OPEN ACCESS RESEARCH ARTICLE

Effect of the Yttrium Oxide (Y_2O_3) Nanoparticles on the Optical Properties of the Polyacrylamide (PAAm)

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Abstract

In this paper, the (PAAm/Y_2O_3) nanocomposites was prepared via casting process with different contented of Y_2O_3NPs (1, 3 and 5wt.%). The opticalproperties was investigated. The optical characteristics, such as optical density, coefficient of absorbance, index of refraction, coefficient of extinction, dielectric constant of real and imaginary and optical conductivity, showed a growing trend with increasing Y_2O_3 NPs concentration in the experiments. However, when the concentration of Y_2O_3 NPs increased, a reduction correlation was seen between these two parameters (transmittance and indirect energy gap, both allowed and banned. Finally, from this result can be used these nanocomposites as the photodetectors application specially in the UV region.

Keywords: PAAm, Y_2O_3, nanocomposites, optical properties

1. Introduction

Natural or synthetic polymers are used to create polymer nanocomposites, which are nanomaterials due to their nanoscale topography or composition[1]. Nanomaterials and nanocomposites may be cutting-edge in the context of materials research, yet their natural occurrence has made them familiar to scientists for decades. Nanoscale structural characterization and manipulation approaches, however, have been stimulated very recently[2].Nanocomposites follow the same structure as any other compound, with a filler and a matrix. While fibers like carbon and glass are commonly utilized as fillers in traditional composites, nanomaterials play that role in nanocomposites. Nanomaterials include things like carbon nanotubes, carbon fiber tubs, and nanoparticles of precious metals, semiconductors, and metals [3]. Polymer nanocomposites, formed by incorporating inorganic nanocomposites into an organic polymer, have attracted a lot of attention in recent years. Because of the basic and crucial part played in their applications by nanostructure control composition and shape, By successfully transferring the qualities of the original components into a single material, nanocomposites can get their new properties [4].

Polyacrylamide (PAAm) is additional watersolvable polymer that has a variedvariety of manufacturingwoollyrequests, rheology-control agents, dragtumbling polymers, and glues. PAAm and their derivatives increased attention during the past years and to the present time [5-7]. PAAm is often used to increase the viscosity of water, polyamides and an acrylic material solid crystal is very stable [8]. The presence of aggregates amine and carboxyl in the dry polymer chains lead to a severe reaction molecule when calculating the hydrogen bonds between chains and polyamides scores with very high melting relatively. Because bonded hydrogen molecular and differences in the hydrogen profile bonded poly amid and effectiveness increases strength and cohesion are used in the formation of fibers, called these kind nylons [9, 11].

Yttrium Oxide(Y_2O_3) is a ceramic substantial known for its amazing belongings, such as excellent rigidity, tallsweetopinion, substantial attireconfrontation, and chemical constancy. The aforementioned characteristics make it a material with great potential for use in applications that need extremely high temperatures [11].

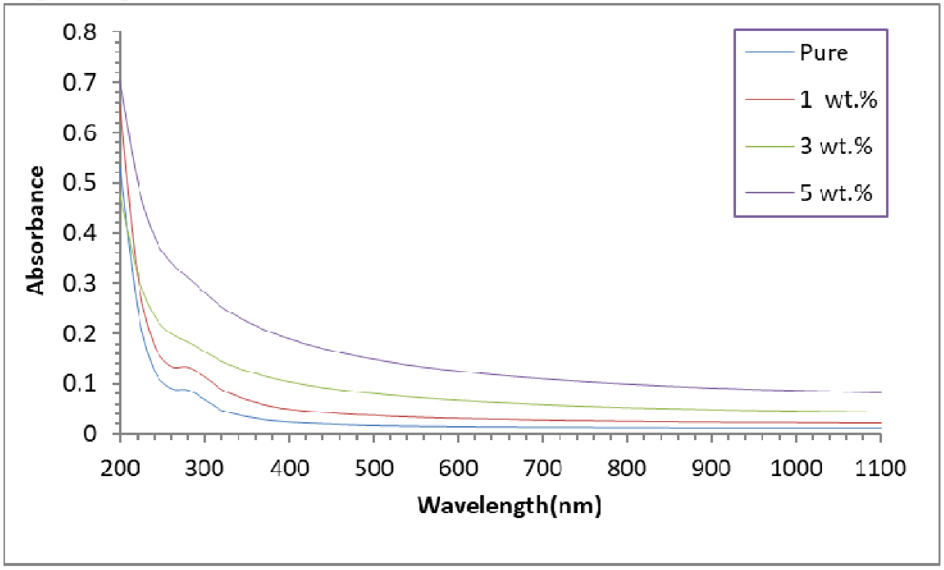
The aim of this work is preparation of the PAAm/Y_2O_3film via casting technique and obtain the effect of the Y_2O_3NPs on the opticalproperties ofpolymer.

3. Preparation of (PVA/PAAm/CMC/ZrC) nanocomposite

A solution was prepared by dissolving 1 g of PAAmpolymer in 50 mL of distilled water. In order to dissolve the substance completely, a magnetic stirrer was used to vigorously mixture the liquid at a temperature of 70 ^{o}C for a period of 30 minutes or until complete dissolution was achieved, resulting in the production of a uniform mixture. The work entailed integrating Y_2O_3NPs into the solution at concentrations of 1, 3 and 5 wt.%, with the aim of producing nanocomposites. Afterwards, the casting procedure was utilized.A Shimadzu UV-1650 PC spectrophotometer, manufactured by Phillips, a Japanese corporation, was used to examine the development of nanocomposite at wavelengths ranging from 200 to 1100 nm.

3. Result and Discussion

The absorption (PAAm/Y_2O_3) nanocomposite with various content (Y_2O_3) nanoparticles were verified at range 200-1100 nm at RT. The optical density for (PAAm/Y_2O_3) nanocomposite through wavelength at the occurrence light are shown in figure (1) respectively. It is observed, the absorbance rises with rising content of Y_2O_3, while in each sample, it is descending by rising wavelength (photon with lower energy) since of the giver level electrons existence to the C.B at high energy. Because photons have sufficient energy to make atoms to respond, it is possible for an electron to be stimulated from a lesser to a developed energy near just by absorbing a photon that has already been established. These results agree with otherstudies[12, 13].



Figure(1): The optical densitywiththe wavelength ofsamples

Figure(2) demonstrates the transmittance of (PAAm/Y_2O_3) nanocomposite with wavelength. The transmittance reduces as the concentration of Y_2O_3 nanoparticles rise, also increased with increasing of wavelength, which is due to the accumulation of nanoparticles with increasing contented [14].

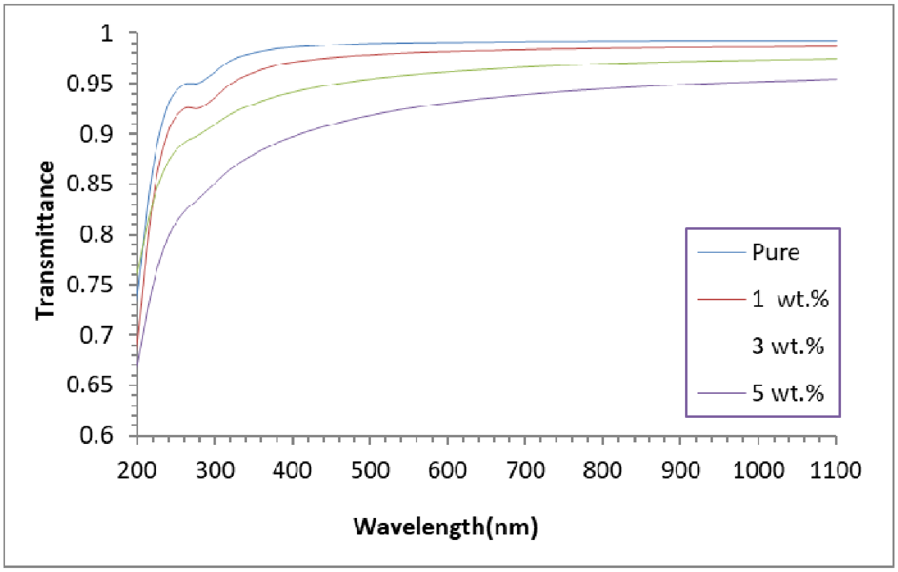


Figure (2): Change transmittance of ($PAAm/Y_2O_3$) nanocompositesversus the wavelengths.

An empirical correlation was utilized to get the absorption coefficient [15].

$$\alpha = 2.303\frac{A}{t}$$

Where A is the absorbance. Figure (3) illustrates the association amid the photon energy and the α of the ($PAAm/Y_2O_3$) nanocomposite. The αmight aid to symbol out what gentle of electron conversiontrade with. It is expected that straight electron conversions occur when the $\alpha$is large ($>10^4$ cm^{-1}). When the α is low ($<10^4$ cm^{-1}), an indirect conversion of electrons is expected thenstandards of α of the ($PAAm/Y_2O_3$) film, the transition of the electron takes place in a roundabout way. Because of anrise in the total amount of charge transporters, the $\alpha$of ($PAAm/Y_2O_3$) nanocomposites increased with increasing of Y_2O_3 nanoparticles. The rise in the value of nanocomposites can be attributed to this phenomenon [16].

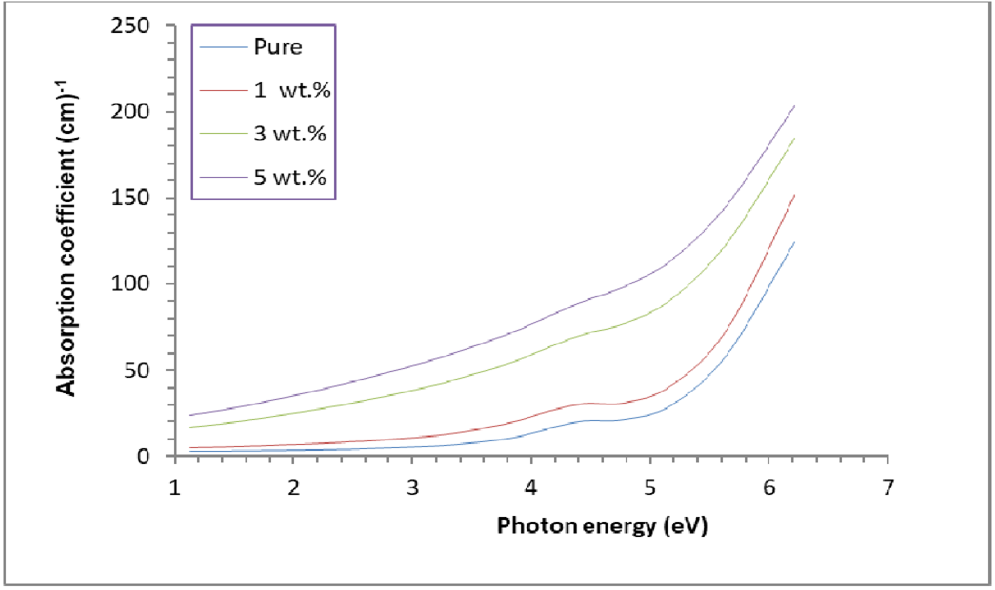


Figure (3): The distinction absorption coefficient of ($PAAm/Y_2O_3$) nanocompositesversus the photon energies.

The energy gap is given by [17]:
$(\alpha h\upsilon)^{1/m} = C(h\upsilon - E_g)$

For any constant C, the E_g is denoted as hυ, the energy gap is represented as Eg, and m can take on the values of 2 and 3 for allowable and prohibited indirect conversions, respectively.The E_g for allowable and prohibitedindirect conversions of (PAAm/Y_2O_3) film are showed in figures (4, 5),utilizing the intercept of the expanded linear segment. A linear segment was generated by isolating a section of the depicted curve to analyze the disparity in energy. From these figures, the E_g are decrease with the rise of the Y_2O_3nanoparticle contents, this act is owing to the creation of energy levels in the $E_g$and therefore, these local stagesdecrease the E_g with growth of the Y_2O_3 nanoparticle contents [18]. The value of the E_g of nanocomposites are recorded in Table (1).

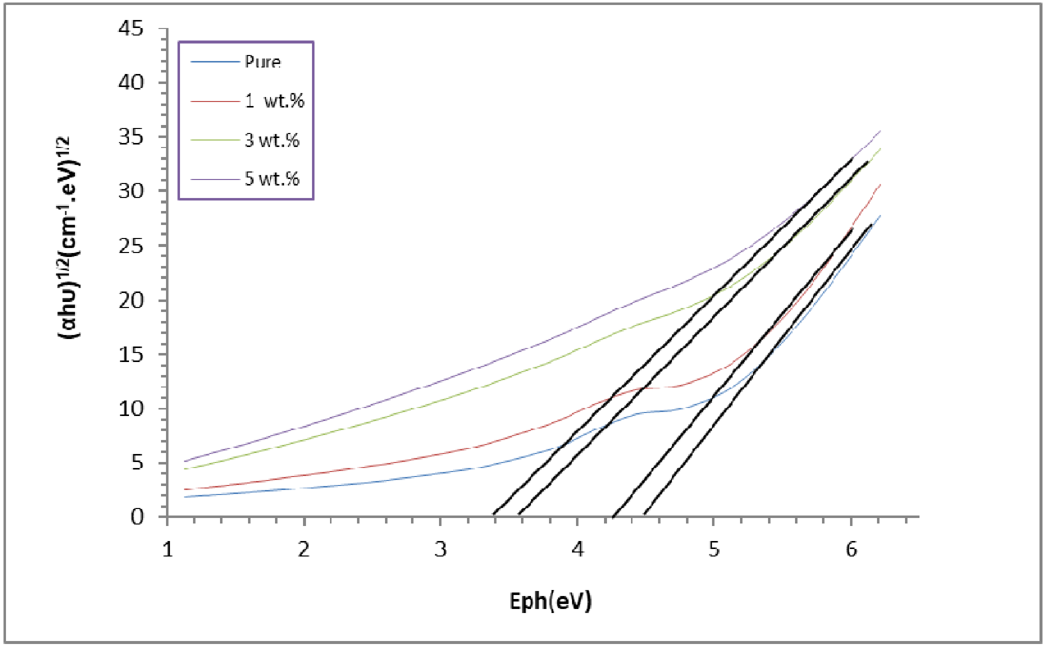
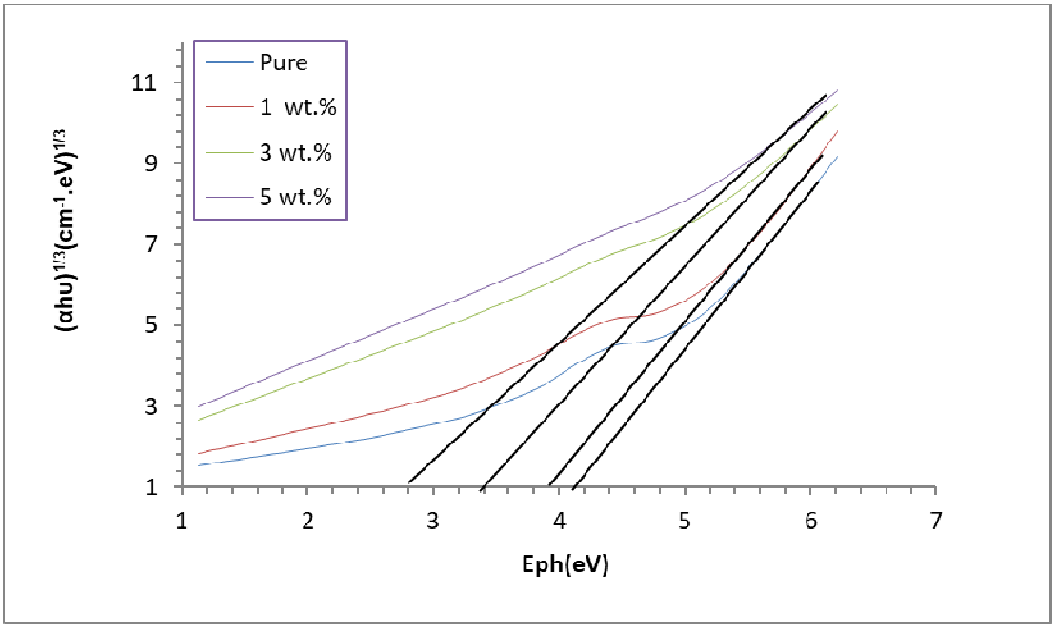


Figure (4): The $(\alpha hv)^{1/2}$ $(cm^{-1}.eV)^{1/2}$ of (PAAm/Y_2O_3)nanocompositesversus photon energy.



Figure(5): The $E_g$for $(\alpha hv)^{1/3}$ $(cm^{-1}.eV)^{1/3}$ of (PAAm/Y_2O_3)nanocompositesversus photon energy.

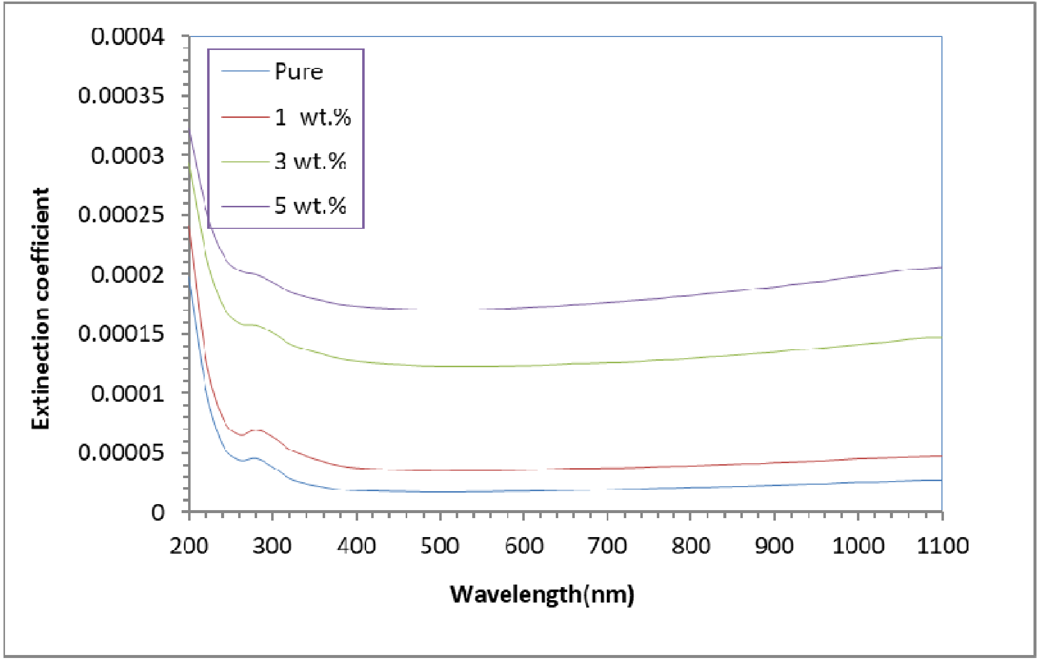
Table (1):The values of indirect optical energy gap of (PAAm/Y_2O_3)nanocomposite

Y_2O_3wt% NPs content	E_g allowed indirect (eV)	E_g forbidden indirect (eV)
4.16	4.5	0
3.95	4.28	1
3.4	3.6	3
2.8	3.4	5

The extinction coefficient (K_o)is assumed by the relation [19]

$k = \alpha\lambda/4\pi$

where λ is the wavelength**.** Figure (6) demonstrates thek of (PAAm/Y_2O_3) with of wavelength. It is detected that the extinction coefficient of nanocomposites growths with the rise of the Y_2O_3 nanoparticlecontents and reduce with rising wavelength, this is owing to the growth inabsorption in the (PAAm) polymer matrix.



Figure(6): Variation of k for (PAAm/Y_2O_3) nanocompositesversus wavelength.

The index of refractive (n) was calculated from relation [15].

$$n = \frac{1+\sqrt{R}}{1-\sqrt{R}}$$

where R is the reflectance.The n of (PAAm/Y_2O_3) with wavelength are revealed in figure (7). It is found that the nrises with the growing of the content of Y_2O_3 nanoparticles and it decreases with the rise of the wavelength. This action is due to the rise of the density of nanocomposites [20].

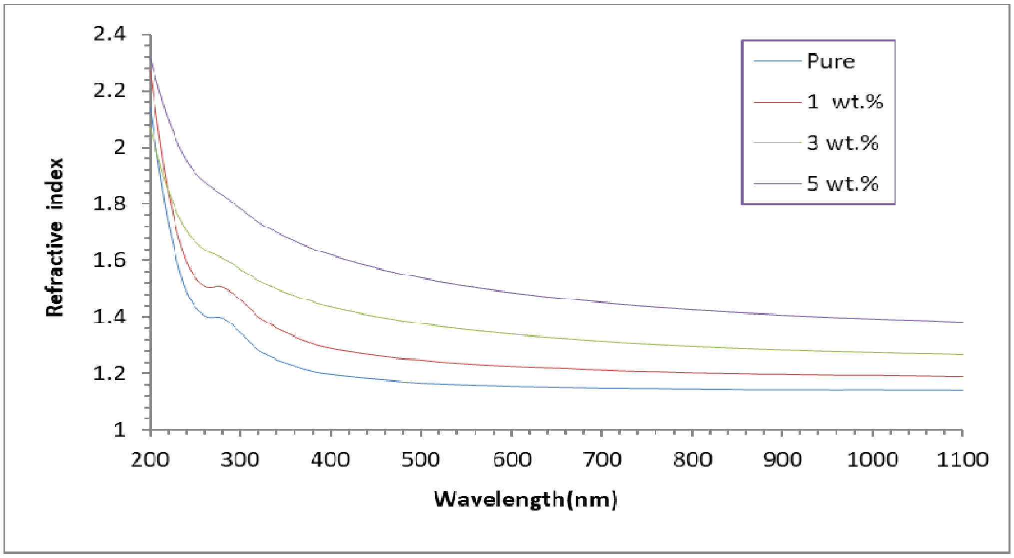


Fig. (7): Differenceof nfor (PAAm/Y_2O_3) nanocompositesversus wavelength

The dielectric constant is composed of two parts: the real part (ε_1) and the imaginary part (ε_2) [21]:

$$\varepsilon_1 = n^2 - k^2$$

$$\varepsilon_2 = 2nk$$

Theε_1 and ε_2 part of insulator constantwith the wavelength for (PAAm/Y_2O_3) are demonstrates in fig. (8) and (9) respectively. The data presented indicates that the insulator constant of PAAm/Y_2O_3nanocomposites has greater values for both the real and imaginary components at shorter wavelengths, and diminishes as the wavelength increases. The nanocomposite films display a prominent increase in both the real and imaginary values as the wavelength decreases. The observed resemblance can be elucidated by the fact that the effective dielectric constant is predominantly influenced by the magnitudes of (n) rather than (k), considering that the latter values are considerably less than the refractive index, particularly when squared [22, 23]

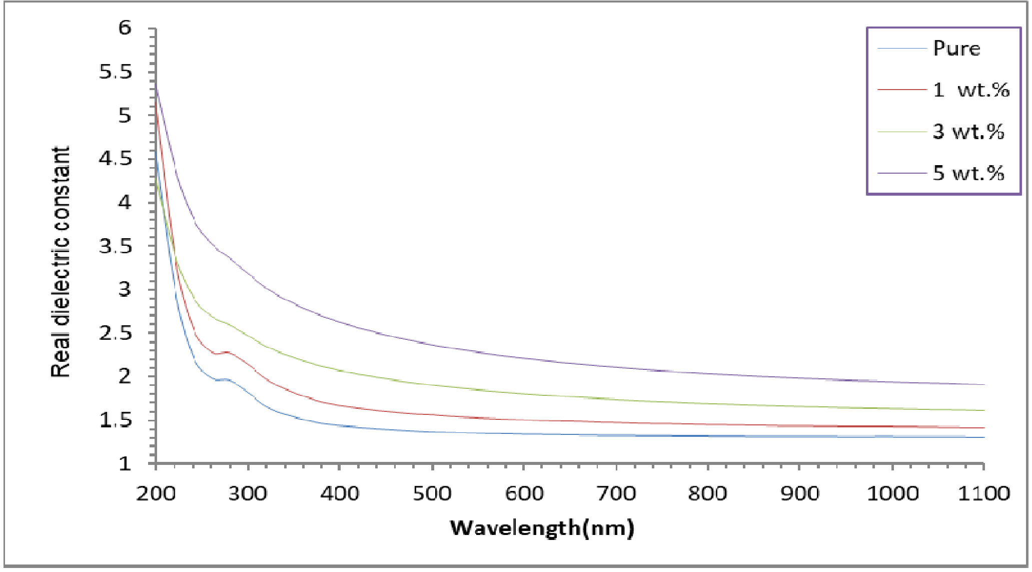
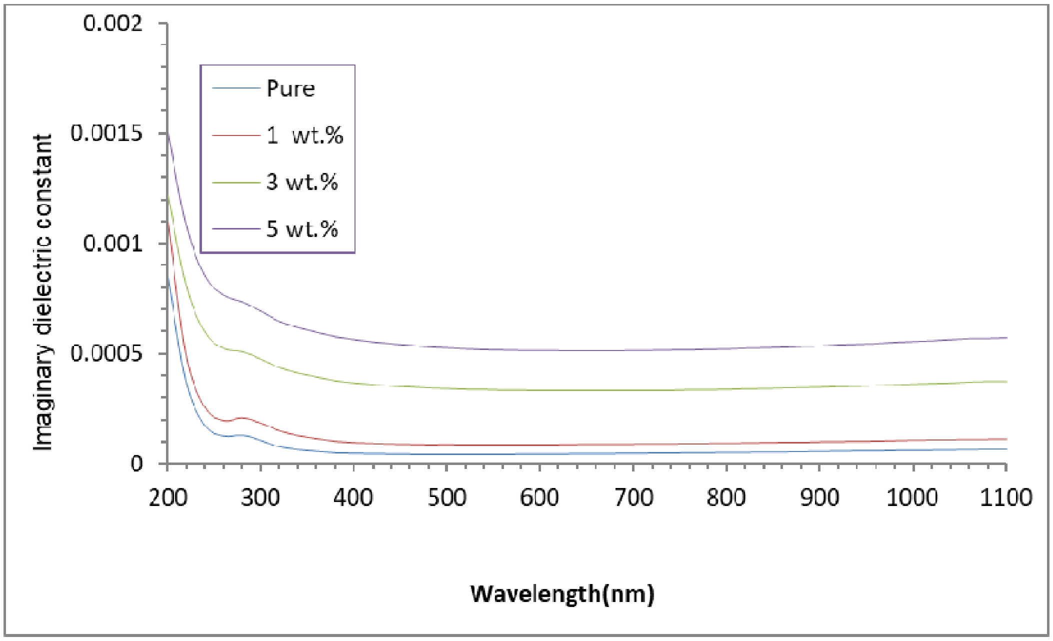


Figure (8): Difference of ε_1 of (PAAm/Y_2O_3)) with the wavelength



Figure(9): Distinction ε_2 of (PAAm/Y_2O_3) with wavelength.

The optical conductivity (σ_{op}) is definite by [24, 25]:

$\sigma_{op} = \alpha nc/4\pi$

where c is the speed of light**.** The $\sigma_{op}$of the of (PAAm/Y_2O_3) with a wavelength is shown in figure (11). The PAAm/Y_2O_3nanocomposites demonstrate a notable enhancement in optical conductivity at shorter wavelengths, followed by a reduction at longer wavelengths. This behavior can be explained by the concurrent increase in the absorption coefficient. The relationship between the concentration ofY_2O_3nanoparticles and the observed optical conductivity is found to be directly proportional[25].

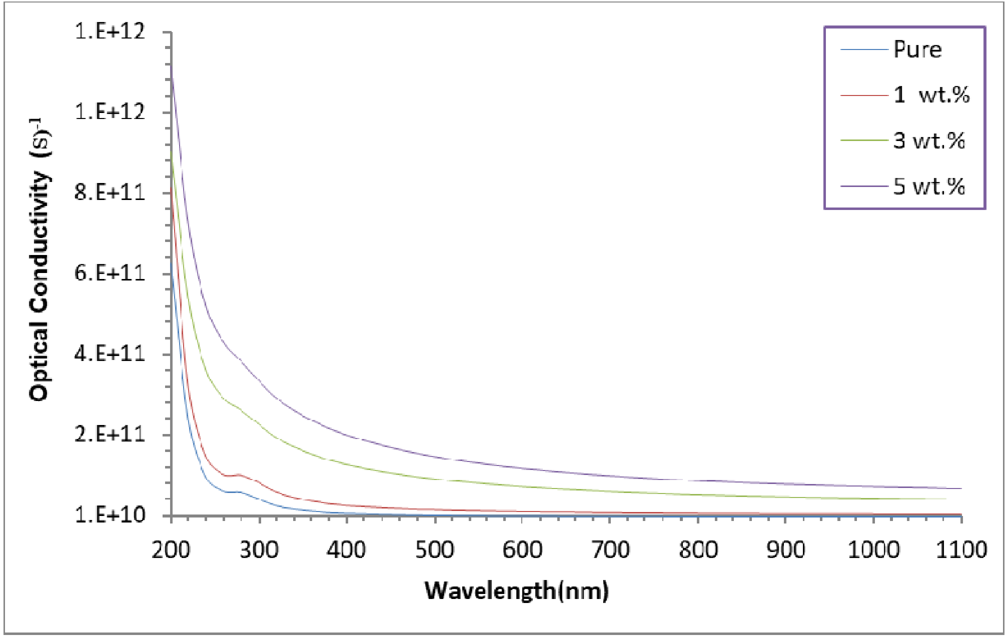


Figure (10): Variation σ_{op} of (PAAm/Y_2O_3) nanocomposites with the wavelength.

4- Conclusion

From these results can be concluded from results revealed that as the concentration of Y_2O_3 NPs increased, various optical properties such as absorbance, absorption coefficient, refractive index, extinction coefficient, real and imaginary dielectric constant, and optical conductivity also increased. Conversely, the transmittance and indirect energy gap reduced with growing concentration of Y_2O_3

NPs.Finally, from this result can be used these nanocomposites as the photodetector application specially in the UV region.

References

[1] A. H. Doulabi, K. Mequanint, and H. Mohammadi, “Blends and nanocomposite biomaterials for articular cartilage tissue engineering,” Materials (Basel)., vol. 7, no. 7, pp. 5327–5355, (2014).

[2] P. M. Ajayan, P. Redlich, and M. Ru¨ hle, “Structure of carbon nanotube□based nanocomposites,” J. Microsc., vol. 185, no. 2, pp. 275–282, (1997).

[3] J. Robertson, “Realistic applications of CNTs,” Mater. Today, vol. 7, no. 10, pp. 46–52, (2004).

[4] E. Tang, G. Cheng, and X. Ma, “Preparation of nano-ZnO/PMMA composite particles via grafting of the copolymer onto the surface of zinc oxide nanoparticles,” Powder Technol., vol. 161, no. 3, pp. 209–214, (2006).

[5] C. Demerlis and D. Schoneker, “Review of the oral toxicity of polyvinyl alcohol (PVA) - PDF Free Download”, Food Chem. Toxicol, Vol. 41, No. 3, pp. 319–326, (2003).

[6] C. Ravindra, M. Sarswati, G. Sukanya, P. Shivalila, Y. Soumya, and K. Deepak, “Tensile and thermal properties of poly (vinyl) pyrrolidone/vanillin incorporated polyvinyl alcohol films”, Res. J. Phys. Sci., Vol. 3, No. 8, pp. 1–6, (2015).

[7] k. Choo, Y. C. Ching, C. H. Chuah, S. Julai, and N. S. Liou, “Preparation and characterization of polyvinyl alcohol-chitosan composite films reinforced with cellulose nanofiber”, Materials, Vol. 9, No. 8, p.644. (2016).

[8]H. Dweik, W. Sultan, M. Sowwan, and S. Makharza, “Analysis characterization and some properties of polyacrylamide copper complexes”, International Journal of Polymeric Materials, Vol. 57, No. 3, pp.228-244,(2008).

[9] Abdul-K. Al-Bermany and Rusul Abdul-Amir Ghazi," Study the effect of increasing Gamma ray doses on some physical properties of Carboxy methyl cellulose", Advances in Physics Theories and Applications, Vol.6,pp. 1-14, 2012

[10] Wang, L., Zhang, F., Dai, W., Cheng, Q., Zhang, K., Wu, Y., ... & He, X. (2019). The synthesis of zirconium carbide nanoparticles by lithium thermal reduction of zirconium dioxide and waste plastic. Chemistry Letters, 48(6), 604-606.

[11] R.A.Abed Jassim," Effect of Chloride Groups ($Cocl_2$,$Crcl_2$ and Mncl2) on the Electrical and Optical Properties for (PVA-PVP) Films", M.Sc. Thesis,University of Babylon, College of Education for Pure Sciences, (2013).

[12] S. Kolpakov, N. Gordon, C. Mou, and K. Zhou, " Toward a New Generation of Photonic Humidity Sensors", Journal of Sensors, Vol.14, PP. 3986-4013; doi:10.3390/s140303986, 2014.

[13] N. B. Rithin Kumar, V. Crasta, R. F. Bhajantri and B.M. Praveen, "Microstructural and Mechanical Studies of PVA Doped with ZnO and WO_3 Composites Films", Journal of Polymers, Vol. 2014, Article ID 846140, 7 pages, 2014.

[14] Khadayeir, A. A., Abass, K. H., Chiad, S. S., Mohammed, M. K., Habubi, N. F., Hameed, T. K., & Al-Baidhany, I. A. (2018). Study the influence of antimony trioxide (Sb2O3) on optical properties of (PVA-PVP) composites. *Journal of Engineering and Applied Sciences*, *13*(22), 9689-9692.

[15] S. Salman, N. Bakr and M. H. Mahmood, "Preparation and study of some optical properties of (PVA- Ni(CH3COO)2) composites", International Journal of Current Research, Vol. 6, No.11, PP.9638-9643, 2014.

[16] Mousavi, Seyedeh S., Batool S. and Mohammad H. M. "Fast response ZnO/PVA nanocomposite-based photodiodes modified by graphene quantum dots" Materials & Design, Vol.162, pp.249-255, (2019).

[17] K. Karthikeyan, N. Poornaprakash, N. Selvakumar and Jeyasubrmanian, "Thermal Properties and Morphology of MgO-PVA Nanocomposite Film", Journal of Nanostructured Polymers and Nanocomposites, Vol. 5, No. 4, PP. 83-88, 2009.

[18] Al-Abbas, S. S., Ghazi, R. A., Al-shammari, A. K., Aldulaimi, N. R., Abdulridha, A. R., Al-Nesrawy, S. H., & Al-Bermany, E. (2021). Influence of the polymer molecular weights on the electrical properties of Poly (vinyl alcohol)–Poly (ethylene glycols)/Graphene oxide nanocomposites. *Materials Today: Proceedings*, *42*, 2469-2474.

[19] N. Arsalani, H. Fattahi and M. Nazarpoor, " Synthesis and characterization of PVP-functionalized superparamagnetic Fe3O4 nanoparticles as an MRI contrast agent", Journal of EXPRESS Polymer Letters Vol.4, No.6, PP. 329–338, 2010.

[20]Soliman, T. S., Vshivkov, S. A., &Elkalashy, S. I. (2020). Structural, thermal, and linear optical properties of SiO2 nanoparticles dispersed in polyvinyl alcohol nanocomposite films. Polymer Composites, 41(8), 3340-3350.

[21] Fal, J., Bulanda, K., Traciak, J., Sobczak, J., Kuzioła, R., Grąz, K. M., ... & Żyła, G. (2020). Electrical and Optical Properties of Silicon Oxide Lignin Polylactide (SiO2-L-PLA). Molecules, 25(6), 1354.

[22] Al-Rubaye, S. A. J., Al-lsawi, N. A., &Abdulridha, A. R. (2021). Preparation andStudy the Electrical and Optical Properties for (PVA-PEG-Sr2O3) Nanocomposites. *NeuroQuantology*, *19*(10), 47.

[23] Soliman, T. S., Vshivkov, S. A., &Elkalashy, S. I. (2020). Structural, thermal, and linear optical properties of SiO2 nanoparticles dispersed in polyvinyl alcohol nanocomposite films. Polymer Composites, 41(8), 3340-3350.

[24] C. Srikanth, C. Sridhar, B. M. Nagabhushana and R. D. Mathad, " Characterization and DC Conductivity of Novel CuO doped Polyvinyl Alcohol (PVA) Nano-composite Films ", Journal of Engineering Research and Applications, Vol. 4, Issue 10, PP.38-46, 2014.

[25] S. D. Meshram, R. Rupnarayan, S. V. Jagtap, V. G. Mete and V. S. Sangawar, "Synthesis and Characterization of Lead Oxide Nanoparticles", International Journal of Chemical and Physical Sciences, Vol. 4, Special Issue, PP. 83-88, 2015