SHORT COMMUNICATION

Synthesis and Charactrization of Au Nanocomposits by Green Capping Agent: Pomegranate Juice for Antibacterial Activity

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ABSTRACT

Objective(s): In this work, pomegranate juice was used as a capping agent for self-assembly to form particles-like Au nanostructures in the presence of AuHCl4.3H2O as aurate source. Besides, to investigate the concentration effect of pomegranate juice as the green capping agent on the morphology and particle size of final products several experiments were performed.

Methods: The as-synthesized products were characterized by X-ray diffraction (XRD), scanning electron microscope (SEM), transmission electron microscope (TEM), Fourier transformation infrared (FT-IR). Au nanostructures exhibited stronger antibacterial properties against Gram-negative bacteria (Salmonella typhi and Escherichia coli) than against Gram-positive bacteria (Staphyloccocus aureus and Staphyloccocus epidermidis).

Results: Microwave irradiation provides a rapid and green method for the synthesis of AuNP. It favors the formation of small and uniform nanoparticles through a fast and homogeneous nucleation and crystallization. Both AuNPs nanocomposites showed antibacterial activity that is stronger against Gram-negative bacteria (E. coli and S. typhi) than against Gram-positive bacteria, (S. aureus and S. epidermidis)

Conclusions: This rapid method of microwave radiation as compared to the classical synthesis, showed promising results in terms of size distribution, surface area, pore diameter and pore volume.

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INTRODUCTION

Among NPs, Au nanoparticles are widely used as a catalyst for medical therapy, gene therapy, and diagnostic and biological purpose [1–2] Recently, it has been investigated that, Au nanoparticles are the resistance of many various bacteria against many synthetic drugs is enhanced day by day and many of them are mesoporous spheres [3-5]. Au, crystals present spinel structure, thus a lot of important properties used in industrial applications [6-8]. Controlling the size, shape, and structure of metal nanoparticles are technologically important because of the strong correlation between these parameters and optical, electrical and catalytic properties [9-12]. The method of using a 'hard template' to control the inner hollow core, also called the core-shell technique, is probably the most effective method for this purpose [13-15]. Conventionally there are many templates, such as organic amines and quaternary ammonium salts, available in the literature. Among them, cetyltrimethylammonium bromide, cetyltrimethylammonium chloride, and n-octylamine are used for mesoporous materials synthesis. Other templates such as tetrapropylammonium bromide, n-propylamine,

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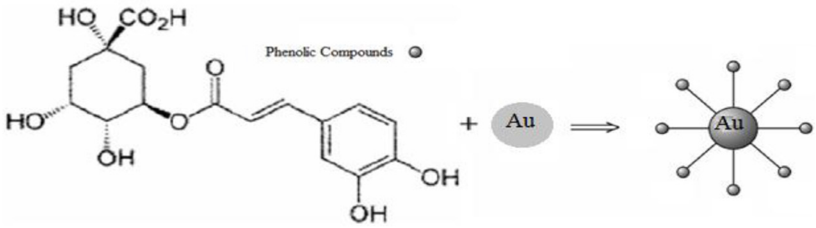

Fig. 1. Schematic formation of Au Nanoparticle.

diethylamine, triethylamine and triethanolamine are not attempted. Besides, polyvinyl pyrrolidine has been used to form hollow structures [16-20]. Au is an attractive material for its distinctive properties, such as good conductivity, chemical stability, catalytic activity and antimicrobial activity [21-26]. Au nanoparticles are used in antimicrobial applications since the antimicrobial effect of Au ions is well known. Fig. 1 shows schematic formation Au nanoparticle.

MATERIALS AND METHODS

Characterization

X-ray diffraction (XRD) patterns were recorded by a Philips-X'Pert Pro, X-ray diffractometer using Ni-filtered Cu Kα radiation at scan range of $10<2\theta<80$ in Tehran university -Iran. Scanning electron microscopy (SEM) images were obtained on LEO-1455VP equipped with an energy dispersive X-ray spectroscopy. Transmission electron microscope (TEM) images were obtained on a Philips EM208S transmission electron microscope images (with an accelerating voltage of 100kV) were obtained on Electronic Nano Laboratory Technical University of Tehran-IRAN.

Synthesis of Au Nanoparticles

In a typical experiment, at first, a certain amount of pomegranate juice as the capping agent was added drop wise into a solution containing 3 mmol of $AuHCl_4.3H_2O$ in 20 mL of distilled water under magnetic stirring. Then, NaOH as a pH controller agent was added to the solution under stirring at room temperature to reach pH value 10. The obtained mixture was stirred at room temperature for 30 min at 80 °C. The resultant white precipitates were filtered, washed by distilled water, absolute ethanol and dried at 60 °C under vacuum. In order to investigate the concentration effect of pomegranate juice as the green capping agent several experiments were performed (Table1).

After thermal treatment, the Teflon container was allowed to cool naturally to room temperature. The products were centrifuged, washed out with distilled water and absolute ethanol several times

RESULTS AND DISCUSSION

Fig. 2 provides a comparison of typical XRD patterns of products obtained from Au nanoparticles. The sample for XRD pattern formed at the microwave (power=600W) for 4 min. All of the reflection peaks can be readily indexed to Au nanoparticles. Based on XRD data, the crystallite diameter (Dc) of Au nanostructures was calculated as 35 nm using the Scherer equation:

$$Dc=K\lambda/\beta\cos\theta \text{ (Scherer equation)}$$

Whereβ is the breadth of the observed diffraction line at its half intensity maximum (101), K is the so-

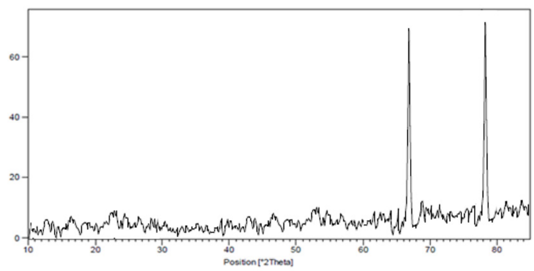

Fig. 2. XRD patterns of Au Nanoparticle. (sample no.1)

Table 1. The concentration effect of pomegranate juice as the green capping agent.

Sample	pomegranate juice concentration (mL)	Morphology
1	0.5	Agglomeration nanoparticles
2	1.5	Nanoparticles

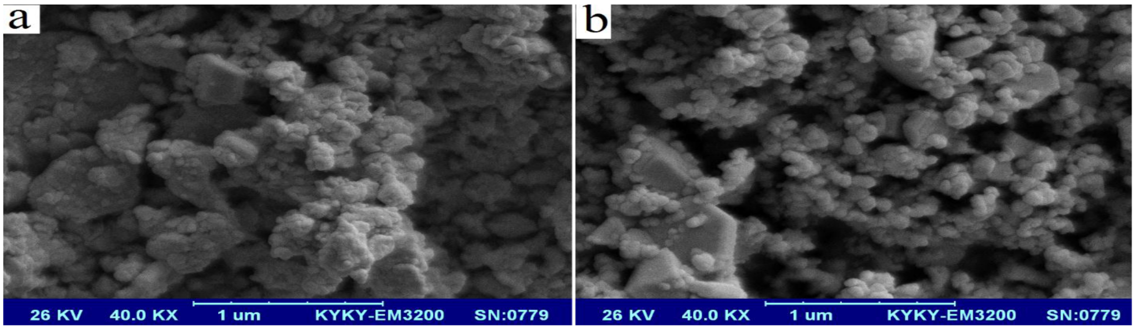

Fig. 3. a) SEM image (a) sample no.1, (b) sample no.2 of the synthesized Au nanoporous.

called shape factor, which usually takes a value of about 0.9, and λ is the wavelength of X-ray source used in XRD. In this paper, pomegranate juice was used as the novel capping agent for synthesis Au nanoporous and the concentration effect of its was investigated on the morphology and particle size of final products (Fig. 3a-b, sample 1-2, respectively). To further investigate the details of morphology, the morphology of all samples is particle-like. However, by increasing the pomegranate juice concentration from 0.5 to 1.5 ml, the particle size of the products increased. TEM images of sample 2 are shown in Fig. 4. According to TEM image, the morphology of Au nanoporous obtained from sample 2 is sphere-like nanostructures composed of nanoparticles with particle size ~ 40–50 nm. Fig. 5. shows excitation (centered at 432 nm) spectra of sample 2. The emission spectrum shows a blue shift (2.68eV), compared to that of the bulk Au nanostructures (Fig. 5). The antibacterial activity of the AuNPs was tested on Gram-positive (Staphyloccocus aureus and Staphyloccocus epidermidis) and Gram-negative (E. coli and Salmonella typhi) bacteria (ATCC 51153). The bacteria (105 CFU) were inoculated in nutrient broth and incubated with AuNPs samples at five different concentrations (3.45 to 100 μg/ml) at a volume ratio of 1:1 for 4 h at 25°C. After the incubation, 0.1 ml of the mixture for each sample was spread on a nutrient agar plate, followed by incubation at 25°C for another 24 h. Fig. 6 Control sample (sterilized distilled water) was prepared and spread on an agar plate for standard comparison. All the agar plates were visually inspected for the presence of bacterial growth, and the results were recorded. Fig. 7 shows the FT-IR spectrum of the achieved Au nanoparticles. Absorptions at 673 and 914 cm^{-1} are attributed to stretching vibrations of Au Also absorptions at 3442 cm^{-1} (attributed to stretching vibrations O–H bond), proved the presence of moisture on the surface of Au nanostructures.

CONCLUSIONS

Microwave irradiation provides a rapid and green method for the synthesis of AuNP. It favors

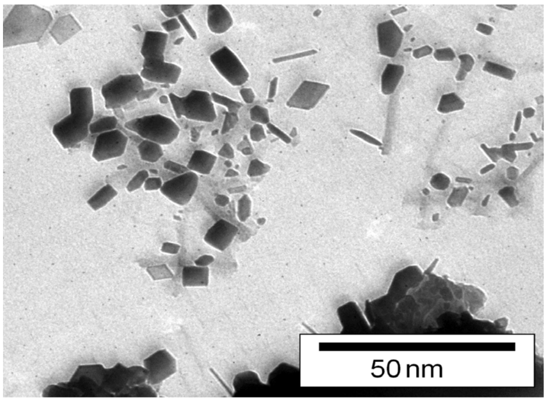

Fig. 4. TEM image sample no.2 of the synthesized Au nanoparticle.

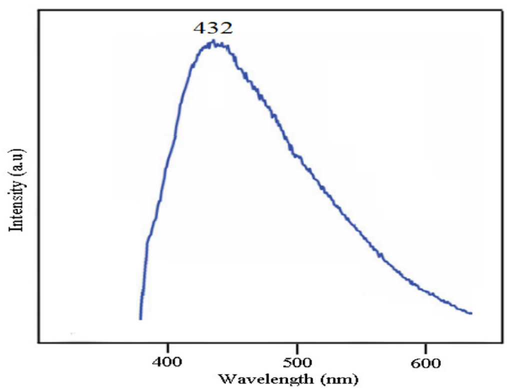

Fig. 5. Pl spectrum of Au nanostructures (sample 2).

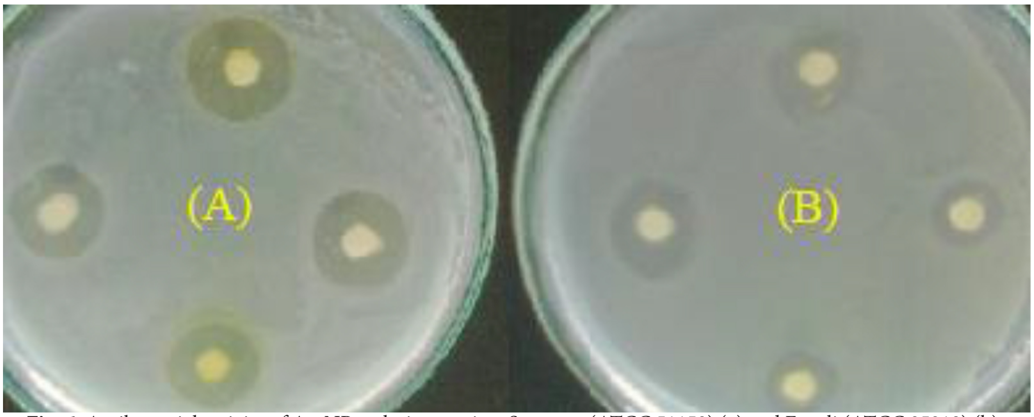

Fig. 6. Antibacterial activity of Au-NPs solution, against S. aureus (ATCC 51153) (a) and E. coli (ATCC 35218) (b). All the concentration of gold nanoparticles are 10µL (5.4 ppm).

the formation of small and uniform nanoparticles through a fast and homogeneous nucleation and crystallization. Both AuNPs nanocomposites showed antibacterial activity that is stronger against Gram-negative bacteria (E. coli and S. typhi) than against Gram-positive bacteria, (S. aureus and S. epidermidis). Meanwhile, the synergistic effect between AuNPs has reduced the Au content without compromising the antibacterial performance. The advantage of this nanocomposite with low AuNPs content will reduce the concern and risk of excessive AuNPs usage, which makes it a potential material for food packaging and wound dressing applications.

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CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest

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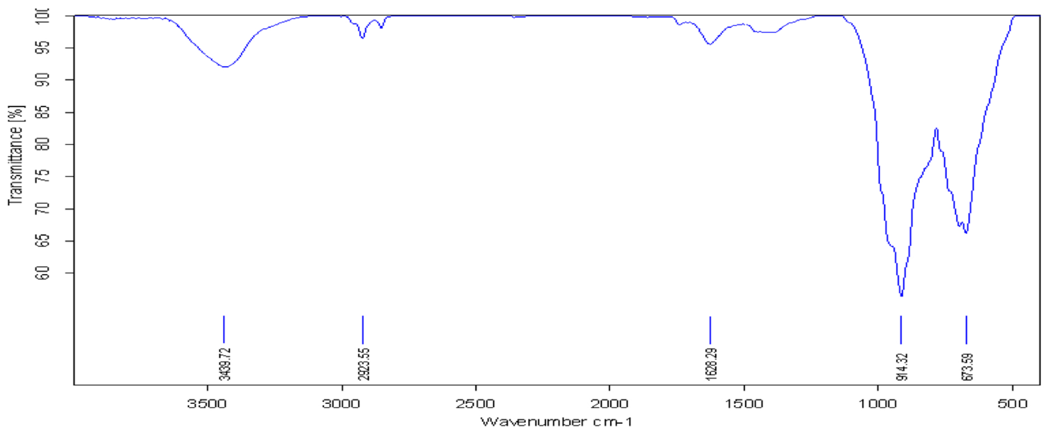

Fig. 7. FT-IR spectrum of Au Nanoparticle (sample 1)

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