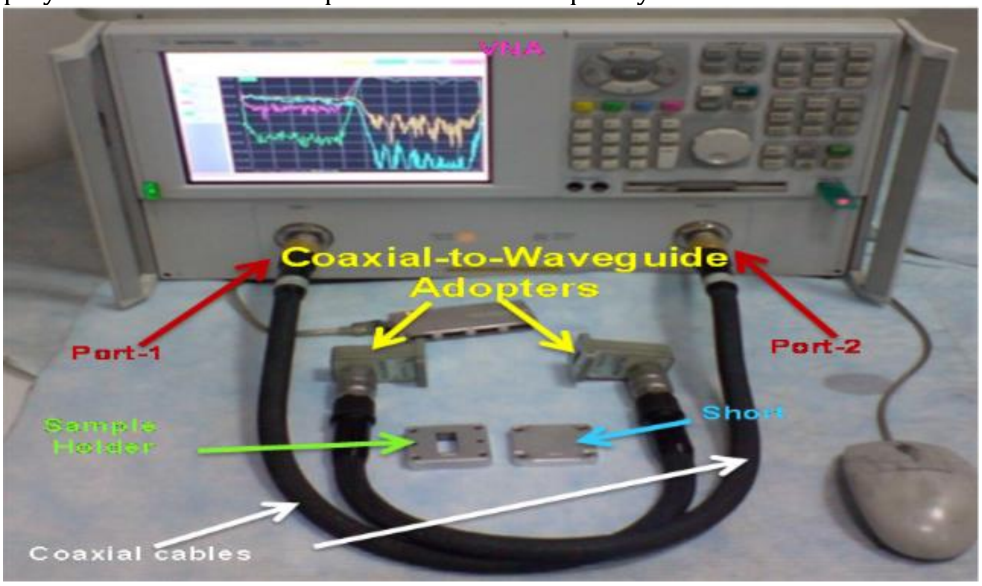


Fig. 3. X-Ray of $ZnFe_2O_3$ Nano powder

By used network analyzer device, figure (4,5,6,7) show the curves of reflectivity, transmittance and impedance related to the formation of electromagnetic properties of Nanocomposites (carbon nanotubes associated with zinc nanometer ferrite), with unsaturated polyester resins evaluated by the waveguide technique. The black line is at (0) dB which corresponds to the evaluation of the reference material (the aluminum plate) that is used in reflectivity measurements, owing to its 100% reflectivity this agreement with (Giorcelli M, 2013). The pure polymer (unsaturated polyester) (without carbon nanotubes and zinc ferrite) placed on the aluminum plate offers us a behavior similar to the reference material, thus, the curves of the metal plate and the polymer matrix occur simultaneously, because the unsaturated polyester resins are transparent in Rated frequency range (8.2 to 12.4 GHz). Measurements of the treated materials show a maximum attenuation value of (-27) dB at (11.19) GHz and (23) dB at (11.61) GHz (attenuation 99.7% and 90.0 %, Respectively) for the combinations of Sample 4 and Sample 5 respectively. These curves show that all the nanostructures signified simultaneous impedance with the air in favor of the electromagnetic wave, and this is consistent with the source (4). And as regards transmittance, Figure (5) shows the convergence in the results values at frequency 11. 6 -11.9 GHz for samples 3, 4, 5 respectively, this means that the transmitted electromagnetic waves were not affected much due to the great loss in their amplitude at the surface of the samples and their reflection at a high rate this agreement with (Micheli D, 2013).



Network analyzer device

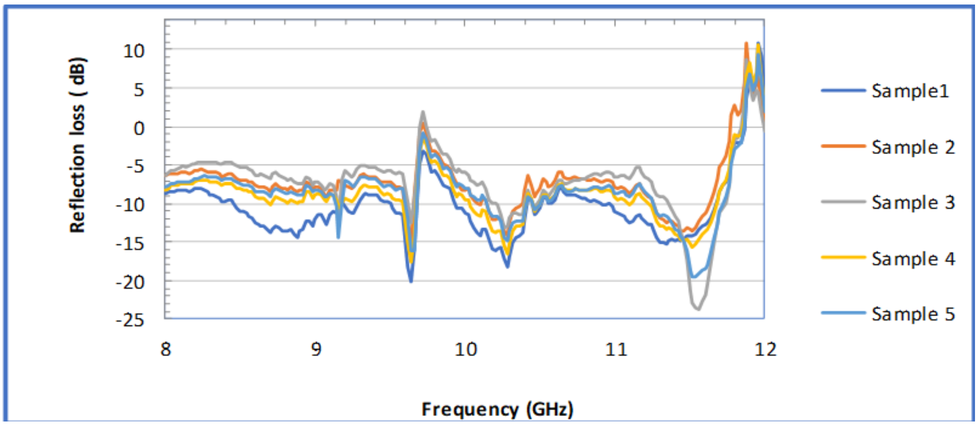


Figure 4. Results of reflectivity values of electromagnetic waves with frequency

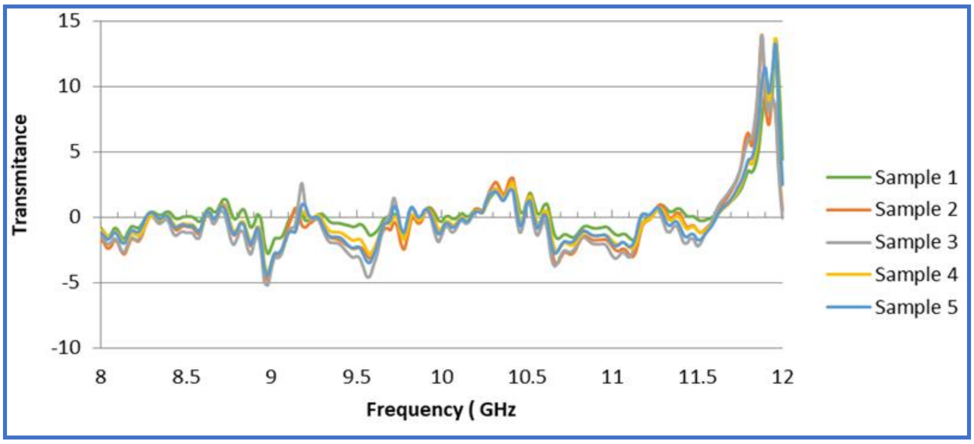


Figure 5. Results of transmittance values of electromagnetic waves with frequency

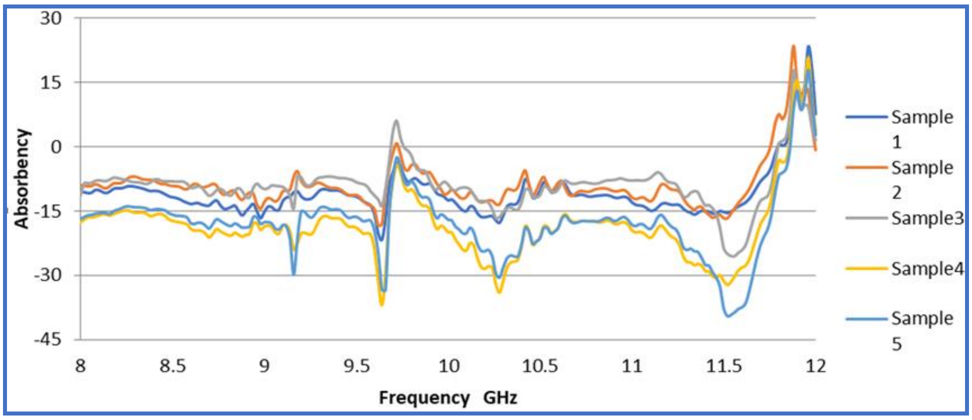


Figure 6. Results of Absorbency values of electromagnetic waves with frequency

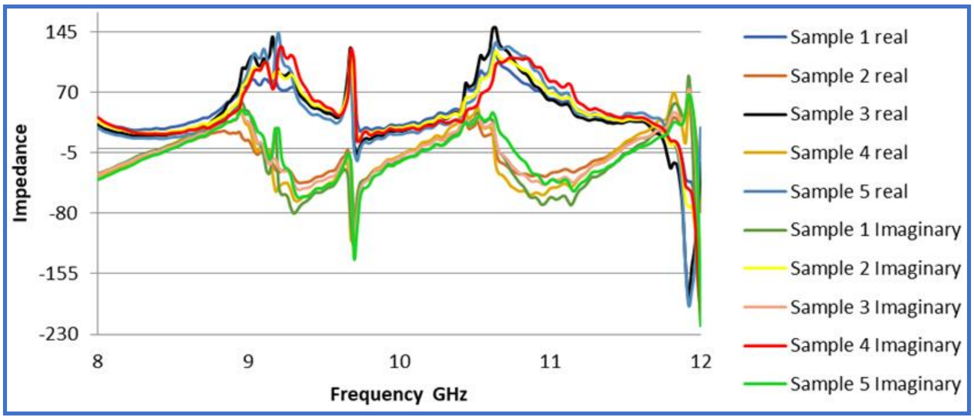


Figure 7. Results of Impedance values of electromagnetic waves with frequency

Conclusions

In this paper, the following can be concluded:

1. Zinc ferric compounds are considered as absorbers of electromagnetic waves within the limits of the x range, and the attenuation process increases with the increase of the powder content up to 3%.
2. The addition of graphene powder to the compound increased the attenuation of the electromagnetic waves and its addition was a constant rate of about 3%.
3. The increase in the distribution and spread of the powder on a regular basis within the polymer (the insulating material) in the direction of nanostructures is robustness and strength to absorb microwaves.

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