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Au Nanoparticles Angered with PVA for Nanocomposites Formation and their Evaluations

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This research aims to prepare a nanocolloidal solution of gold and gold capped with PVA by chemical reduction method by sodium tri-citrate as a reducing agent and using gold chloride as a source of gold ions in aqueous solution at room temperature (RT). The prepared materials were diagnosed by scanning electron microscope (SEM) with the elemental composition analysis by energy dispersive X-ray (EDX), as well as the X-ray diffraction (XRD). The obtained results showed that the shape of the prepared particles is spherical with enhanced diameters close to 10 nanometers and with good scattering.

Keywords: Gold nanoparticles; polymer-gold (Au-PVA); nanocomposites; structural; optical; morphology analysis.

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1. Introduction

Interdisciplinary nanotechnology is an area of science that deals with the manufacture, manipulation of materials and usage of nanoparticles ranging in size from less than 1 nanometer to 100 nanometers. Nanoscience is a subfield of nanotechnology. Nanomaterials, as a result of their size, dispersion, shape and other factors, exhibit valuable properties that are both original and improved. The noble metal nanoparticles have generated a great deal of interest in optical characteristics, magnetic properties, catalytic properties and so on which are also particle size-dependent.[1] The plasmon resonance absorption metal nanoparticles exhibit in the UV–Visible band is an additional factor. Electrons located in the conduction band occur in an orderly manner because of the small particle size of the material. The particle size, chemical environment, adsorbed species on the surface and dielectric constant[2–4] are all factors that influence the particle shift. Gold nanoparticles (Au NPs) and silver nanoparticles (Ag NPs) have distinct optical properties, notably with respect to color. Collective oscillations of conduction electrons paired with incident light make them useful for a range of applications.[5,6]

Gold is a noble and vital metal due to its resistance to chemical abrasion and oxidation as well as its resilience to high temperatures and temperature fluctuations, which can affect surrounding conditions such as metalworking.[7] Au NPs are readily functionalized, having a wide range of functionality. The most appropriate ones for bioimaging applications are a variety of ligands ranging from polymers, DNA, peptides, RNA and fluorescent compounds as well, numerous cytotoxicity investigations showed their low cytotoxicity.[8] Inertness due to the atomic weight of Au results in toxicity flexible chemistry, environmentally acceptable design and versatility in numerous domains that make polymeric matrices a good choice for hybrid nanocomposites synthesis.[9–11]

Interest in nanoparticles made of noble metals like silver and gold has surged because of their unique electrical, optical, physical, chemical and magnetic capabilities.[12] Because of their peculiar physical features, particularly, the prominent plasmon absorption peak, they exhibited in the visible range and are of great interest for use in biophysical, biochemical and biotechnological applications. Another important advantage is that both Ag and Au nanoparticles were stable for a period of months. In addition to their chemical stability, gold and silver nanoparticles often display surface-enhanced Raman scattering (SERS) in the visible wavelength's region which can lead to a significant boost in a number of optical cross-sections. The optical qualities of the material near the particle have a significant impact on the resonance frequencies.[13] For instance, silver has been used as an antibacterial for thousands of years; on the flip side, its significance as a catalyst is undeniable.[14] However, because of their fascinating size-dependent chemical, electrical and optical properties, gold nanoparticles have attracted substantial attention in recent years for possible uses in nanomedicine. Additionally, gold nanoparticles exhibit promise in boosting the efficacy of different targeted cancer treatments like radiation and photothermal therapy.[15]

The research and development of biosensors frequently make use of nanoparticles. Colloidal gold, also known as gold nanoparticles (AuNPs), is fluid suspensions of gold particles with sizes ranging from 1 to 100 nm that has been protected with a capping reagent. Colloidal gold is also known as gold nanoparticles. Because of their unique optical and electrical characteristics, as well as their high level of biocompatibility, Au NPs are one of the nanomaterials that have received the most research attention.[16]

In this paper, the optical, morphological and structural properties of Au NPs were tested and discussed before and after using PVA polymer as a capping agent.

2. Experimental Section

2.1. *Au colloid synthesis*

Gold nanoparticles were prepared by chemical reduction method using materials gold chloride as a source for gold ions and trisodium citrate as a reduction agent. Here, the gold chloride solution was diluted to reach a concentration of 0.005 M by dissolving it in non-ionic water. Five milliliters of 0.005 gold source were mixed with 35 milliliters of deionized water on a magnetic apparatus and heated until it reached a boiling point and left boiling for 15–20 s. One mL from Sodium citrate (prepared from dissolving 1 g from TSC powder in 100 mL DI water) was added to the mixture in the paragraph above, then, the heat was turned off and left on the magnetic mixing device. The solution turned colorless and then turned dark red (violet and then to bright red), which is a guide to reaching gold nanoparticles of size smaller (less than 20 nm).

2.2. *Au-PVA nanocomposites*

Au-PVA nanocomposites were prepared by chemical reduction method using materials such as Gold chloride as a source for gold ions and trisodium citrate as a reduction agent and PVA as a capping agent. Here, the gold chloride solution was diluted to reach a concentration of 0.005 M by dissolving it in non-ionic water. Five milliliters from 0.005 gold source were mixed with 35 milliliters of deionized water on a magnetic apparatus and heated until it reached a boiling point and left boiling for 15–20 s. Ten mL of 1% PVA solution was mixed the with solution above. One mL from Sodium citrate (prepared by dissolving 1 g of TSC powder in 100 mL DI water) was added to the mixture (mentioned in the paragraph above) then the heat was turned off and left on the magnetic mixing device. The solution turned colorless and then dark red (violet and then to bright red, which is a guide to reaching gold nanoparticles.

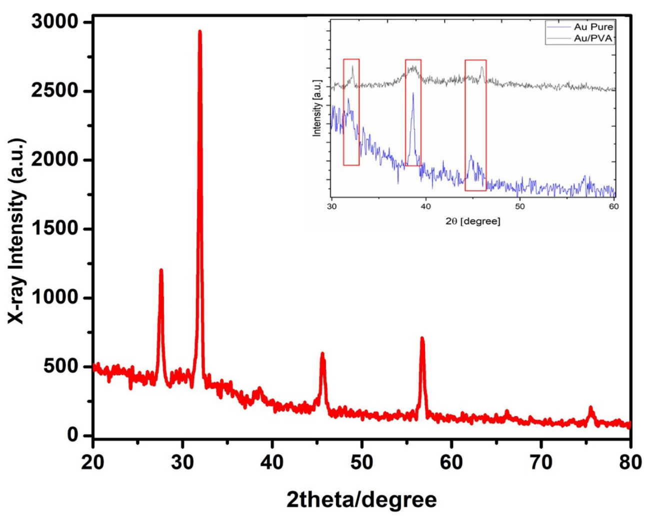

Fig. 1. XRD patterns of Au-NPs.

3. Results and Discussions

Powder X-ray diffraction (XRD) pattern in Fig. 1 demonstrates the Au nanocolloidal. An intense peak can be seen in the band at the coordinates $2 = 38.47^\circ$ and 44.84°, which correspond to the (1 1 1), (2 0 0) plane, demonstrating that the structure of Au-NPs is a face-center cubic lattice (fcc). Comparing the XRD pattern of the Au-NPs to the database, namely the JCPDS file number 00-004-0784, reveals that the crystallinity of the Au-NPs is unadulterated.[17,18] In the case of Au-PVA, the same peaks appeared at the same corresponding planes with small shift towered higher angles.[19,20]

Figure 2 illustrates the SEM images which indicate the mean size of the synthesized nanoparticles. The particles are spherical in shape with good homogeneity for both Au and Au-PVA. The average diameter is about 10 nm for both samples.

Chemical composition examination has been conducted by EDX to reveal the elements presented in the prepared samples. Figure 3 displays the EDX spectra of Au and PVA-Au nanocomposite. From the figure, it can be seen that the Au element is the only element that appears in the cure for both pure Au and Au capped with PVA. This confirms the preparation of highly pure materials without any impurities.

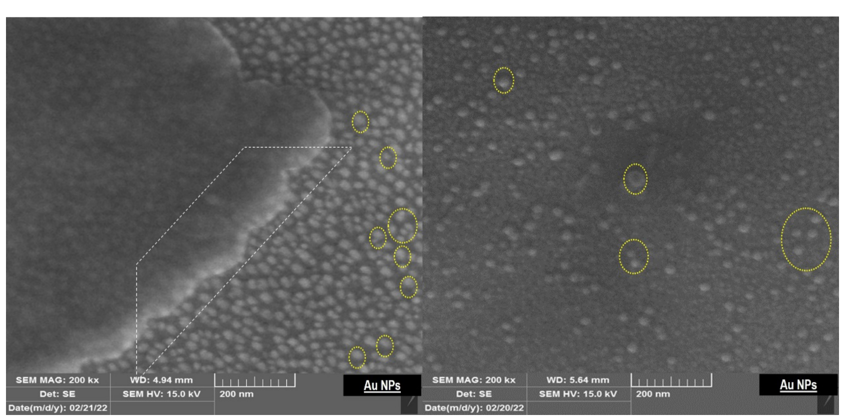

Fig. 2. FESEM images of Au-NPs.

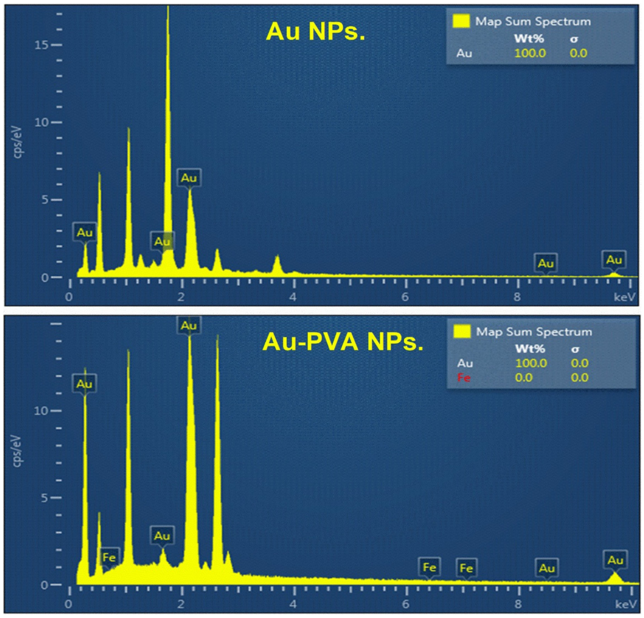

Fig. 3. EDX spectra of Au NPs.

The optical studies by UV–Vis spectroscopy are used to study the absorption spectra of gold nanoparticles (Au-NPs). Figure 4 shows the UV–Visible absorbance spectrum of Au-NPs. The figure exhibits the surface plasmon resonance (SPR) position around 540 nm.[21]

The absorption spectra of Au-PVA nanocomposite colloid solution are shown in Fig. 5. Absorption spectrum of Au-PVA colloid has surface plasmon absorption band of 520 nm which is the maximum wavelength.[22,23] This study reveals both the existence of the effect of quantum size as well as the production of Au-NPs within the PVA matrix.

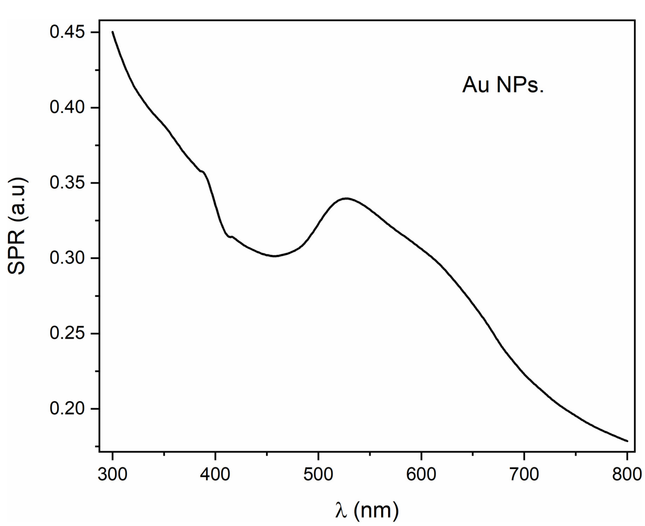

Fig. 4. Absorption spectrum of Au-NPs.

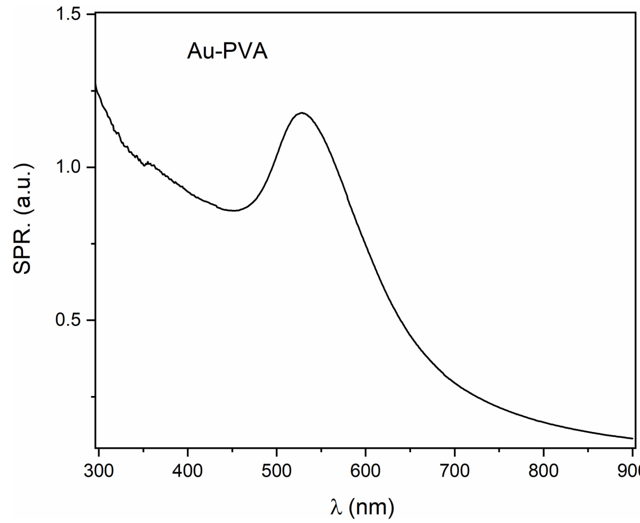

Fig. 5. UV–Visible absorption spectrum of Au-PVA.

The process of crosslinking polymer molecules results in a considerable increase in the molecular mass of the polymer molecules, which in turn results in an increase in the number of polymer chains that surround the Au-NPs.[24] The location and form of the plasmon absorption are determined by the particle size and the surrounding medium's dielectric constant.[25] From the observation of structural XRD, morphology SEM and optical SPR-based Au-NPs explored uniform spherical size nanoparticles anchored with the polymer composites. These nanocomposites could be very useful for smart electronics and biomarkers for future pandemic virus early detections.[26–31]

4. Conclusion

The gold nanoparticle (Au-NPs) and gold (Au) capped with polymer nanocomposites (Au-PVA) were synthesized using trisodium citrate as a reducing agent. The gold nanoparticles were systematically characterized by XRD, FESEM with EDX, UV–Visible results display the characteristics of SPR absorbance peak of Au-NPs ranging from 520 to 540 nm. There was a noticeable alteration detected in the peak location. Structural XRD and optical spectrum shifts appear in the peak position of Au when PVA was used as a capping agent. These Au-NPs explored uniform spherical-sized nanoparticles anchored with the polymer composites. These nanocomposites could be very useful for smart electronics and biomarkers for future pandemic virus early detection.

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