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Green synthesis of silver nanoparticles using aqueous rinds extract of *Brucea javanica* (L.) Merr at ambient temperature

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A B S T R A C T

Aqueous rinds extract of *Brucea javanica* (L.) Merr has been used as the medium/reducing system for the formation of silver nanoparticles colloids. A solution of 0.01 N $AgNO_3$ (1 ml) was added to the rind extracts (4 ml) at room temperature, and the formation of silver nanoparticles was observed using ultraviolet–visible spectrophotometer. The shape and size of the nanoparticles have been characterized using Transmission Electron Microscope (TEM) analysis. The experimental results show that the silver nanoparticles are formed easily in the extract at ambient temperature. The resulting nanoparticles were in the spherical form and the average size of the nanoparticles was about 38.00 ± 14.00 nm.

1. Introduction

The rapid development of the biosynthesis of metal nanoparticles using plant and animal extracts [1] encouraged many scientists to investigate other possible extracts for synthesizing nanoparticles of specific size, shape, structure and morphology, since such physical properties play an important role in modulating their optical and electrical properties. Many studies have also focused on the investigation of the reduction mechanism using plant extract [2]. The reviews in this area have been summarized by many researchers [1,2]. The biosynthesis of metal nanoparticles has also been achieved using enzymes, proteins, and amino acids [3]. In addition, the other major reason of the development of biosynthesis of nanoparticles is the need of environmentally benign processes [1–4]. There is a large body of references on the preparation of metal nanoparticles using some chemicals such as hydrazine, sodium borohydrate ($NaBH_4$) and dimethylformamide (DMF) that have been considered to have some environmental and biology risk [5].

In line with the above reasons, we would like to report the formation of silver nanoparticles using aqueous extract of *Brucea javanica* (L.) Merr rinds. *B. javanica* (L.) Merr in Indonesia known as Buah Makasar. The *B. javanica* plant is a member of the family *Simaroubaceae* [6]. The plant was known for its medicinal purposes in Asian countries, including Indonesia. In Indonesia, the fruit of this plant has anti-malarial and homeostatic effects [7]. On the other hand the rind parts of *B. javanica* are not widely used and they are thrown as solid waste. We report herein the utility of unused materials to give more benefit, especially for the reduction system in the preparation of silver nanoparticles.

2. Materials and methods

Silver nitrate ($AgNO_3$) was purchased from Sigma-Aldrich. The *B. javanica* (L.) Merr ripe fruits were obtained from Bengkulu city, subsequently the rinds of the fruit were peeled and dried under sunlight (Fig. 1). All the aqueous solutions were prepared using ultrapure water. The extract was obtained by boiling a mixture of 1 g of rinds in 100 ml of ultrapure water for 20 min. The mixture has been filtered to remove any material debris, a light brown solution was obtained (Fig. 1a).

One milliliter of 0.01 N $AgNO_3$ was added to 4 ml of rinds extract solution of *B. javanica* at room temperature. The reduction progress of silver ions to form silver nanoparticles was followed using ultraviolet–visible (UV–vis) spectroscopy (CARRY 60 UV–vis spectrophotometer). Transmission Electron Microscopy (TEM) analysis was carried out employing JEM 1400 on the film coated with a drop of nanoparticles and the particle size distributions of nanoparticles were determined using the UTHSCSA Image Tool® Version 3.00 program (UTHSCSA Dental Diagnostic Science, San Antonio, TX, USA).

3. Results and discussions

The synthesis of silver nanoparticles of different size, shape and morphology was possible by changing the reaction system

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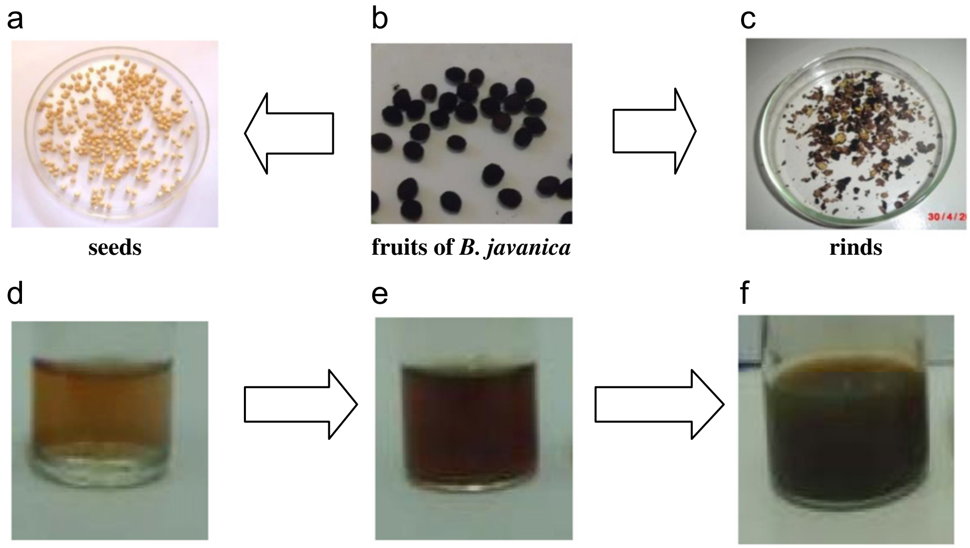

Fig. 1. The fruits (b), seeds (a) and rinds (c) of *Bruce javanica* (L.) Merr and the aqueous rinds extract before addition of $AgNO_3$ (d), the color changes after 2 h of addition of the $AgNO_3$ solution (e), and after 24 h (f).

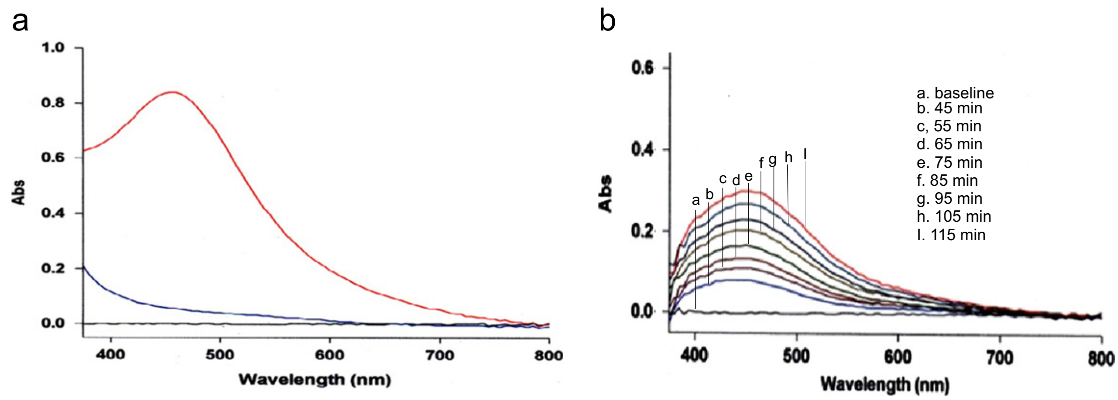

Fig. 2. UV–vis pattern of the nanoparticle colloids after 24 h (a) and UV–vis pattern of the nanoparticle colloids against the reaction time (b). (For interpretation of the references to colour in this figure, the reader is referred to the web version of this article.)

and condition. The present work has demonstrated a new development for the biosynthesis of silver nanoparticles using *B. javanica* rinds extract. The aqueous extract of rinds of *B. javanica* acts as a reservoir of organic compounds that could be used as a reduction system for the synthesis of silver nanoparticles. The experimental results show that the reaction proceeded at ambient temperature. The reaction of the $AgNO_3$ solution with aqueous rinds extract of *B. javanica* can be observed with the change of color from light brown to deep brown after 24 h (Fig. 1d–f).

To strengthen the evidence that the synthesis of silver nanoparticles was accomplished using aqueous rinds extract of *B. javanica*, a series of measurements using a UV–vis spectrophotometer was carried out to see the appearance of the specific surface plasmon resonance (SPR) of silver nanoparticles. When the spectrum of *B. javanica* rinds aqueous extract was taken in the range of 375–800 nm, there was no peak observed (Fig. 2a, blue line). Fortunately, when the solution as shown in Fig. 1f (reaction after 24 h) was measured in the same wavelengths, a peak is observed between 425 and 460 nm, which indicates the reduction of silver (I) ions to silver (0). The UV-vis absorption band in the current visible light region (425–460 nm) is an evidence of the presence of surface plasmon resonance (SPR) of silver nanoparticles.

Fig. 2b shows the UV-visible spectra of the reduced silver nanoparticles obtained by the reduction of silver ions after reaction periods of 45–115 min at room temperature. The absorption peaks observed at 425–460 nm correspond to silver nanoparticles. The silver nanoparticles solutions with reaction periods 115 min and 24 h were found to have no considerable change in the shift with respect to the 45 min reaction period. This result suggests no change in the size of the silver nanoparticles. It is already known that the red shift or blue shift is related to the nanocrystalline sizes [8]. The UV–vis spectra also show that the absorbance of AgNPs depends on the amount of the nanoparticles. Fig. 2b indicates that the absorbance at 450 nm increases as the amount of nanoparticle increases. Therefore, keeping the reaction vessel of the colloidal solutions for long times without any other treatment such as UV irradiation or heating of the solution is sufficient for the preparation of high-concentration solutions of AgNPs. It was observed that the silver nanoparticles solution remains stable for several days indicated by the slow aggregation of particles in solution. It is assumed that this might be due to the presence of unknown compounds that act as capping agents that protect the passive surface of the nanoparticles in the colloids. To give more evidence that silver nanoparticles were obtained using the present reduction system, the nanoparticle colloids were subjected to TEM analysis. Fig. 3 illustrates that silver nanoparticles are predominantly in spherical form. Based on the calculation, the particle sizes were found to range from 8 to 50 nm with a mean diameter of 37.8 ± 14.3 nm.

It is noteworthy that when aqueous seed extract of *B. javanica* was subjected to similar procedures, the silver nanoparticles were not

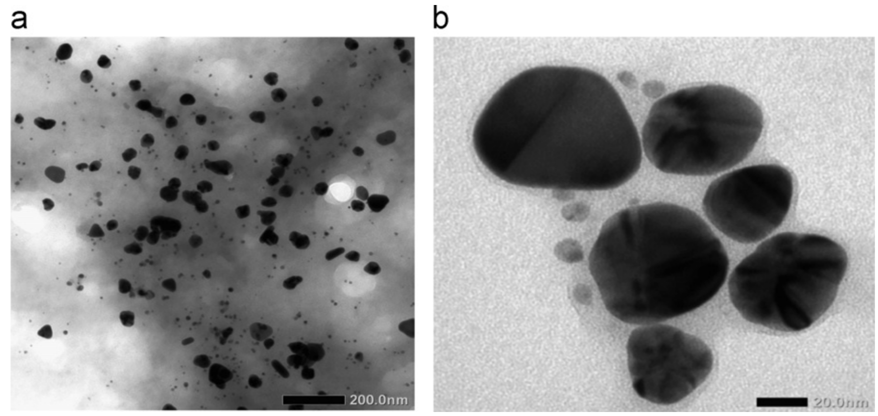

Fig. 3. TEM patterns of the spherical silver nanoparticles, scales of 200 nm (a) and 20 nm (b).

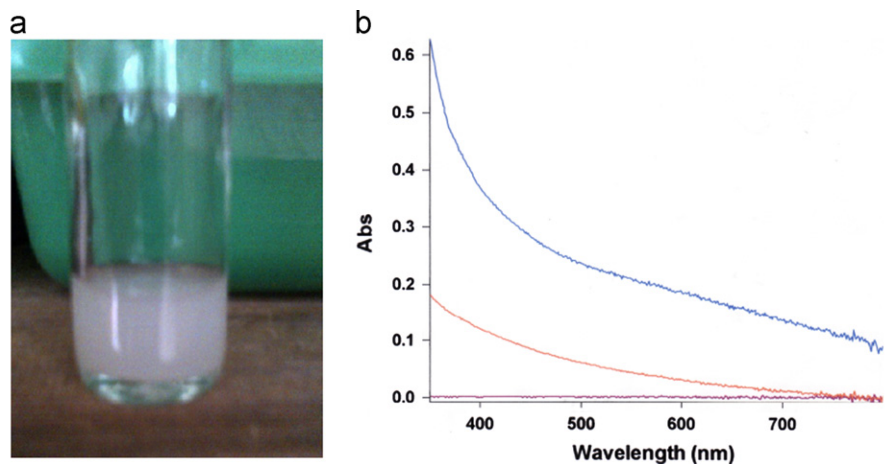

Fig. 4. Suspension resulting from the mixing of $AgNO_3$ and seed extract for 24 h (a) and UV–vis patterns of seed extract solution (b, red-line) and the suspension after 24 h (b, blue-line). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

observed. When the solution of $AgNO_3$ was added to the seed extract and the mixture was allowed to stand at room temperature for 24 h, the formation of white suspension was observed (Fig. 4a). The UV–visible spectrophotometry analysis revealed that there is no SPR peak for silver nanoparticles in the range of 400–460 nm (Fig. 4b).

In summary, the use of environmentally benign and renewable materials such as aqueous rinds extract of *B. javanica* as the medium/reduction system gives some benefits especially in the course of laboratory practices. The procedure is simple and elevated temperature is not needed. We foresee that this reduction system can be extended to the preparation of other coinage metal nanoparticles (Cu, Au, and Pt) under appropriate conditions.

References

[1] (a) Durán N, Priscyla DM, Oswaldo LA, Souza GIHD, Eposito E. Mechanistic aspects of biosynthesis of silver nanoparticles by several fusarium oxysporum strains. J Nanobiotechnol 2005:1–7;
(b) Bar H, Dipak KB, Gobinda PS, Prianka S, Sangkar PD, Ajay M. Green synthesis of silver nanoparticles using seed extract of *Jatropha curcas*. Colloid Surf A: Phycochem Eng Aspects 2009:212–6;
(c) Geethalakshmi R, Sarada DVL. Synthesis of plant-mediated silver nanoparticles using *Trianthema Decandra* extract and evaluation of their anti microbial activities. Int J Eng Sci Technol 2010;2(5):970–5 and references therein.
[2] (a) Kumar V, Yadav K. Plant-mediated synthesis of silver and gold nanoparticles and their application. J Chem Technol Biotechnol 2008;84:151–7;
(b) Mohanpuria P, Rana KN, Yadav SK. Biosynthesis of nanoparticles: technological concepts and future applications. J Nano Res 2008;10:507–17;
(c) Silvaraman SK, Iniyan E, Sanjev K, Venugopal S. A green protocol for room temperature synthesis of silver nanoparticles in second. Curr Sci 2009;97(7):1055–8;
(d) Song JY, Kim BS. Rapid biological synthesis of silver nanoparticles using plant leaf extracts. Bioprocess Biosyst Eng 2009;32:79–84;
(e) Narayanan KB, Sakthivel N. Green synthesis of biogenic metal nanoparticles by terrestrial and aquatic phototrophic and heterotrophic eukaryotes and biocompatible agents. Adv Colloid Interface Sci 2011;169:59–79;
(f) Durán N, Marcato PD, Durán M, Yadav A, Gade A, Rai M. Mechanistic aspects in the biogenic synthesis of extracellular metal nanoparticles by peptides, bacteria, fungi, and plants. Appl Microbiol Biotechnol 2011;90:1609–24.
[3] (a) Selvakanan PR, Anita S, Srisathiyanarayanan D, Pravin SS, Renu P, Mandale. B, et al. Synthesis of aqueous Au core Ag shell nanoparticles using tyrosine as a pH-dependent reducing agent and assembling phase-transferred silver nanoparticles at the air water interface. Langmuir 2004;20:7825–36;
(b) Akbarzadeh A, Davood Z, Ali F, Mohammad RM, Dariush N, Shahram T, et al. Synthesis and characterization of gold nanoparticles by tryptophane. Am J of App Sci 2009;6(4):691–5.
[4] Iravani S. Green synthesis of metal nanoparticles using plants. Green Chem 2011;13:2638–50.
[5] Raveendran P, Fu J, Wallen SL. Completely green synthesis and stabilization of metal nanoparticles. J Am Chem Soc 2003;125(46):13940–1.
[6] (a) Bawm S, Matsuura H, Elkhateeb A, Nabeta K, Subeki, Nonaka N, et al. In vitro antitrypanosomal activities of quassinoid compound from the point of medicinal plant *Brucea javanica*. Vet Parasitol 2008:288–94;
(b) WHO Monographs on selected medicinal plants, vol. 1. Geneva: World Health Organization (WHO); 1999.
[7] Subeki, Matsuura H, Takahashi K, Nabeta K, Yamasaki M, Maede Y, et al. Screening of Indonesian medicinal plant extracts for anti-babesial activity and isolation of new quasionids from *Brucea javanica*. J Nat Prod 2007:1654–7.
[8] Kiran PP, Bhaktha BNS, Rao DA, De G. Non-linear optical properties and surface plasmon enhanced optical limiting in Ag–Cu nanoclusters co-Doped in SiO2 Sol–Gel Films. J Appl Phys 2004;96(11):6717–23.