Preparing and studying of Au Nanocomposites Synthesized with different polymer matrix

Amer N. Jarad[1], Ahmed S. Abed[2], Kahtan A. Mohammed[2,3*], Rahman S. Zabibah[4], Mohammed Al-khafaji[5], Sameer Algburi[6], Shubham Sharma[7,8,9]

[1] Department of Material Science, Polymer Research Centre, University of Basrah, Iraq
[2] Jabir Ibn Hayyan Medical university, Najaf, Iraq
[3] Department of Medical Physics, Hilla University College, Babylon, Iraq
[4] Medical Laboratory Technology Department, College of Medical Technology, the Islamic University, Najaf, Iraq.
[5] National University of Science and Technology, Dhi qar, Iraq
[6] Computer Engineering Techniques Department, College of Engineering Techniques, Al-Kitab University, Iraq .
[7] Mechanical engineering Department, University Center for research and Development, Chandigarh University, Mohali, Punjab, 140413, India
[8] Department of Mechanical Engineering, Lebanese American University, Kraytem 1102-2801, Beirut, Lebanon
[9] Faculty of Mechanical Engineering, Opole University of Technology, 45-758 Opole, Poland.
Kahtan444@gmail.com

Abstract. This work investigates the impact of several polymer matrix types, which are utilised as a capping layer around gold particles, on the optical properties. Nanocomposite materials consisting of gold and polymers such as polyethylene oxide, polyvinyl alcohol, and polyvinyl pyrrolidone were produced by a chemical reduction process. Tri sodium citrate was employed as the reducing agent. using the drop casting approach, nanocomposites based on gold were successfully put as a film on glass substrates.. An investigation was conducted to determine the influence of the polymer matrix type on the optical properties, including surface plasmon resonance, direct band gap, and indirect band gap. Furthermore, the absorption spectra of the materials that were synthesised demonstrated that the selection of the polymer that was utilised during the preparation process has a considerable impact on the location of the plasmonic absorption peak as well as the magnitude of the energy gap. Within the range of 1.9 to 2.3 electron volts (eV), the band gaps were found to be present.

Keywords: Nanocomposites; Au nanoparticles; surface plasmon resonance; polymer matrix; chemical reduction

1 Introduction

Nanoparticles composed of noble metals have sparked significant interest. The size of objects also affects their optical features, magnetic properties, catalytic properties, and other similar attributes [1]. An additional factor that contributes to the phenomenon is the presence of plasmon resonance absorption in metal nanoparticles that operates within the ultraviolet-visible spectrum. The small particle size of the material is responsible for the orderly arrangement of electrons that can be found in the conduction band. The particle shift is affected by a number of characteristics, including the size of the particles, the chemical environment, the species that are adsorbed on the surface, and the dielectric constant itself. [2-4]. Gold nanoparticles (Au NPs) and silver nanoparticles (Ag NPs) exhibit unique optical characteristics, particularly in terms of colour. Conduction electrons, when combined with incoming light, exhibit collective oscillations that have several practical uses[5,6].

Gold is regarded as a noble and essential metal because of its resistance to chemical abrasion and oxidation, as well as its resistance to high temperatures and temperature variations, which can affect the conditions of the surrounding environment, such as when metalworking and other activities are being performed [7]. Both of these properties make gold a valuable and essential metal. A wide variety of functionalities can be achieved with AuNPs, which are easily functionalized. A wide range of ligands, including polymers, DNA, peptides, RNA, and fluorescent chemicals, are the ones that are most suitable for use in bioimaging applications. In addition, a large number of cytotoxicity studies demonstrated that they had a low level of cytotoxicity [8]. Platinum's atomic weight causes it to be inert, which in turn causes it to be toxic. Polymeric matrices are an excellent option for the synthesis of hybrid nanocomposites [9-17] due to their adaptable chemistry, ecologically friendly design, and adaptability in a wide range of domains. This paper details the growth and optical properties of polyvinylpyrilidone (PVP), polyvinyl alcohol (PVA), and polyethylene oxide (PEO) nano-composite systems, which use metal nanoparticle-sized particles of gold. The paper focuses on the absorption and indirect and direct energy gaps of the system.

2 EXPERIMENTAL PART:

2.1 Synthesis of gold nanocomposites

gold nanocomposites were synthesized via a chemical reduction method and incorporated of PEO, PVP and PVA in order to study the effect of polymer type on optical properties . Au composites were synthesized using TSC as reduction agents via the chemical method. PVA, PEO and PVP solutions were prepared by dissolving 0.1 g from each polymer in 10 mL of deionized water. The colloidal solutions are obtained by mixing 10 of 0.005 M aqueous solutions of gold chloride and 10 ml of PEO, PVP and PVA minutes using a magnetic stirrer to get a homogeneous solution. polymers were added to gold ions due to the formation of hydrophobic domains that surround particles and protect them against agglomeration. These were followed by adding the appropriate amount of 0.01 M TSC under vigorous stirring for 30 minutes at 70 C .

3 Results and discussion

The analysis of the absorption spectra of gold nanocomposites is accomplished by the utilization of UV-Vis spectroscopy. FIGURE 1 demonstrates the UV–Vis absorption spectra of gold nanocomposites that were synthesized by utilising (a) PEO, (b) PVP, and (c) PVA.
Figure 1. a shows Au-PEO surface plasmon resonance in the range 550 nm whichis comparable in this instance, and peak boarding shows that the particles are polymeric. The dispersed sharp peak reflects the particle size homogeneity [18,19].

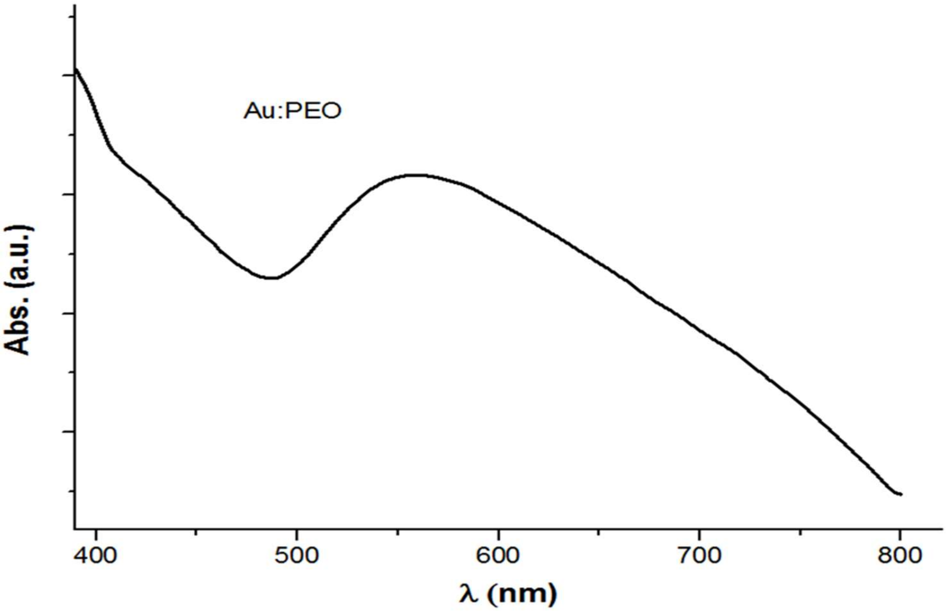

Figure 1. A absorbance spectrum of Au-PEO

The absorption spectrum of the Au capped with PVP nanocomposite colloid solution are presented in Figure 1. It is worth noting that the absorption spectrum of the Au colloid does not exhibit a surface plasmon absorption band, which may be attributed to aggregation [20].

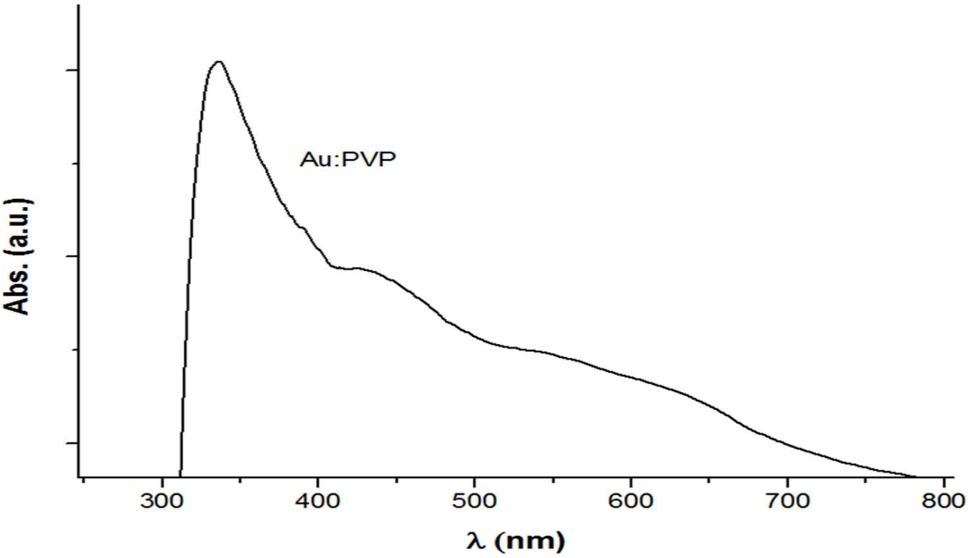

Figure 1. b absorbance spectrum of Au-PVP
Figure 1 presents a visual representation of the absorption bands that are present in the Au-PVA nanocomposite colloid solution. At a wavelength of 550 nm, the wavelength at which the surface plasmon absorption band is observed in the absorption spectra of the gold colloid is the maximum.

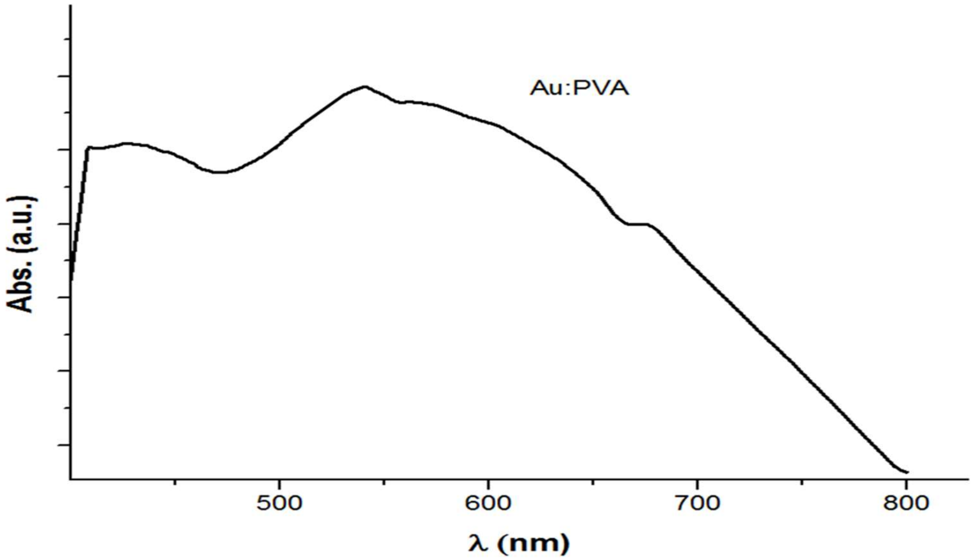

Figure 1. C absorbance spectrum of Au-PVA

Figures 2,3 depicts the direct and indirect energy band gaps for Au/PEO, PVA/Au nanocomposites, and PVP/Au nanocomposites as a function of hv. (a.b.c), as well as Figure 2. (a.b.c) and figure 3. (a,b,c).From the intercepts of the best-fit lines on the x-axis, the direct and indirect energy band gaps were calculated and published in Table 1.

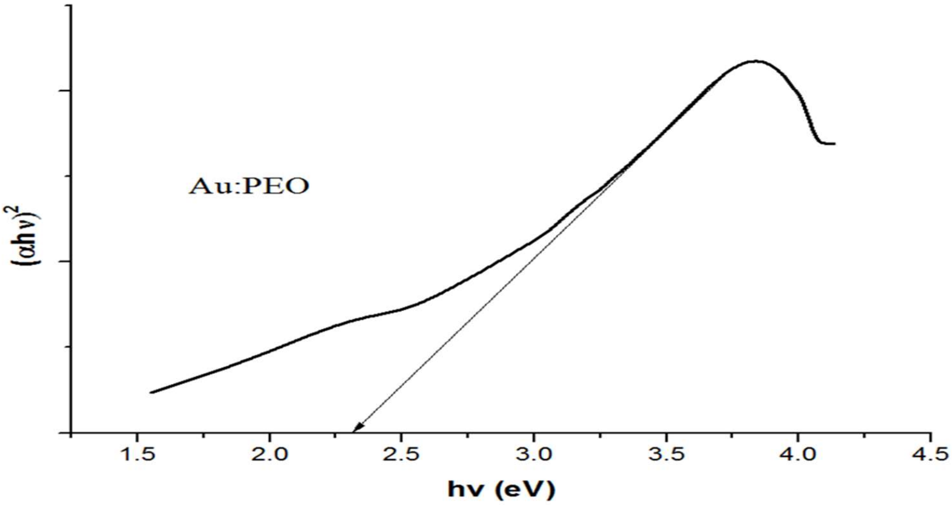

Figure 2. a. The energy band gap forAu/PEO

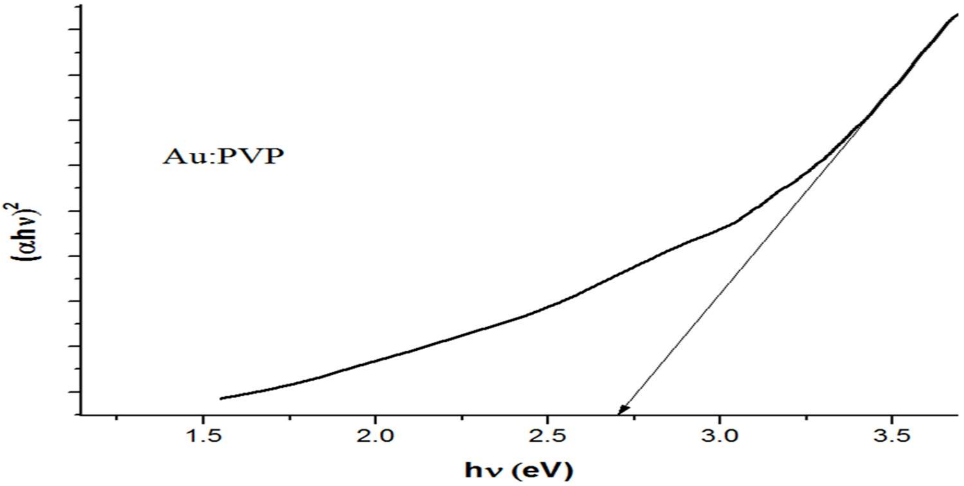

Figure 2. b Eg of Au/PVP

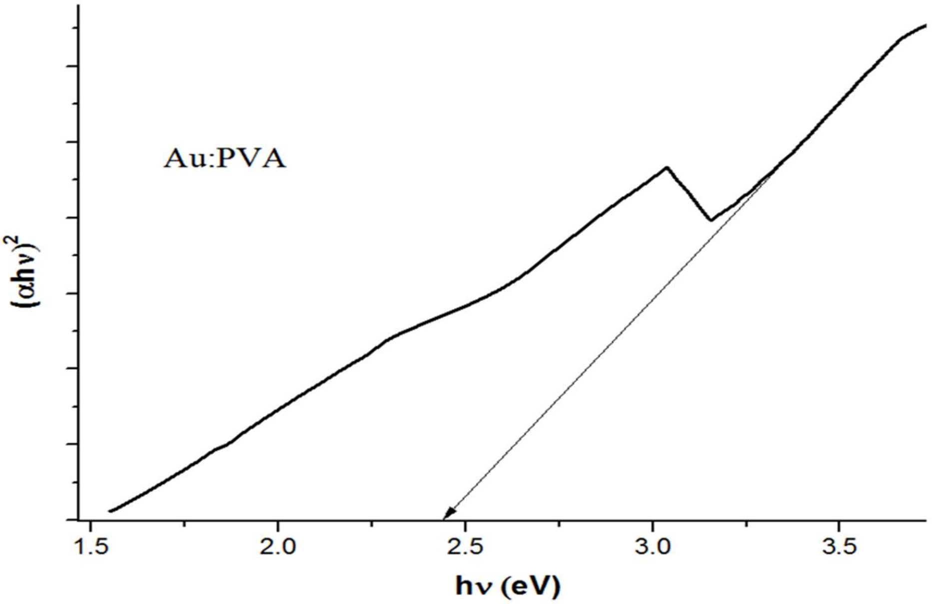

Figure 2. c Eg of Au/PVA

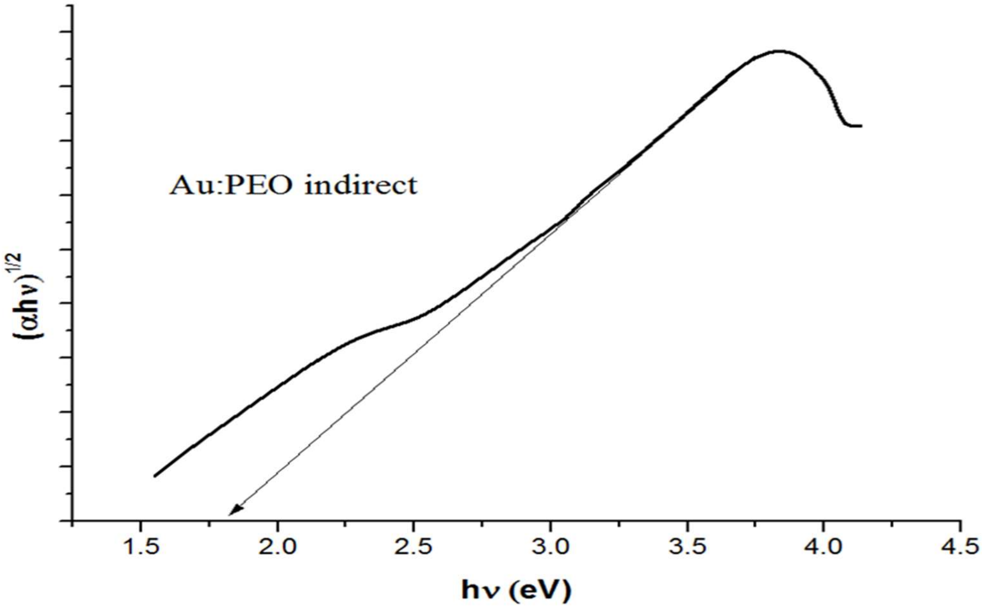

Figure 3 .a The indirect Eg of Au/PEO.

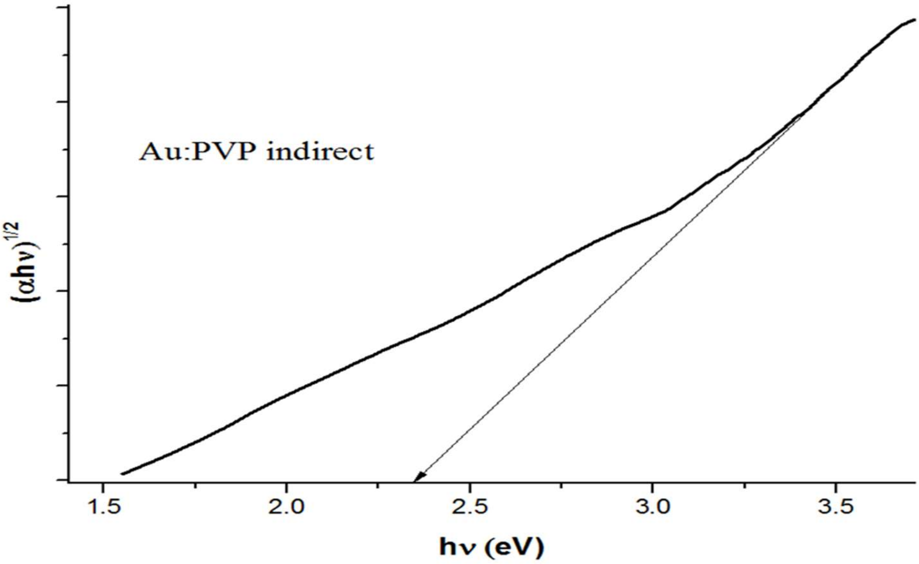

Figure 3. b The indirect Eg of Au/PVP

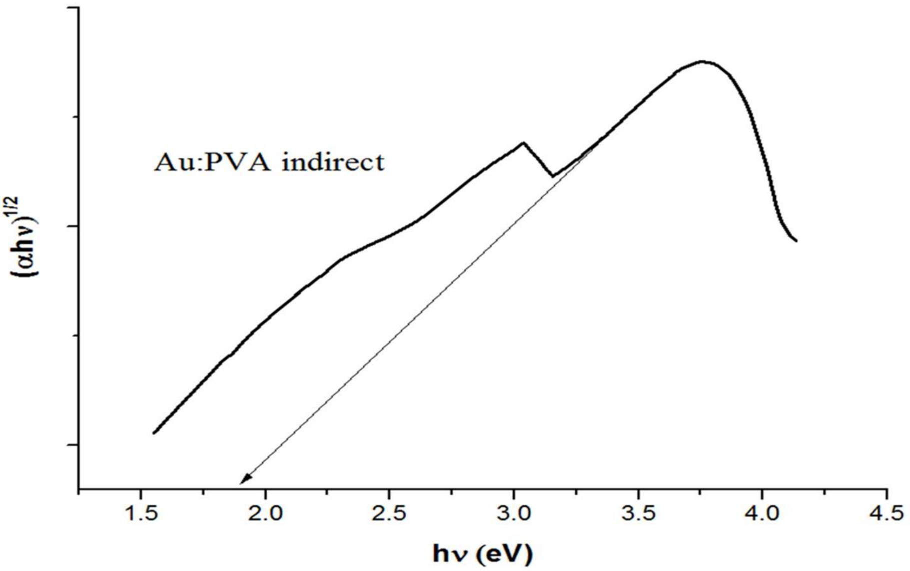

Figure 3. C. The indirect Eg of Au/PVA

Table 1 values of direct and indirect Eg of nanocomposites

Sample	Abs.	Direct band gap	Indirect band gap
Au/PEO	540	2.3	1.9
Au/PVP	-	2.2	2.02
Au/PVA	550	2.25	2

To determine if chemical bonding between the PEO matrix and the Au nanoparticles takes place, IR measurements of the Au-PEO nanocomposites were performed. figure 4. demonstrations FT IR spectra for Au:PEO. There are many bonds appearing at different wavenumbers all these bonds appeared in the spectra.

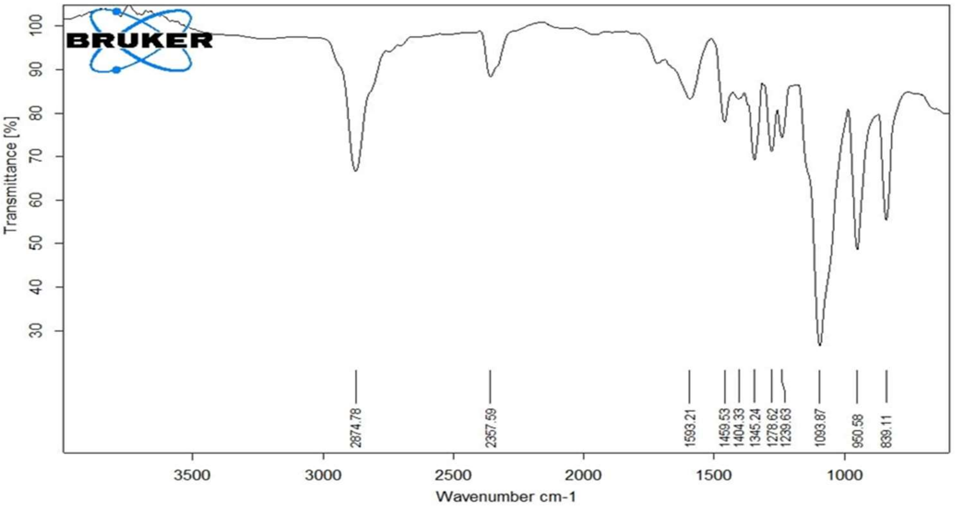

Figure 4. FTIR spectra of AU:PEO nanocomposite

The appearance of FTIR interactions among silver and PVP molecules is established by the spectrum of FTIR in the ranges of wavelengths 400–4000 cm- to the synthesized Au nanoparticle was presented in Figure 5. The spectrum for the silver nanoparticles shows various peaks. the peak at 16 cm- belong to C-O prove the interaction of PVP with Au nanoparticles.

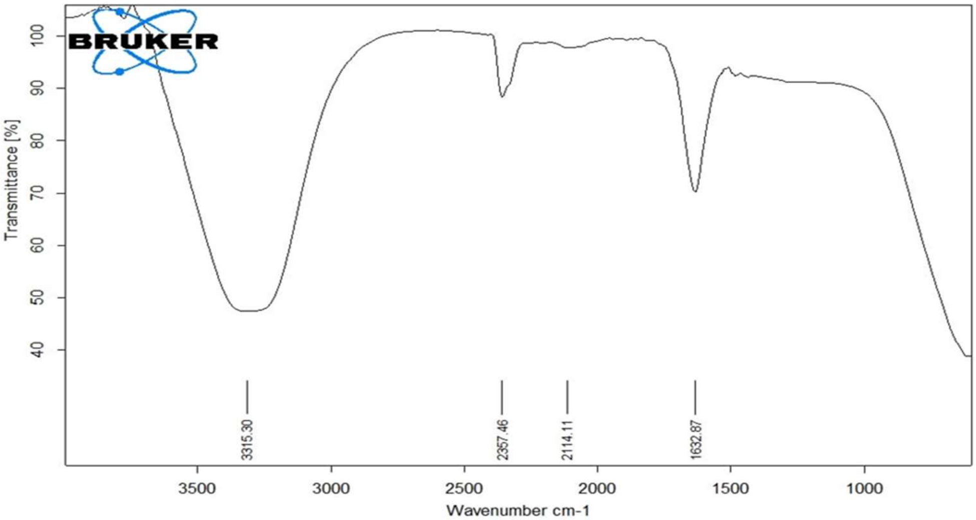

Figure 5. FTIR spectra of Au:PVP nanocomposite

FTIR was used to test the physicochemical interactions between Au and PVA.The appearance of FTIR interactions among silver and PVA molecules is established by the spectrum of FTIR in the ranges of wavelengths 400–4000 cm- to the synthesized Au nanoparticle was presented in Figure 6. peaked at 12 cm—as a result of a symmetric C–C stretching mode that is crystalline in nature PVA regions. The broad apex of approximately 3500 cm was coupled with the addition of OH.

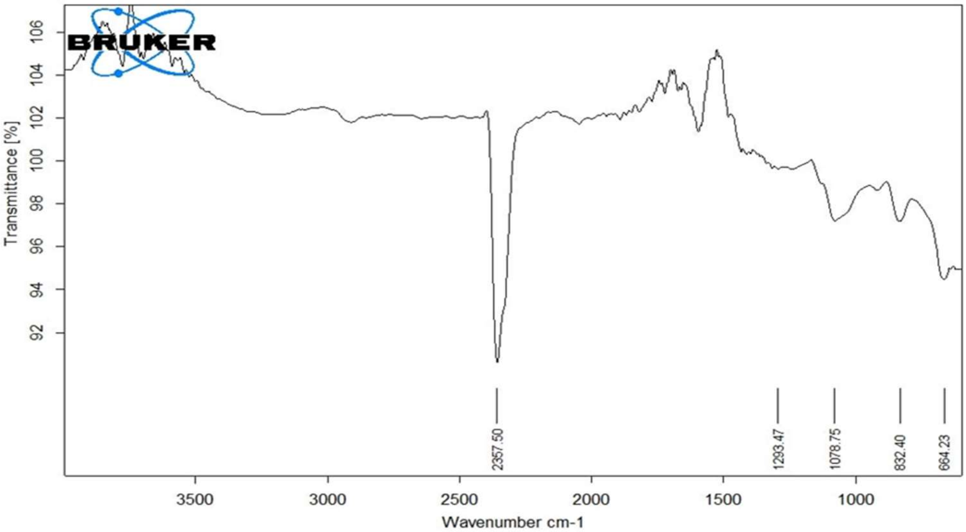

Figure 6. FTIR spectra of Au:PVA nanocomposite

CONCLUSION

As a reducing agent, tri-sodium citrate was utilised in the synthesis of gold nanocomposites that contained a variety of polymer matrix formulations. The UV/Vis and FTIR spectroscopies were used to characterise the gold nanoparticles. The distinctive Plasmon absorption peak for the gold lies between 530 and 550 nanometers, as shown by the ultraviolet and visible spectra. Within the peak location, there was a discernible shift that was detected.

References

1. Mohammed, K. A., Habieb, A. A., Swary, A. O., Ahilfi, D. N., & Thbayh, D. K. (2020). Effect of Laser Energy on Optical and Morphological Properties of Gold Nanoparticles. *Advanced Science, Engineering and Medicine*, *12*(7), 989-993.
2. Burda, C., Chen, X., Narayanan, R., & El-Sayed, M. A. (2005). Chemistry and properties of nanocrystals of different shapes. *Chemical reviews*, *105*(4), 1025-1102.
3. Tessier, P. M., Velev, O. D., Kalambur, A. T., Rabolt, J. F., Lenhoff, A. M., & Kaler, E. W. (2000). Assembly of gold nanostructured films templated by colloidal crystals and use in surface-enhanced Raman spectroscopy. *Journal of the American Chemical Society*, *122*(39), 9554-9555.
4. Mulvaney, P. (1996). Surface plasmon spectroscopy of nanosized metal particles.*Langmuir*, *12*(3), 788-800.
5. De Matteis, V., & Rizzello, L. (2020). Noble metals and soft bio-inspired nanoparticles in retinal diseases treatment: A perspective. *Cells*, *9*(3), 679.
6. Khlebtsov, N. G., & Dykman, L. A. (2010). Optical properties and biomedical applications of plasmonic nanoparticles. *Journal of Quantitative Spectroscopy and Radiative Transfer*, *111*(1), 1-35.

7. Mohammed, K.A.; Habieb, A.A.; Soary, A.O. Effect of Particles Diameters on The Theoretical and Experimental Surface Plasmon Absorption (SPA) of Gold Nanoparticles Prepared by Laser Ablation Method. Mat Int 2020, 2, 0271-0276. https://doi.org/10.33263/Materials23.271276.
8. Brust, M., Walker, M., Bethell, D., Schiffrin, D. J., & Whyman, R. (1994). Synthesis of thiol-derivatised gold nanoparticles in a two-phase liquid–liquid system. *Journal of the Chemical Society, Chemical Communications*, (7), 801-802.
9. Molnár, Z., Bódai, V., Szakacs, G., Erdélyi, B., Fogarassy, Z., Sáfrán, G., ... & Lagzi, I. (2018). Green synthesis of gold nanoparticles by thermophilic filamentous fungi. *Scientific reports*,*8*(1), 1-12.
10. Orooji, Y., Jaleh, B., Homayouni, F., Fakhri, P., Kashfi, M., Torkamany, M. J., & Yousefi, A. A. (2020). Laser ablation-assisted synthesis of poly (vinylidene fluoride)/Au nanocomposites: crystalline phase and micromechanical finite element analysis. *Polymers*, *12*(11), 2630.
11. Mishra, R. R., Panda, A., Sahoo, A. K., & Kumar, R. (2022). Research progress on nano-metal matrix composite (NMMC) fabrication method: A comprehensive review. *Materials Today: Proceedings*, *56*, 2104-2109.
12. Yassin, A. Y. (2023). Synthesized polymeric nanocomposites with enhanced optical and electrical properties based on gold nanoparticles for optoelectronic applications. *Journal of Materials Science: Materials in Electronics*, *34*(1), 46.
13. Bag, R., Panda, A., Sahoo, A. K., & Kumar, R. (2020). A brief study on effects of nano cutting fluids in hard turning of AISI 4340 steel. *Materials Today: Proceedings*, *26*, 3094-3099.
14. Vieira, F. M., Calisto, C. G., & Izumi, C. (2023). Construction of SERS substrates by gold nanoparticles assembly on polymeric matrices. *Applied Surface Science*, *612*, 155818.
15. Awwad, N. S., Abd El-Kader, M. F. H., Ibrahium, H. A., Asnag, G. M., & Morsi, M. A. (2021). Green synthesis of different ratios from bimetallic gold: Silver nanoparticles core@ shell via laser ablation scattered in Chitosan-PVA matrix and its electrical conductivity behavior. *Composites Communications*, *24*, 100678.
16. Salim, K. H., Khudair, H. F., Mohammed, K. A., Zabibah, R. S., Al-Khafaji, M. A., Elayaperumal, M., & Saxena, K. K. (2023). Eco friendly Synthesis of Ag-ZnO Nanocomposite and Its antibacterial activity, photocatalysis toward degradation of (CB) dye and Removal wastewater pollution. *International Journal of Nanoscience*.
17. Jarad, A. N., Hamood, F. J., Kareem, A. S., Alkhafaji, M. A., Zabibah, R. S., Mohammed, K. A., & Saxena, K. K. (2023). Au Nanoparticles Angered with PVA for Nanocomposites Formation and their Evaluations. *International Journal of Nanoscience*, 2350021.
18. Zhang, Q., He, L., Rani, K. K., Wu, D., Han, J., Chen, Y., & Su, W. (2021). Colorimetric detection of neomycin sulfate in tilapia based on plasmonic core–shell Au@ PVP nanoparticles. *Food Chemistry*, *356*, 129612.
19. Xiao, C., Chen, S., Zhang, L., Zhou, S., & Wu, W. (2012). One-pot synthesis of responsive catalytic Au@ PVP hybrid nanogels. *Chemical Communications*, *48*(96), 11751-11753.
20. Alshehri, S. M., Almuqati, T., Almuqati, N., Al-Farraj, E., Alhokbany, N., & Ahamad, T. (2016). Chitosan based polymer matrix with silver nanoparticles decorated multiwalled carbon nanotubes for catalytic reduction of 4-nitrophenol. *Carbohydrate polymers*, *151*, 135