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Research Article
A Sonochemical-assisted Simple and Green Synthesis of Silver Nanoparticles and its Use in Cosmetics

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Abstract

Background and Objective: Extensive application of silver nanoparticles encourages the need for synthesizing them through easy, efficient, green and eco-friendly techniques. Sonochemistry is one of the earliest approaches used to prepare nanosized particles. The objective of this study is to develop efficient facile simple green sonochemical route for the preparation of silver nanoparticles and its use in cosmetics. **Methodology:** About 20 mL of silver nanoparticles solution (0.1 M) having gelatin (1 wt.%) was sonicated under the irradiation of high-intensity ultrasound at room temperature for 15 min. The effect of irradiation time on the formation of silver nanoparticles has been investigated. The produced silver nanoparticles were characterized by means of UV-vis spectroscopy. **Results:** The UV-vis spectra confirmed the synthesis of silver nanoparticles by viewing typical peak between which give characteristic peak between 380-450 nm and increases with increasing irradiation times. Mechanism for Ag-NPs formation by the assistance of ultrasonic waves was described by pheromone of acoustic cavitation. Sonochemical synthesized Ag-NPs were found very stable and have enough preservation efficacy. **Conclusion:** It is concluded that the sonochemical-fabrication of silver nanoparticles seem to be suitable preservative in cosmetics and can be used for the production of other metals nanoparticles due to it is very simple and no toxic reagents are used.

Key words: Silver nanoparticles, gelatin, sonochemical cosmetics

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Generally, the preparation of nanoparticle don by using different physicochemical methods means of toxic and hazardous chemicals. Nevertheless, green methods for nanoparticles perpetration are another source of usual method and have good antimicrobial activity[1]. These green methods for production of nanoparticles can be considered as one of fast and best approaches.

Newly, ultrasound irradiation (sonochemical synthesis) was used as a green method for nanoparticle preparation[2]. In sonochemical synthesis, there are interaction takes place between energy and matter. There are 3 stages that proceeds including formation, then growth and ends with implosive collapse of bubbles. Sonochemical synthesis method is clean and simple method[3]. According to literatures nanoparticle synthesis was improved by sonochemistry[4].

Recently, gelatin as friendly, cost effective and available was used as alternative stabilizer compared to other organic stabilizers like polyvinylpyrrolidone[5] and polyethyleneglycol[6] in the preparation of nanoparticles. Gelatin is three-chain structure collagen protein contains positive and negative charges in addition to hydrophobic domains[7]. Gelatin stabilizes nanoparticle surfaces through steric barrier formation[8]. To date, little studies done on the synthesis of Ag-NPs by means of gelatin stabilizer[9].

This study aims to prepare Ag-Nps by using green, friendly sonochemical synthesis its stabilization using natural polymeric media like gelatin.

MATERIALS AND METHODS

All chemicals used in this study were of analytical grade. The $AgNO_3$, gelatin (99%, Merck, Germany) as silver precursor, gelatin (Sigma-Aldrich, USA) was used as capping agent. All glassware were washed using nitric and hydrochloric solution (3:1, v/v), then washed by distilled water and dried prior to use.

The Ag-Nps were prepared using sonochemical synthesis using equipment similar to that described elsewhere[10] in presence of gelatin (1 wt.%) as stabilizer[9]. Briefly, 20 mL of $AgNO_3$ solution (0.1 M) having gelatin (1 wt.%) under the irradiation of high-intensity ultrasound at room temperature for 15 min. This done by using ultrasonic liquid processors (Misonix Sonicator S-4000, USA, 20 kHz). The products were precipitated by centrifugation and purified by five more centrifugation/rinsing/redispersion steps with deionized water and ethanol.

The formation of silver nanoparticles at various time intervals measured using UV-visible on UV-1700 Shimadzu UV-visible spectrophotometer from 300-600 nm. Before measurement the solutions were diluted 20 times using deionized water.

RESULTS AND DISCUSSION

Now a days, ultrasounds have widespread applications in the synthesis of metal nanoparticles from its solutions. The process of nanoparticle synthesis includes the production of thermostatic chamber at which salts solution are introduced under a high ultrasonic power. This give a powerful ultrasonic energy streams that can leads to bond cleavage[11]. Sonochemical synthesis still need stabilizing or capping agent that inhibit aggregation of nanoparticles. According publications, gelatin can be considered as a useful capping agent for silver nanoparticle preparation specially UV irradiation[12]. Gelatin is effective in these reactions due to its good biocompatibility and biodegradability. Gelatin backbone have amine groups able to stabilize metal nanoparticles and inhibit them from aggregation[13].

The results in this study showed that gelatin solution in combination with ultrasonic irradiation played an essential role in the preparation of silver nanoparticles (Ag-NPs). The interaction solution containing silver ions and gelatin changes from colorless to pale red, wine red, light brown and dark brown with increasing reaction time. The formation of dark brown representing Ag-NPs development. The UV-vis spectroscopy: Probably one of the most universally utilized spectroscopy techniques, the absorption of electromagnetic radiation in the range from ultraviolet to visible is still a versatile research tool. The UV-vis can be used to analyze certain compounds used in the functionalization of nanoparticles for dispersions and applications. Changes in the UV part of the spectrum can commonly be contributed to Charge Transfer (CT) bands between a surface metal cation and the functional ligand. The UV-vis spectra confirmed the synthesis of silver nanoparticles by viewing typical peak between which give characteristic peak between 380-450 nm as shown in Fig. 1.

Eight aqueous samples containing 0.1 M $AgNO_3$ and 1.0 wt.% gelatin are exposed to ultrasound irradiated at different time intervals of 5, 10, 20, 30, 40, 50, 60 and 70 min. According to time of irradiation, the color of reaction solutions changed from yellow to brown colors. The UV-vis spectroscopy showed that the values of absorption due to silver nanoparticle formation at different experimental

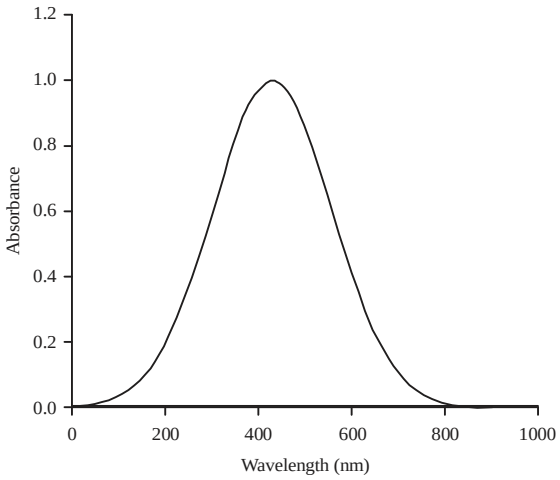

Fig. 1: UV- vis spectra of Ag-NPs synthesized by sonochemical and gelatin as a capping agent

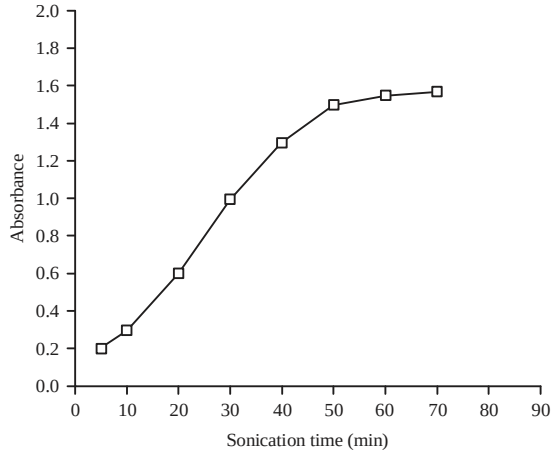

Fig. 2: Effect of sonication time on the formation of Ag-Nps

parameters changed from 428-444 nm. The spherical shape of silver nanopartic indicated by the presence of one Surface Plasmon Resonance (SPR) bands[14]. There is no UV-vis absorption characteristic of Ag-NPs before 5 min-ultrasonic irradiation. Peak at 435 nm is specifies the formation of silver nanoparticles (Ag-NPs). Increasing irradiation times, from 5-50 min as seen in Fig. 2, increase the equivalent peak intensities, with blue shifts from 435-430 nm. After 50 min there is no increase in the absorbance.

According to Mie's theory[15], different sizes metal nanoparticles have different SPR band due to their different optical properties. Smaller Ag-NPs have been obtained under longer ultrasonic irradiation time due to SPR band gave blue shift with decreasing particle size[16]. Irradiation time more than 50 min, peak became broader with no increase in their intensities. This phenomenon can be due to the degradation of gelatin under long-time of ultrasonic irradiation. At long time ultrasonic irradiation, gelatin molecules degrade and some metal nanoparticles agglomerate into larger particles. Consequently, the Ag-NPs number decreases and the peak intensity become steady constant.

Mechanism: Lately, sonochemical synthesis found to be a valuable method for the preparation of novel smaller size nanomaterials with unique physical characteristics[17]. Sonochemical influence in solution arises from phenomena of acoustic cavitation: The nucleation, growth and rapid implosive collapse of micro bubbles in liquids. Bubble collapses produce a momentary increase in temperature and pressure followed by rapid cooling. These extreme local conditions leads to bond breakage and formation of free radical, thus give an alternate way for inducing chemical reactions (sonochemistry). The major advantage of sonochemistry that it is easy to get nanoparticles of different properties of particle size, shape and purity under control of different factors including sonication power, temperature, solvent and chemical species.

Applications in cosmetics: Silver-nanoparticles are widely used in cosmetic and food industries as a preserving agent[18]. The Ag-NPs are largely being applied for numerous commercial products such as soap, shampoo, shoes and detergent. The chemical ingredient compounds are typically synthetic with side effects to human being. Consequently, green synthetized Ag-NPs are alternate for preserving agents in health care and food industries.

CONCLUSION

A simple, economical, green, effective, safe and ecofriendly method to prepare silver particles in nano scale by using gelatin as stabilizing agent under ultrasound irradiation was investigated. Reduction using sonochemical approach gives a good method for fabricating colloidal silver nanoparticles. Absorption spectra peak at 430 nm conform the formation of Ag-Nps. The possible mechanism is proposed using phenomena of acoustic cavitation. This method brings forward a broad idea to synthesize other metal nanoparticles with numerous morphologies and unique properties.

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