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Mango peel extract mediated novel route for synthesis of silver nanoparticles and antibacterial application of silver nanoparticles loaded onto non-woven fabrics

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ABSTRACT

Silver nanoparticles were successfully synthesized from aqueous silver nitrate through a simple green route using the extract of Mango peel as a reducing as well as capping agent. The possible biochemical mechanism leading to the formation of silver nanoparticles was studied using FTIR. The various operational parameters were evaluated for biosynthesis process. The results obtained from UV–vis spectrum, X-ray diffraction (XRD), and Transmission electron microscope (TEM) revealed that the biosynthesis of silver nanoparticles are in the size range of 7–27 nm and is crystallized in face centered cubic symmetry. Further, the antibacterial application of these biologically synthesized silver nanoparticles loaded onto non-woven fabrics has also been discussed. The results show that non-woven fabrics loaded with biosynthesis silver nanoparticles displayed excellent antibacterial activity.

1. Introduction

Silver nanoparticles are important materials that have been studied extensively. They can be synthesized by several physical, chemical and biological methods (Annadhasan et al., 2012; Abbasi et al., 2012; Vijayaraghavan et al., 2012). Although existing chemical and physical methods have successfully produced well-defined silver nanoparticles, these processes are usually costly and involve the use of toxic chemicals. In addition, synthesis of silver nanoparticles using chemical methods could still lead to the presence of some toxic chemical species being adsorbed onto the surface of nanoparticles which may cause adverse effects in their applications. Because of this, the bio-inspired synthesis of silver nanoparticles has become significant in the recent years. Several biological systems including bacteria, fungi and algae have been used for this purpose (Pugazhenthiran et al., 2008; Fayaz et al., 2009; Xie et al., 2007). And applications in diverse fields such as drug delivery (Keun et al., 2008), biosensors (Amanda et al., 2005), bio-imaging (Mohammed et al., 2009), antimicrobial activity (Mohammed et al., 2010), food preservation (Mohammed et al., 2009) have been reported. However, an extensive literature survey revealed that there are few reports (Rajendran et al., 2012) on the synthesis of silver nanoparticles using agricultural wastes. A classical example of such an abundantly available natural material is the mango peel. Mango is consumed all over the world. The production of this fruit is very high. After consumption of the pulp, the peel is generally discarded. In the literature there are a few applications of this peel (Kim et al., 2012; Zainuri et al., 2012). This study hypothesized that the polymers composing mango peel such as Polysaccharide, lignin, flavonoid, hemicellulose and pectins (Wilkinson et al., 2011) could be applied in the synthesis of silver nanoparticles. To the best of our knowledge, the use of mango peel has not been investigated so far for their ability in the biosynthesis of silver nanoparticles. In this paper, a novel biological route for the synthesis of silver nanoparticles using an extract derived from Mango peel is demonstrated. The silver nanoparticles structures have been characterized by UV–Visible spectroscopy, TEM, XRD. The possible mechanism for the formation and stabilization of silver nanoparticles was investigated using FTIR. The various operational parameters were evaluated for the biosynthesis process and the antibacterial application of these biologically synthesized silver nanoparticles loaded onto non-woven fabrics is also discussed.

2. Materials and methods

2.1. Plants and chemicals

The mango (*Mangifera indica Linn*) was purchased from an agricultural market located in Taigu, China. Silver nitrate was purchased from Sigma–Aldrich and used as received. All the other

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chemicals were used as received. The experiments were done in triplicates. Double distilled water was used for the experiments.

2.2. Preparation of the mango peel extract

Mango peel was washed thoroughly with double distilled water. Such peels (100 g) were added to 250 mL distilled water and crushed by a juicer. The extract was filtered through a cheese cloth and stored at −4 °C for further experiments.

2.3. Synthesis of silver nanoparticles

For all experiments, the source of silver was silver nitrate ($AgNO_3$) in distilled water. Typical reaction mixtures contained 3 mL of the extract in 27 mL of $AgNO_3$ solution (1 mM). Other reaction conditions included incubation at 80 °C in a water bath for 15 min unless otherwise stated. All experiments were carried out in triplicates and representative data is presented here. The effect of pH on nanoparticle synthesis was determined by adjusting the pH of the reaction mixtures to 2.0, 3.0, 5.0, 7.0, 9.0, and 11.0. The effect of the silver salt was determined by varying the concentration of $AgNO_3$ (0.5, 1.0, 2.0 and 4.0 mM). The extract content was varied (0.1, 0.4, 0.7, 1.0 and 3.0 mL). To study the effect of temperature and incubation time on nanoparticle synthesis, reaction mixtures were incubated at 25, 40, 60, 80 and 100 °C for 15, 30, 45, 60, 75 and 90 min, respectively. The stability of nanoparticles was examined by exposing them to ambient condition for several months. It was observed that the nanoparticles solution was extremely stable for more than 3 months with no signs of aggregation even at the end of this period.

2.4. Silver nanoparticles loaded onto non-woven fabrics

Non-woven fabric cut into little squares were immersed in a preformed synthesized silver nanoparticles solution (temperature: 80 °C, silver nitrate concentration: 0.5 mM, pH 11, 0.1 mL of the extract and incubation time: 90 min). For the successive treatment of non-woven fabric with colloidal silver, the solution was agitated continuously for 30 min. The non-woven fabric was then dried at 120 °C for 5 min under vacuum condition. The dried samples were washed with distilled water to removal the unreduced Ag^+ ions. The washed samples were again dried at 120 °C for 5 min under vacuum conditions. The antibacterial efficacy was evaluated for: (1) samples treated with mango peel extract (0.1 mL in 27 mL distilled water) (control) and (2) samples treated with silver nanoparticles solution.

2.5. Characterization of silver nanoparticles and nano-silver non-woven fabrics

The optical absorption spectra of the synthesized nanoparticles were observed by UV-2450 Shimadzu UV spectrometer. The morphology and size of freshly synthesized silver nanoparticles were evaluated using a transmission electron microscope model (Jeol JEM100SX). FTIR analysis was carried out after the removal of the free biomolecules that were not absorbed by the nanoparticles after repeated centrifugation and redispersion in water. Thereafter, the purified and dried silver nanoparticles was subjected to FTIR analysis (Shimadzu FTIR spectrophotometer 8400). X-ray diffraction pattern of dried silver nanoparticle powder was obtained using XPERT-PRO diffractometer using Cu Kα radiation (λ = 0.1542 nm). The morphology of nano-sized silver particles incorporated into non-woven fabrics was studied with SEM (Hitachi S-4500 SEM machine) after gold coating.

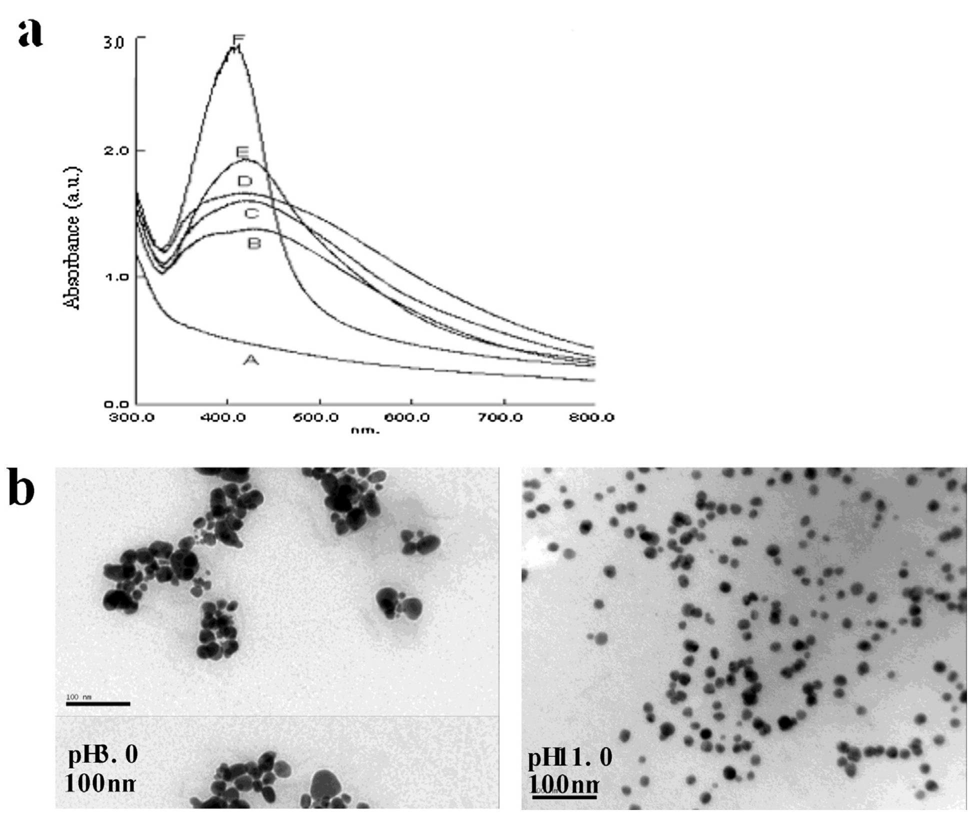

Fig. 1. (a) UV–vis spectra of the silver nanoparticles synthesized at different pH values [A: 2.0, B: 3.0, C: 5.0, D: 7.0, E: 9.0, and F: 11.0] and (b) TEM images of the silver nanoparticles prepared at pH 3.0 and 11.0.