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Fabrication of (PS-Cr_2O_3/ $ZnCoFe_2O_4$) Nanocomposites and Studying their Dielectric and Fluorescence Properties for IR Sensors

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IN PRESENT work, study of dielectric and fluorescence properties of polystyrene (PS)-chromium oxide (Cr_2O_3) and polystyrene- chromium oxide doped by zinc cobalt iron oxides nanocomposites have been investigated. The samples have been prepared by adding $ZnCoFe_2O_4$ nanoparticles concentrations to the (PS-Cr_2O_3) nanocomposites by different weight percentages are (0, 2,4,6 and 8) wt.%. The results showed that the dielectric constant, dielectric loss and A.C electrical conductivity of (PS-Cr_2O_3) nanocomposites increase with an increase in $ZnCoFe_2O_4$ nanoparticles concentrations. The dielectric constant and dielectric loss decrease while the electrical conductivity increases with an increase in frequency. The results of dielectric and fluorescence properties showed that the (PS-Cr_2O_3/$ZnCoFe_2O_4$) nanocomposites can be used in different optoelectronics applications.

Keywords: Nanocomposites, Fluorescence, $ZnCoFe_2O_4$, Polystyrene, Optoelectronics.

Introduction

Nanocomposites can be defined as a composite material in which at least one of the phases (mostly the filler) shows dimensions in the nanometer range, as the fillers size reaches the nanometer level, the interactions at the interfaces become considerably large with respect to the size of the inclusion and thus the final properties show significant changes [1]. A nanocomposite, like a traditional composite has two parts, filler and the matrix, a traditional composite typically uses a fiber such as carbon fiber or fiberglass as the filler, in a nanocomposite the filler is a nanomaterial [2]. Nanocomposites materials have properties combine the properties of the filler and matrix. The new material has applications in fields: antibacterial, humidity sensors , pressure sensors and piezoelectric , radiation shielding and thermal energy storage and release [3]. Polystyrene (PS) is amorphous polymer with bulky sidegroups. General purposes PS are hard, rigid, and transparent at room temperature and glass like thermoplastic material which can be soften and distort under heat. It is soluble in aromatic hydrocarbon solvents, cyclohexane and chlorinated hydrocarbons [4]. In technological applications, metal oxides have traditionally been used in the fabrication of microelectronic circuits, sensors, piezoelectric devices, fuel cells, coatings for the passivation of surface against corrosion, and as catalyst. In the emerging field of nanotechnology, a goal is to make nanostructures or nanoarrays with special properties with respect to those of bulk or single par- ticles species. Metal oxides as nanoparticles can exhibit unique chemical properties due to their limited size and high density of corner or edge surface sites. Among metal oxides, special attention has been focused on the formation and properties of chromia (Cr_2O_3) which is important as heterogeneous catalyst, coating material, wear resistance, advanced

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colorant, pigment and solar energy collector [5]. Generally, study of optical, electrical and dielectric properties of nanocomposites or composites deal with enhancement the properties of the matrix [6-13] to use them for different applications such as antibacterial [14-16] and electronic applications [17]. This work deals with the fabrication of (PS-Cr_2O_3/ $ZnCoFe_2O_4$) new nanocomposites and studying their dielectric and fluorescence properties for IR sensors.

Materials and Methods

The materials used in this paper are polystyrene (PS), chromium oxide (Cr_2O_3) and zinc cobalt iron oxides ($ZnCoFe_2O_4$). The specimens were prepared using casting technique thickness ranged between (147-150)µm. The weight percentages of $ZnCoFe_2O_4$ nanoparticles which are added to (PS-Cr_2O_3) nanocomposites are (0,2,4,6 and 8) wt.%. The dielectric properties (dielectric constant, dielectric loss, A.C electrical conductivity of (PS-Cr_2O_3/$ZnCoFe_2O_4$) nanocomposites were measured by using (LC Meter) in the frequency(f) range (100 Hz -5MHz) at room temperature. The measured capacitance, C_p was used to calculate the dielectric constant ,έ using the following equation [18,19] :-

$$\varepsilon' = \frac{C_p}{C_o} \qquad ....(1)$$

The dielectric loss is given by [20,21]

$$\varepsilon'' = \varepsilon' D \qquad ....(2)$$

The dissipated power in the insulator is represented by the existence of alternating potential as a function of the alternating conductivity, using equation (3) [22-24]:

$$\acute{o}_{AC} = w\mathring{a}''\mathring{a}_o \qquad ......(3)$$

$\acute{o}_{AC}$ is a measurement for the generated temperature in the insulating material resulting from the rotation of the dipoles in their positions, (or thevibration of the charges) as a result of the alternating of the field [25].

Fluorescent spectra have been measured for blocked models Using fluoroscopy (Spectrofluoromete)were calculated Fluorescence lifetime (τ_f) and Quantum Yield fluorescence (Q_f) were calculated using relationships[26]

$$\tau_F = \frac{a \times \tau_{fRB}}{a_{RB}} \qquad .....(4)$$

$$\phi_F = \frac{\int F(\nu')d\nu'}{\int \varepsilon(\nu')d\nu'} \qquad ......(5)$$

Results and Discussion

Figures 1 and 2 show the variation between the dielectric constant and dielectric loss of (PS-Cr_2O_3/$ZnCoFe_2O_4$) nanocomposites with frequency at room temperature for different $ZnCoFe_2O_4$ nanoparticles concentrations. These figures showed that the dielectric constant and dielectric loss decrease with an increase in frequency; this behavior attributed to decrease the space charge polarization to the total polarization.

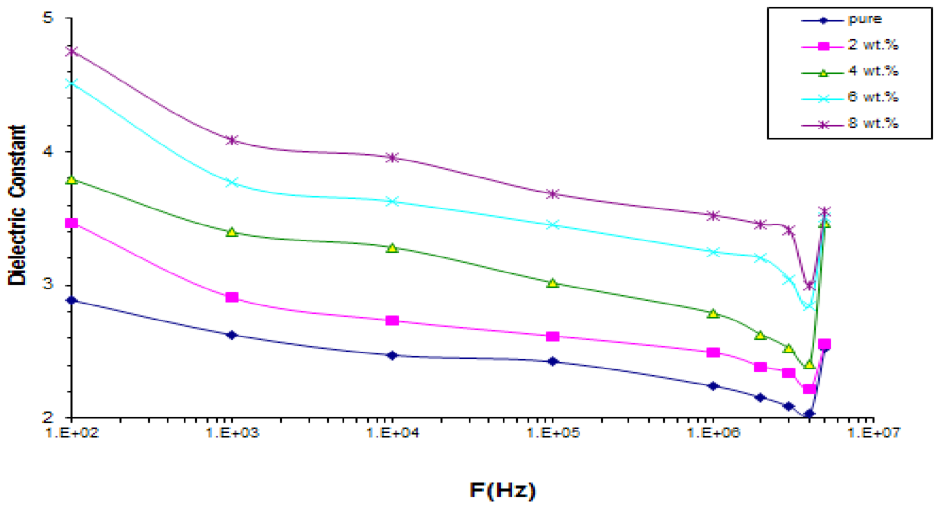


Fig. 1. The variation of dielectric constant with the frequency at room temperature.

At lower frequency the dipole can respond rapidly to follow the field and dipole polarization has its maximum value, so highest dielectric constant and dielectric loss. At higher frequencies, the polarizability will be minimum, as the field con not induce the dipole moment, so dielectric values attain minimum [27].

The variation of dielectric constant and dielectric loss of (PS-Cr_2O_3) nanocomposites with $ZnCoFe_2O_4$ nanoparticles content at room temperature are shown in Fig. 3 and 4. The increase of the dielectric constant and dielectric loss with $ZnCoFe_2O_4$ nanoparticles concentrations can be attribute to increase of charges number which can be increased due to increasing filler content [28].

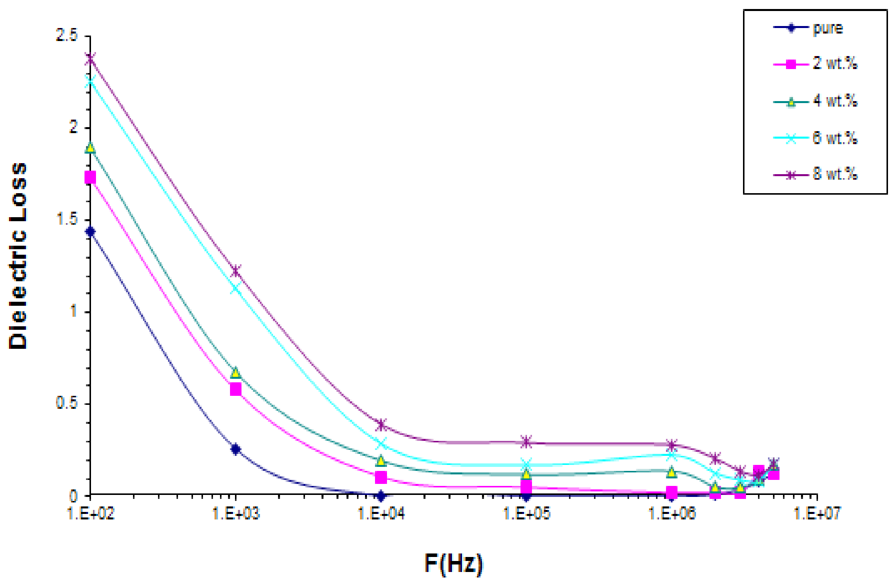


Fig. 2.The variation of dielectric loss with the frequency at room temperature.

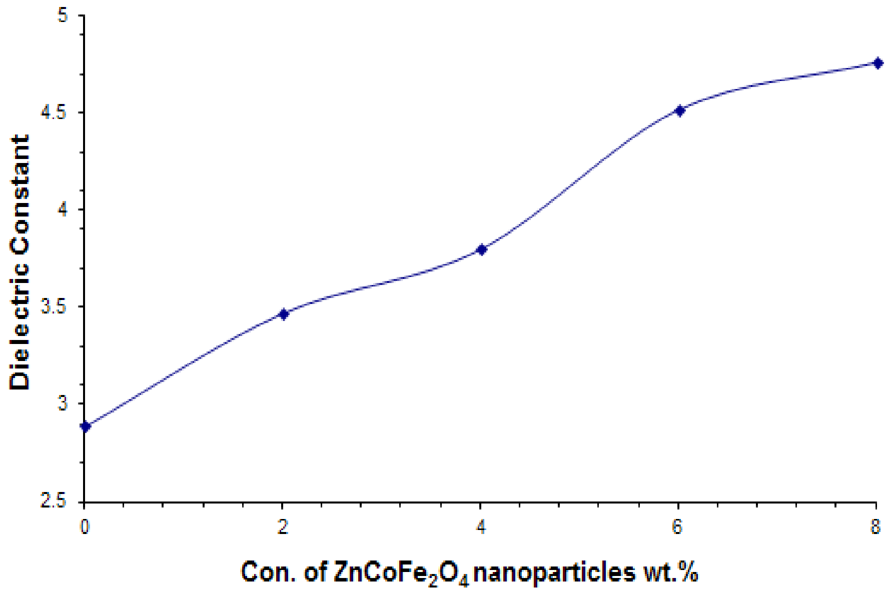


Fig. 3. The variation of dielectric constant for (PS-Cr_2O_3) nanocomposites with $ZnCoFe_2O_4$ nanoparticles content at 100Hz.

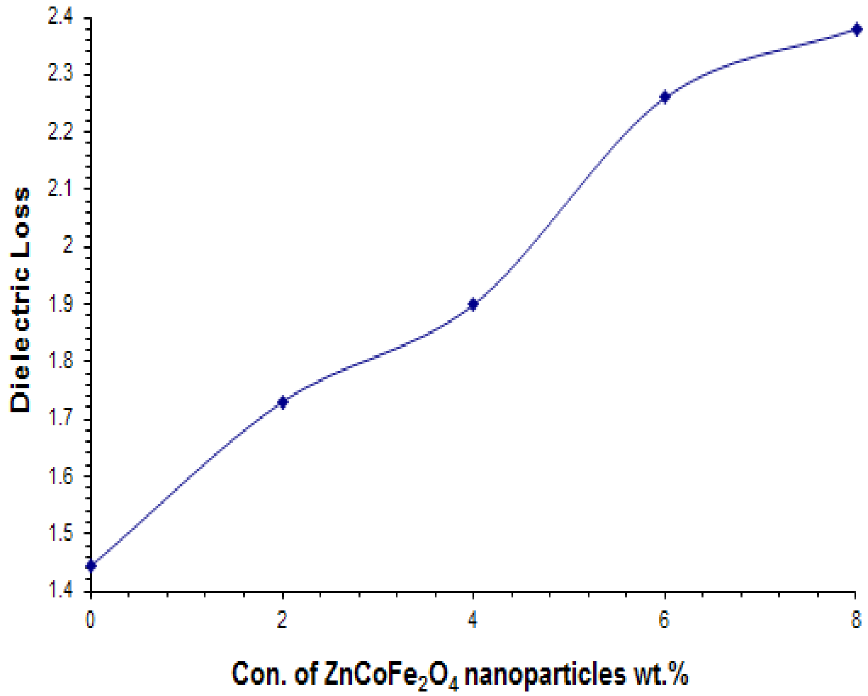


Fig. 4. The variation of dielectric loss with the concentration of filler at 100Hz.

Figure 5 shows the variation of the A.C electrical conductivity of (PS-Cr_2O_3/$ZnCoFe_2O_4$) nanocomposites with frequency. The figure shows that the A.C electrical conductivity increases when increasing the frequency, this behavior can be attributed to the interfacial polarization [29].

The variation of electrical conductivity of (PS-Cr_2O_3) nanocomposites as function of the $ZnCoFe_2O_4$ nanoparticles concentrations at 100Hz is shown in Figure 6. The A.C electrical conductivity increases with an increase in $ZnCoFe_2O_4$ nanoparticles concentrations which is due to increase of the charge carrier density in polymer matrix[30].

Fluorescence Spectra

Fluorescent spectra have been measured for blocked models Using fluoroscopy (Spectrofluoromete)were calculated Fluorescence lifetime (τ_f) and Quantum Yield fluorescence (Q_f). Figure 7 shows the Fluorescent spectra increases with increase the $ZnCoFe_2O_4$ concentrations.

Fluorescence spectroscopy results were possible Fluorescence lifetimes (τ_f) and Quantum Yield fluorescence (Q_f) were calculated using the relationships (5) and (6), respectively. After calculating the area under curve (a) for the absorption and fluorination curve using the software (GEUP 6) and the results as shown in the Table1.

Figure 8 shows the Fluorescence lifetimes decreased with increase the concentration of $ZnCoFe_2O_4$.

Figure (9) shows the Quantum Yield fluorescence increases with increase the concentration of (PS-Cr_2O_3/$ZnCoFe_2O_4$).

Conclusions

1. The dielectric constant and dielectric loss of (PS-Cr_2O_3/$ZnCoFe_2O_4$) nanocomposites decrease while the A.C electrical conductivity increases with increase in frequency.
2. The dielectric constant, dielectric loss and the A.C electrical conductivity of (PS-Cr_2O_3) nanocomposites are increased with increase in $ZnCoFe_2O_4$ nanoparticles concentrations.
3. The Quantum Yield fluorescence increases and the Fluorescence lifetimes decrease with increase in $ZnCoFe_2O_4$ nanoparticles concentrations.

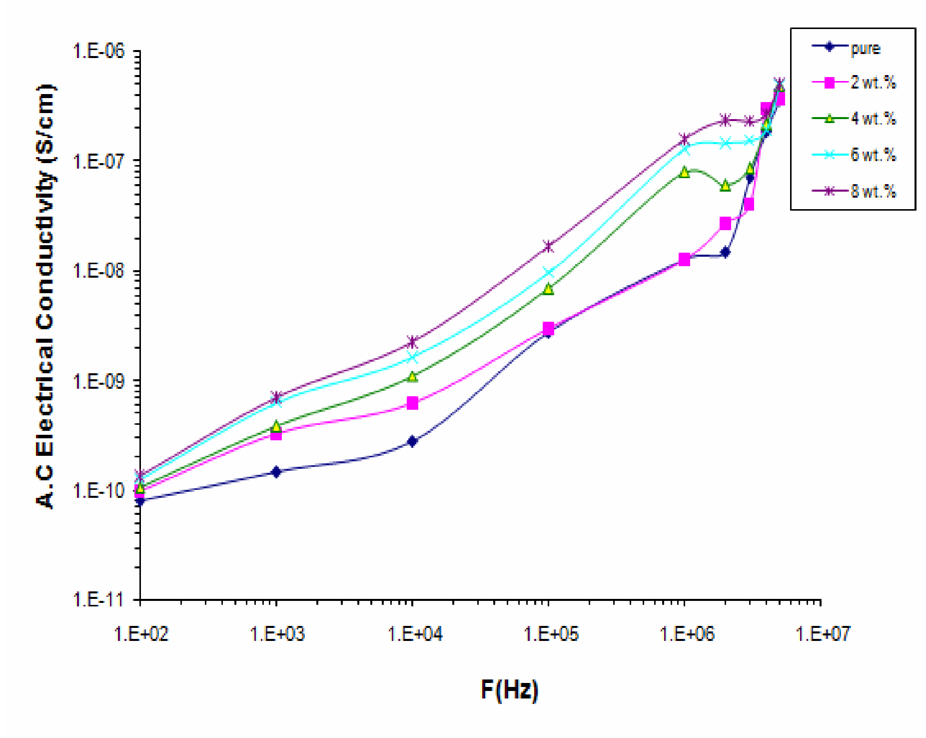


Fig. 5. The variation of electrical conductivity with the frequency at room temperature.

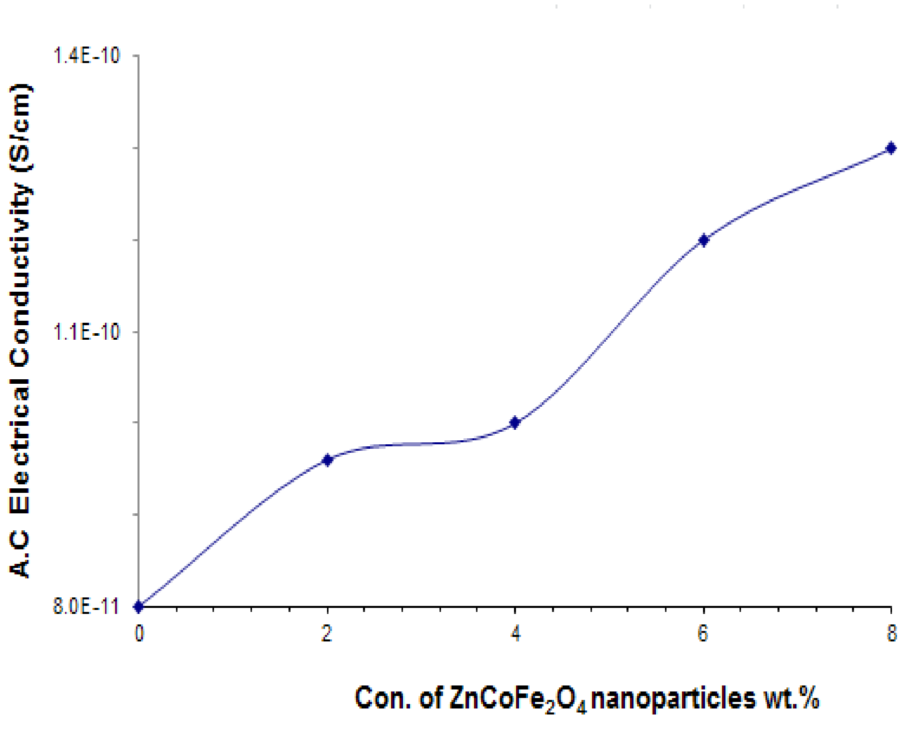


Fig. 6. The variation of electrical conductivity of (PS-Cr_2O_3) nanocomposites as function of the $ZnCoFe_2O_4$ nanoparticles concentrations at100Hz.

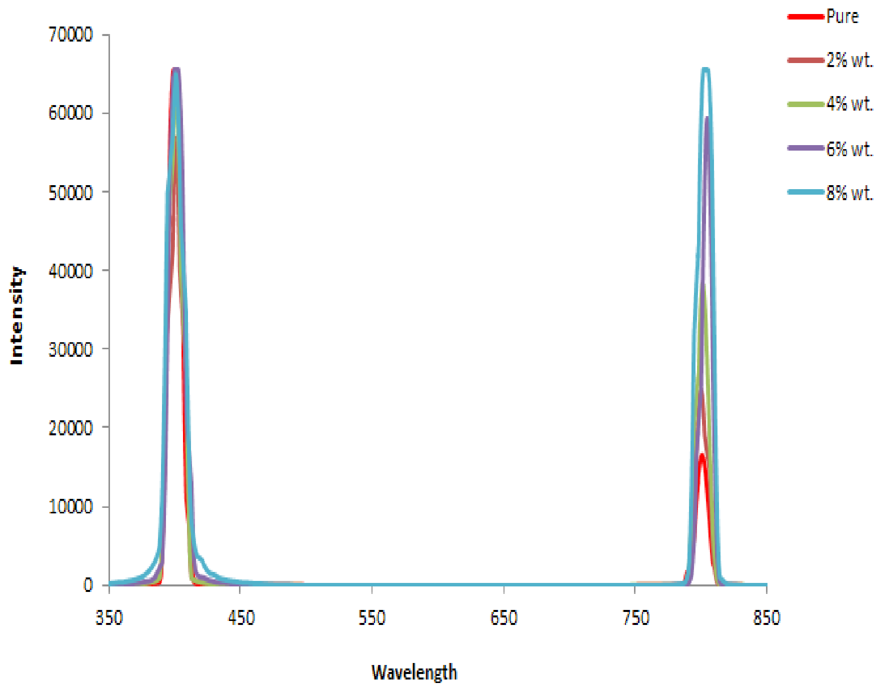
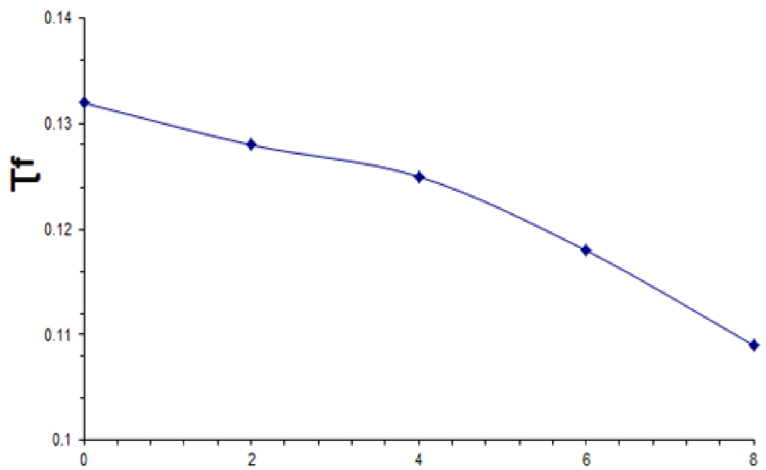


Fig. 7. The Fluorescent spectra of (PS-Cr_2O_3/$ZnCoFe_2O_4$) nanocomposites.

TABLE 1. values of Fluorescence lifetimes (τ_f) and Quantum Yield fluorescence (Q_f).

Concentration of $ZnCoFe_2O_4$ wt.%	τ_f(ns)	Q_f
0	0.132	0.82
2	0.128	0.87
4	0.125	0.92
6	0.118	0.95
8	0.109	0.97



Con. of $ZnCoFe_2O_4$ nanoparticles wt.%

Fig. 8. Fluorescence lifetimes with the concentration of filler .

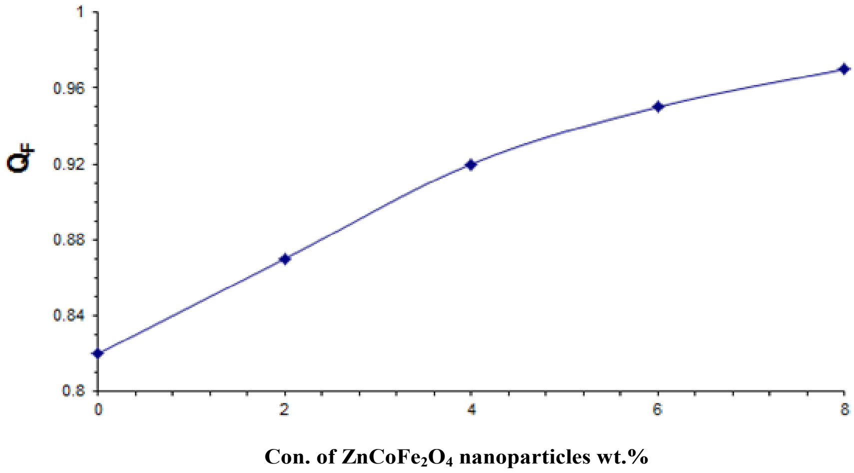


Fig. 9. Quantum Yield fluorescence with the concentration of filler .

References

1. C. Uzunpinar, “Effect of Dispersion of Swanston the Viscoelastic andFinal Properties of Epoxy Based Nanocomposites”, *M.Sc. Thesis,* Graduate Faculty , Auburn University (2010).

2. J. Robertson, “Realistic applications of CNTs” *Materials Today*, Vol. **7**, No.5, pp. 46- 52 (2004).

3. A. Hashim, Z. Sattar Hamad, Fabrication Polyvinyl alcohol - Poly-Acrylic acid/ Niobium Carbide New Bio-Films for Antibacterial Applications, *Advances in Environmental Biology,* Vol. **10**. 22587, No.13, (2018).

4. B. H Rabee, A.Hashim, M. Ali Habeeb, Preparation of (PS-PMMA-ZnCl2) Composites and Study their Electrical and Optical Properties, *International Journal of Science and Research (IJSR),* Vol. **3**, No.10,(2012).

5. Rakesh, S. Ananda, N. M. Made Gowda, Synthesis of Chromium (III) Oxide Nanoparticles by Electrochemical Method and Mukia Maderaspatana Plant Extract, Characterization, KMnO4 Decomposition and Antibacterial Study, *Modern Research in Catalysis,* Vol. **2** No. 4 (2013).

6. Ahmed Hashim, Zinah S. Hamad, Lower Cost and Higher UV-Absorption of Polyvinyl Alcohol/ Silica Nanocomposites For Potential Applications, *Egypt. J. Chem.,* DOI: 10.21608/ EJCHEM.2019.7264.1593 (2019).

7. A. Hashim, M. A. Habeeb, A. Khalaf and A. Hadi, Fabrication of (PVA-PAA) Blend-Extracts of Plants Bio-Composites and Studying Their Structural, Electrical and Optical Properties for Humidity Sensors Applications, *Sensor Letters,* Vol.15, PP. 589–596 (2017).

8. Ahmed Hashim and Majeed Ali Habeeb, Synthesis and Characterization of Polymer Blend-$CoFe_2O_4$ Nanoparticles as a Humidity Sensors For Different Temperatures, *Transactions on Electrical and Electronic Materials,* DOI: 10.1007/s42341-018-0081-1 (2019).

9. Ahmed Hashim and Majeed Ali Habeeb, Structural and Optical Properties of (Biopolymer Blend-Metal Oxide) Bionanocomposites For Humidity Sensors, *Journal of Bionanoscience,* Vol. 12, No.5 (2018).

10. Ahmed Hashim, Majeed Ali Habeeb, and Aseel Hadi, Synthesis of Novel Polyvinyl Alcohol–Starch-Copper Oxide Nanocomposites for Humidity Sensors Applications with Different Temperatures, Sensor Letters, Vol. **15**, No. 9, pp. 758–761 (2017).

11. Falah Ali Jasim, Farhan Lafta, Ahmed. Hashim, Majeed Ali, Angham. G. Hadi, Characterization of palm fronds-polystyrene composites, *Journal of Engineering and Applied Sciences,* Vol. **8** , No.5, PP. 140-142, 2013..

12. Farhan Lafta Rashid, Ahmed Hashim, Majeed Ali Habeeb, Saba R. Salman, Hind Ahmed, Preparation of PS-PMMA copolymer and study the effect of sodium fluoride on its optical properties, *Journal of Engineering and Applied Sciences,* Vol. **8** , No.5, PP. 137-139, (2013).

13. M. A. Habeeb, A. Hashim, and A. Hadi, Fabrication of New Nanocomposites: CMC-PAA-PbO_2

Nanoparticles for Piezoelectric Sensors and Gamma Radiation Shielding Applications, *Sensor Letters,* Vol. **15**, No. 9, PP. 785–790, (2017).

14. Hind Ahmed, Ahmed Hashim and Hayder M. Abduljalil, Analysis of Structural, Electrical and Electronic Properties of (Polymer Nanocomposites/ Silicon Carbide) for Antibacterial Application, *Egypt. J. Chem.,* Vol. **62**, No. 4. pp.1167– 1176, DOI: 10.21608/EJCHEM.2019.6241.1522, (2019).

15. Ahmed Hashim, Hayder M. Abduljalil, Hind Ahmed, Fabrication and Characterization of (PVA-TiO2)1-x/ SiCx Nanocomposites for Biomedical Applications, *Egypt. J. Chem.,* DOI: 10.21608/ EJCHEM.2019.10712.1695, (2019).

16. Hind Ahmed, Ahmed Hashim, Fabrication of PVA/NiO/SiC Nanocomposites and Studying their Dielectric Properties For Antibacterial Applications, *Egypt. J. Chem.,* DOI: 10.21608/ EJCHEM.2019.11109.1712, (2019).

17. Ahmed Hashim, Hayder Abduljalil, Hind Ahmed, Analysis of Optical, Electronic and Spectroscopic properties of (Biopolymer-SiC) Nanocomposites For Electronics Applications, *Egypt. J. Chem.,* DOI: 10.21608/EJCHEM.2019.7154.1590, (2019).

18. Qayssar M. Jebur, Ahmed Hashim, Majeed A. Habeeb, Fabrication, Structural and Optical properties for (Polyvinyl Alcohol–Polyethylene Oxide– Iron Oxide) Nanocomposites, *Egypt. J. Chem.,* DOI:10.21608/EJCHEM.2019.10197.1669, (2019).

19. Ahmed Hashim, Majeed A. Habeeb and Qayssar M. Jebur, Structural, Dielectric and Optical properties for (Polyvinyl Alcohol–Polyethylene Oxide-Manganese Oxide) Nanocomposites, *Egypt. J. Chem.,* DOI: 10.21608/ejchem.2019.14849.1901, (2019).

20. Qayssar M. Jebur, Ahmed Hashim, Majeed A. Habeeb, Structural, A.C electrical and Optical properties of (Polyvinyl alcohol–Polyethylene Oxide–Aluminum Oxide) Nanocomposites for Piezoelectric Devices, *Egypt. J. Chem.,* DOI: 10.21608/ejchem.2019.14847.1900, (2019).

21. Noor Hayder, Majeed Ali Habeeb and Ahmed Hashim, Structural, Optical and Dielectric Properties of (PS- In_2O_3/$ZnCoFe_2O_4$) Nanocomposites, *Egypt. J. Chem.,* DOI: 10.21608/ ejchem.2019.14646.1887, (2019).

22. Ahmed Hashim, Majeed Ali Habeeb, Aseel Hadi, Qayssar M. Jebur, and Waled Hadi, Fabrication of Novel (PVA-PEG-CMC-Fe_3O_4) Magnetic Nanocomposites for Piezoelectric Applications, *Sensor Letters*, Vol. **15**, doi:10.1166/sl.2018.3935, (2017).

23. Majeed Ali Habbeb, Ahmed Hashim, Abdul-Raheem K. AbidAli, The dielectric properties for (PMMA-LiF) composites , *European Journal of Scientific Research,* Vol. **61**, No.3, pp. 367-371, (2011).

24. Qayssar M. Jebur, Ahmed Hashim, Majeed A. Habeeb, Structural, Electrical and Optical Properties for (Polyvinyl Alcohol–Polyethylene Oxide–Magnesium Oxide) Nanocomposites for Optoelectronics Applications, Transactions on Electrical and Electronic Materials, https://doi.org/10.1007/s42341-019-00121-x, (2019).

25. A. Muheisin, "Study of Electrical Conductivity for Amorphous and Semi crystalline Polymers Filled with Lithium Fluoride Additive", *M.Sc. Thesis*, University of Mustansiriah ,Col. of Sci. (2009).

26. D. M. Hercules, "*Fluorescence & Phosphorescence Analysis",* Inter Science Publisher a division of J. Wiley & Sons. New York. London. Sydney (1960).

27. Basavaraja., Min, Tae H., Sung D. and Wook, 2007,"Preparation Characterization and Low Frequency a.c conduction of Polypyrrole-Lead Titanate composites", *Bull. Korean Chem. Soc.,* Vol. **28**, No.7.

28. F.Hussain, and A. Zihlif, *J. of Thermoplastic Composite Material,* Vol. **6**, pp. 108-116 (1993).

29. A. Hashim, B. H. Rabee, Dielectric Properties of (PS-BaSO4.5H2O) Composites, *European Journal of Social Sciences,* Vol. **32,** No.3, pp. 316-320, (2012)

30. Shui G., Hu J., Qiu M., Wei M. and Xiao D., *J. Chinese Chem. Letters,* Vol. **15** , No. 12 , pp. (1501-1504), (2004).

تصنيع المتراكبات (PS-Cr_2O_3/ $ZnCoFe_2O_4$) النانوية ودراسة خصائصها العزلية والفلورة كمتحسسات للأشعة تحت الحمراء

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في العمل الحالي، تم دراسة الخصائص العزلية والفلورة لبولي ستايرين (PS)- اوكسيد الكروم (Cr_2O_3) و بولي ستايرين- اوكسيد الكروم المطعم باكاسيد خارصين كوبلت حديد النانوية. حضرت العينات باضافة جسيمات $ZnCoFe_2O_4$ النانوية للمتراكبات (PS-Cr_2O_3) النانوية و بنسب وزنية مختلفة هي (0, 2,4,6,8) نسبة وزنية. بينت النتائج ان ثابت العزل الكهربائي ، والفقدان العزلي الكهربائي والتوصيلية الكهربائية المتناوبة للمتراكبات (PS-Cr_2O_3) النانوية تزداد مع الزيادة في تراكيز جسيمات $ZnCoFe_2O_4$ النانوية. ان ثابت العزل الكهربائي والفقدان العزلي الكهربائي يقلان بينما التوصيلية الكهربائية تزداد مع زيادة التردد. نتائج الخصائص العزلية والفلورة بينت ان المتراكبات (PS-Cr_2O_3/$ZnCoFe_2O_4$) النانوية يمكن ان تستعمل في التطبيقات الكهروضوئية المختلفة.