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Development of Polymeric Blend/Yttrium Oxide Nanocomposites for Antibacterial Applications

Ammar Yahya[1], Hind Ahmed[1], Ahmed Hashim[1], Majeed Ali Habeeb[1], and Aseel Hadi[2]

[1]*College of Education for Pure Sciences,*
Department of Physics,
University of Babylon,
Babylon, Iraq
[2]*College of Materials Engineering,*
Department of Ceramic and Building Materials,
University of Babylon,
Babylon, Iraq

Fabrication of polyvinyl alcohol–polyethylene glycol–yttrium oxide nanocomposites and their structure and UV-characterizations for antibacterial applications are investigated. The PVA–PEG–Y_2O_3 nanocomposites are prepared with different concentrations of yttrium oxide nanoparticles and polymers. The results show that the optical parameters of blend are increasing while energy-gap decreases with an increase of yttrium oxide content. The results of optical characterization indicate that the PVA–PEG–Y_2O_3 nanocomposites may be used as high-activity antibacterial materials.

Досліджено виготовлення нанокомпозитів полівініловий спирт–поліетиленгліколь–оксид Ітрію та їхні структуру і УФ-характеристики для антибактеріяльних застосувань. Нанокомпозити PVA–PEG–Y_2O_3 готуються з різними концентраціями наночастинок оксиду ітрію та полімерів. Результати показують, що оптичні параметри суміші збільшуються, в той час як енергетична щілина зменшується зі збільшенням вмісту оксиду ітрію. Результати оптичної характеризації свідчать про те, що нанокомпозити PVA–PEG–Y_2O_3 можуть використовуватися як антибактеріяльні матеріяли високої активности.

Key words: nanocomposites, blends, yttrium oxide, optical parameters, antibacterial activity.

Ключові слова: нанокомпозити, суміші, оксид ітрію, оптичні параметри, антибактеріяльна активність.

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1. INTRODUCTION

Nanotechnology is promising as a fast growing area with its technological application for the reason of developed new substance in nanosize. It can be proved a boon, because it has a large possibility to get benefits in fields as information and communication technology, drug improvement, water decontamination. Nanomaterials' canister is also used for particular medical applications such as fabrication of new drug delivery, improving the presentation of biomedical instruments or fabrication of the analytical imaging substances. The antimicrobial indicate to a matter that death or control the growth of bacteria. Metal oxide nanoparticles are acknowledged to their strong antibacterial properties [1]. Polymers have to an increasing extent developed into attractive because of their broad of applications, *viz.*, optoelectronics, biotechnology and photonics. Polyvinyl alcohol (PVA) is water soluble with excellent mechanical and thermal characterizations. PVA has wide uses in fields such as building, electronics, medicine and other industries [2]. The properties of polymer–semiconductor nanocomposites dependent on size compose these materials especially attractive in conditions of their potential application in a variety of fields of technical such as single electron transistors, optical switch, solar cells, non-linear optics, and optoelectronics devices [3]. Yttrium oxide is promising for optoelectronic devices and for chemical catalysis. It is used for biological imaging applications [4]. Many papers investigated the potential of nanoparticle, permeation inside the bacterial as a potential toxicity method. Usually, three paths for nanoparticles' entree into cells occur: channel implication, endocytosis and diffusion. When come in the cell, nanoparticles may be possibly generating H_2O_2. This is the purpose of a particular mechanism occurring to void the existence of hydrogen peroxide for detoxifying the cell [5]. The addition of micro- and nanoparticles to the polymers deals with enhancement the properties of polymers such as electrical properties [6–9], dielectric properties [10–16], optical properties [17–19], *etc.* In this paper, fabrication and some physical properties of PVA–PEG–Y_2O_3 nanocomposites are investigated for biological applications.

2. THEORETICAL PART

Absorption coefficient α of nanocomposites is given using [20]:

$$\alpha = 2.303A/t, \quad (1)$$

where A is absorbance and t is thickness. The indirect transition type for amorphous materials calculated using the equation [21]:

$$\alpha h\nu = B(h\nu - E_g)^r\,, \tag{2}$$

where B is constant, $h\nu$—photon energy, E_{gg}—energy gap, for allowed transition ($r = 2$) or forbidden indirect ($r = 3$) transition.

Extinction coefficient k of nanocomposites is given as follows [22]:

$$k = \alpha\lambda/(4\pi). \tag{3}$$

Refractive index n is given using the relationship [23]:

$$n = (1 + R^{1/2}) / (1 - R^{1/2})\,. \tag{4}$$

The real (ε_1) and imaginary (ε_2) parts of dielectric constant are given by [24]:

$$\varepsilon_1 = n^2 - k^2,\ \varepsilon_2 = 2nk. \tag{5}$$

The optical conductivity is given using the equation [25]:

$$\sigma = \alpha nc / (4\pi)\,. \tag{6}$$

3. EXPERIMENTAL PART

Films of PVA–PEG–Y_2O_3 nanocomposites were fabricated from (polyvinyl alcohol-polyethylene glycol) as matrix and yttrium oxide nanoparticles as additive by using of the casting method. The 1 gm of 78 wt.% PVA/22 wt.% PEG was dissolved in 20 ml of distilled water.

The magnetic stirrer used to mix the materials for 1 hour. The Y_2O_3 added to the PVA/PEG with ratios are 2, 4 and 6 wt.%. Optical characterizations of PVA–PEG–Y_2O_3 nanocomposites test by using spectrophotometer (Shimadzu, UV-1800A) at wavelength of photons 200–800 nm.

4. RESULTS AND DISCUSSION

Figure 1 represents of absorbance variation with wavelength. From this figure, the optical absorbance spectra increase with increase the concentration of additive. In addition, the figure shows that the absorption spectra increase at UV that related to the electrons excitement at UV energies, so the optical absorption spectra of nanocomposites have low values at visible and near infrared areas [26–30]. The behaviour of absorbance spectra is consistent with the re-

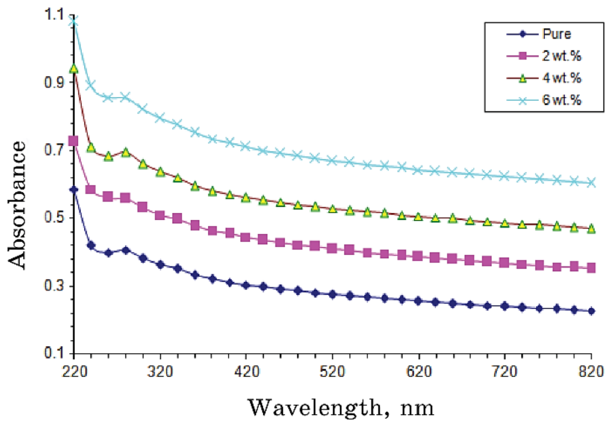

Fig. 1. The absorbance with wavelength for nanocomposites.

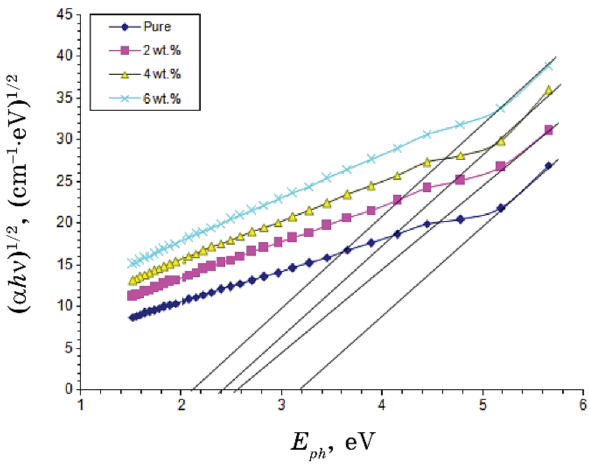

Fig. 2. Energy gap of PVA–PEG–Y_2O_3 nanocomposites for allowed indirect transition.

sults [31–35].

The energy gaps of PVA–PEG–Y_2O_3 nanocomposites are shown in Fig. 2 for allowed indirect transition. The energy gap decreases with the increase in Y_2O_3 percentages due to the levels formation in the energy gap [36, 37].

The electronic conduction depends on Y_2O_3 concentrations and increases with increase in Y_2O_3 percentages [38] shown in Fig. 3.

The refractive index with wavelength is shown in Fig. 4. The refractive index increases with increasing of Y_2O_3 concentrations that attributed to increase of the density of nanocomposites [39–43].

Figure 5 shows the dielectric constant with wavelength. The real

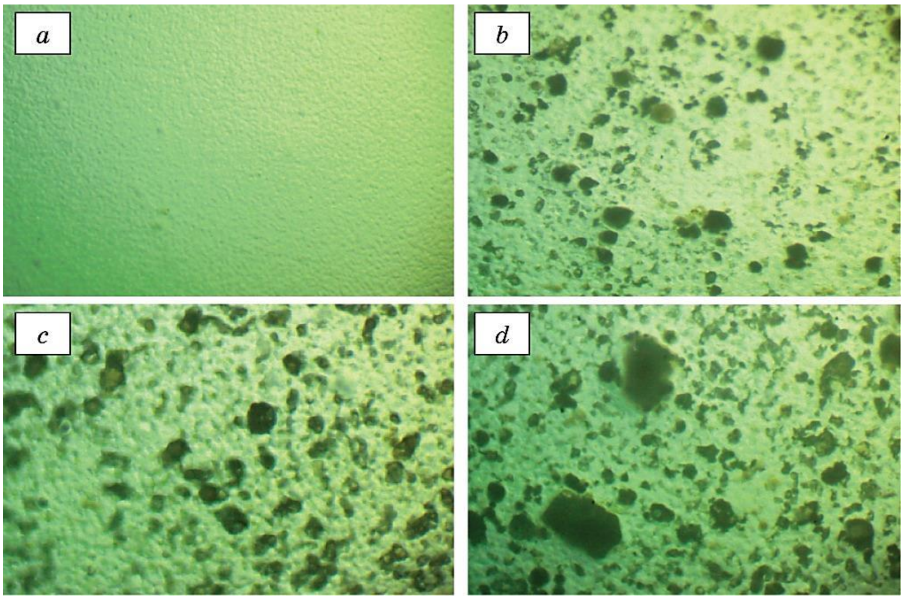

Fig. 3. Microscope images (×10): (*a*) pure blend; (*b*) 2 wt.% Y_2O_3; (*c*) 4 wt.% Y_2O_3; (*d*) 6 wt.% Y_2O_3.

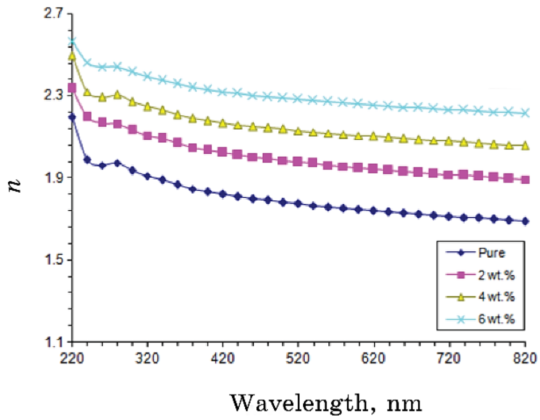

Fig. 4. Refractive index as a function of wavelength.

part generally depends on n^2 because the k^2 values are small [44, 45].

Figure 6 shows the optical conductivity variation with wavelength. The conductivity increases with increase of Y_2O_3 concentrations. The increase of optical conductivity related to the new levels formation in the band gap [46–50].

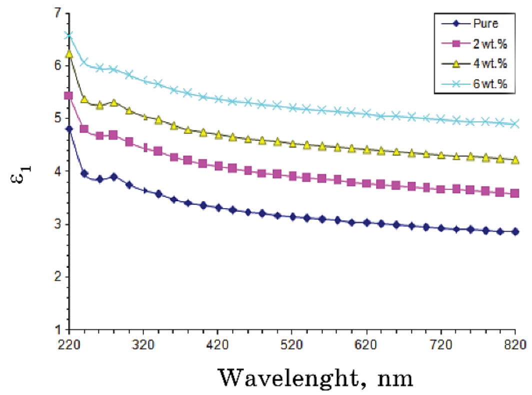

Fig. 5. Real part of dielectric constant with wavelength.

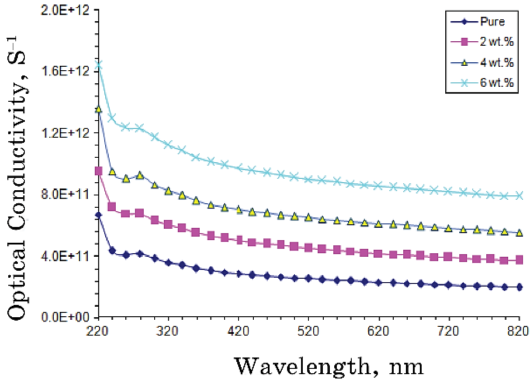

Fig. 6. Optical conductivity variation with wavelength.

5. CONCLUSION

The optical absorbance of PVA/PEG blends changes with an increase of Y_2O_3 concentration. The energy gap of polymer blend decreases with an increase of weight percentages of Y_2O_3 nanoparticles. The optical parameters change as Y_2O_3 nanoparticles' concentrations increase.

REFERENCES

1. S. Pişkin, A. Palantöken, and M. Yılmaz, *International Conference on Emerging Trends in Engineering and Technology—ICETET'2013 (December 7–8, 2013, Patong Beach, Phuket, Thailand)*.
2. S. M. K. Kamath, H. G. H. Kumar, R. Chandramani, and M. C. Radhakrishna, *Archives of Phys. Res.*, **6**, No. 2: 18 (2015).
3. A. Novruzova, M. Ramazanov, A. Chianese, F. Hajiyeva, A. Maharramov,

and U. Hasanova, *Chem. Eng. Transactions.*, **60**: 61 (2017); doi:10.3303/CET1760011
4. S. K. Kannan and M. Sundrarajan, *Bull. Mater. Sci.*, **38**, No. 4: 945 (2015).
5. M Bonnet, C. Massard, P. Veisseire, O. Camares, K. O. Awitor, *J. of Biomaterials and Nanobiotechnology*, **6**: 213 (2015).
6. H. Abduljalil, A. Hashim, and A. Jewad, *European Journal of Scientific Research*, **63**, No. 2: 231 (2011).
7. Z. Al-Ramadhan, A. Hashim, and A. J. K. Algidsawi, *AIP Conference Proceedings*, **1400**, No. 1: (2011); https://doi.org/10.1063/1.3663109
8. A. Hashim and Z. S. Hamad, *J. Nanostruct.*, **9**, No. 2: 340 (2019); doi:10.22052/JNS.2019.02.016
9. K. H. H. Al-Attiyah, A. Hashim, and S. F. Obaid, *J. of Bionanoscience*, **12**, Iss. 2: (2018); doi:10.1166/jbns.2018.1526
10. M. A. Habbeb, A. Hashim, and Abdul-Raheem K. AbidAli, *European Journal of Scientific Research*, **61**, No. 3: 367 (2011).
11. A. Hashim, M. A. Habeeb, A. Hadi, Q. M. Jebur, and W. Hadi, *Sensor Letters*, **15**: 998 (2017); doi:10.1166/sl.2018.3935
12. A. Hashim and A. Hadi, *Sensor Letters*, **15**, No. 12: 1019 (2017); doi:10.1166/sl.2017.3910
13. A. Hashim and Q. Hadi, *Sensor Letters*, **15**, No. 11: 951 (2017); doi:10.1166/sl.2017.3892
14. D. Hassan and A. H. Ah-Yasari, *Bulletin of Electrical Engineering and Informatics*, **8**, Iss. 1: 52 (2019); doi:10.11591/eei.v8i1.1019
15. D. Hassan and A. Hashim, *Bulletin of Electrical Engineering and Informatics*, **7**, Iss. 4: (2018); doi:10.11591/eei.v7i4.969
16. A. Hashim and A. Hadi, *Ukrainian Journal of Physics*, **63**, No. 8: 754 (2018); https://doi.org/10.15407/ujpe63.8.754
17. A. Hashim and M. A. Habeeb, *Transactions on Electrical and Electronic Materials*, **20**: 107 (2019); doi:10.1007/s42341-018-0081-1
18. A. Hashim and A. Jassim, *Journal of Bionanoscience*, **12**: 170 (2018); doi:10.1166/jbns.2018.1518
19. A. Hashim and M. A. Habeeb, *J. of Bionanoscience*, **12**, No. 5: 660 (2018); https://doi.org/10.1166/jbns.2018.1578
20. M. Al-Tweissi, M. A. Tarawneh, M. Q. Owaidat, M. Alsboul, and M. Alsboul, *J. of Nano- and Electronic Physics*, **10**, No. 5: (2018).
21. Z. Heiba, M. Mohamed, and N. Imam, *Intern. Polym. Processing*, (2018); doi:10.3139/217.3469
22. O. Guirguis and M. Moselhey, *J Mater Sci.*, **46**: 5775 (2011); doi:10.1007/s10853-011-5533-5
23. S. Agarwal, Y. K. Saraswat, and V. K. Saraswat, *Open Phys., J.*; 3: 63 (2016).
24. M. Ghanipour and D. Dorranian, *J. of Nanomaterials*, **2013**: 897043 (2013).
25. M. Aslam, M. Kalyar, and Z. Raza, *J. Materials Sci.: Mater Electron.*, (2017); doi:10.1007/s10854-017-7177-y
26. A. P. Indolia and M. S. Gaur, *J. of Polym. Res.*, **20**, No. 43: 1 (2013).
27. I. R. Agool, F. S. Mohammed, and A. Hashim, *Advances in Environmental Biology*, **9**, No. 11: 1 (2015).
28. B. H. Rabee and A. Hashim, *European Journal of Scientific Research*, **60**, No. 2: 247 (2011).
29. N. H. Al-Garah, F. L. Rashid, A. Hadi, and A. Hashim, *Journal of Bionano-*

science, **12**: 336 (2018); doi:10.1166/jbns.2018.1538

30. H. Ahmed, H. M. Abduljalil, and A. Hashim, *Transactions on Electrical and Electronic Materials*, **20**: 218 (2019); https://doi.org/10.1007/s42341-019-00111-z
31. S. Hadi, A. Hashim, and A. Jewad, *Australian Journal of Basic and Applied Sciences*, **5**, No. 9: 2192 (2011).
32. F. A. Jasim, A. Hashim, A. G. Hadi, F. Lafta, S. R. Salman, and H. Ahmed, *Research Journal of Applied Sciences*, **8**, Iss. 9: 439 (2013).
33. F. A. Jasim, F. Lafta, A. Hashim, M. Ali, and A. G. Hadi, *Journal of Engineering and Applied Sciences*, **8**, No. 5: 140 (2013).
34. A. Hashim and A. Hadi, *Sensor Letters*, **15**, No. 10: (2017); doi:10.1166/sl.2017.3900
35. A. Hashim, M. A. Habeeb, A. Khalaf, and A. Hadi, *Sensor Letters*, **15**: 589 (2017); https://doi.org/10.1166/sl.2017.3856
36. A. J. Kadham, D. Hassan, N. Mohammad, and A. Hashim, *Bulletin of Electrical Engineering and Informatics*, **7**, No. 1: 28 (2018); doi:10.11591/eei.v7i1.839
37. A. Hashim and Q. Hadi, *J. of Inorganic and Organometallic Polymers and Materials*, **28**, Iss. 4: 1394 (2018); https://doi.org/10.1007/s10904-018-0837-4
38. H. Ahmed, H. M. Abduljalil, and A. Hashim, *Transactions on Electrical and Electronic Materials*, **20**: 206 (2019); https://doi.org/10.1007/s42341-019-00100-2
39. A. Hashim and A. Jassim, *Sensor Letters*, **15**, No. 12: 1003 (2017); doi:10.1166/sl.2018.3915
40. A. Hashim, I. R. Agool, and K. J. Kadhim, *Journal of Materials Science: Materials in Electronics*, **29**, Iss. 12: 10369 (2018); https://doi.org/10.1007/s10854-018-9095-z
41. A. Hashim, K. H. H. Al-Attiyah, and S. F. Obaid, *Ukr. J. Phys.*, **64**, No. 2: (2019); https://doi.org/10.15407/ujpe64.2.157
42. K. H. H. Al-Attiyah, A. Hashim, and S. F. Obaid, *International Journal of Plastics Technology*, **23**, No. 1: (2019); https://doi.org/10.1007/s12588-019-09228-5
43. A. Hashim and Z. S. Hamad, *J. of Bionanoscience*, **12**, No. 4: 488 (2018); doi:10.1166/jbns.2018.1551
44. A. Hashim and Q. Hadi, *Journal of Materials Science: Materials in Electronics*, **29**: 11598 (2018); https://doi.org/10.1007/s10854-018-9257-z
45. A. Hashim and N. Hamid, *Journal of Bionanoscience*, **12**, No. 6: 788 (2018); doi:10.1166/jbns.2018.1591
46. A. Hashim and Z. S. Hamad, *J. of Bionanoscience*, **12**, No. 4: 504 (2018); doi:10.1166/jbns.2018.1561
47. D. Hassan and A. Hashim, *J. of Bionanoscience*, **12**, No. 3: 341 (2018); doi:10.1166/jbns.2018.1533
48. D. Hassan and A. Hashim, *J. of Bionanoscience,* **12**, No. 3: 346 (2018); doi:10.1166/jbns.2018.1537
49. O. Gh, B. Aziz, and D. Mohammed, *Indian Journal of Applied Research*, **3**, Iss. 11: 477 (2013).
50. M. Venkatarayappa, S. Kilarkaje, A. Prasad, and D. Hundekal, *J. of Materials Science and Engineering A*, **1**: 964 (2011).