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One-pot green synthesis of gold nanoparticles and studies of their anticoagulative and photocatalytic activities

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ABSTRACT

A green approach for synthesis of gold nanoparticles (Au NPs) using dried biomass of *Momordica cochinchinensis(Lour.) Spreng.* leaf is reported. The as-synthesized nanoparticles were characterized by time-dependent UV–visible, Fourier transform infrared (FT-IR), powder X-ray diffraction (XRD), transmission electron microscopy (TEM) and energy-dispersive X-ray spectroscopy (EDX) analyses. The UV–visible spectra of synthesized Au NPs showed surface plasmon resonance (SPR) at 552 nm after 12 h. The TEM image showed the Au NPs are mostly spherical, oval and triangular with sizes 10–80 nm. As-synthesized Au NPs shows pronounced photocatalytic effect on degradation of dyes under solar light illumination. Ability of Au NPs to inhibit coagulation of human blood plasma was also investigated.

1. Introduction

Biotechnology and nanotechnology provides the tool and technology platform towards improvement of human life in society [1]. Noble metal nanoparticles continue to attract interest among the researchers due to their wide range of application in various fields such as medicine, biotechnology, optics, microelectronics, catalysis, information storage and energy conversion [2–5]. Design of new synthesis methods of nanoparticles is still a challenge among the scientific community due to their environmental consequences. Traditional methods of synthesis of Au NPs both by chemical and physical usually encounter problems of stability, control of particle growth and their aggregation [6,7]. It has been widely reported that synthesis of Au NPs using plant extracts often lead to highly controlled size and morphology. Moreover, such pathways are cost effective and do not use toxic chemicals, high pressure and temperature. A number of bio-inspired approaches were explored over the years using leaf extract of various plants.

Textile industry customarily use organic non-biodegradable dyes which lead to considerable rise in environmental pollution [7]. Therefore tackling this problem is major concern for people in industry. Among the various known methods, photocatalytic techniques have been extensively considered as energy-saving and a "green" means to degrade the soluble dyes from wastewater.

Thrombotic disorder happens due to imbalance between procoagulant and anticoagulant forces, may lead serious health problems to human being [8–10]. One of the clinical ways to prevent coagulation of blood is by inactivating the platelets. Au NPs with suitably manipulated sizes can pass through cell membranes and can cause inactivation of platelets thus preventing coagulation of blood [8]. However, such potential of Au NPs have not been explored extensively till date. We have recently reported biosynthesis of Ag NPs and exploited its anticoagulation property for human blood [11]. Therefore, it is expected that Au NPs may have similar potential towards anticoagulation of blood and will eventually contribute significantly in medicine science in controlling thrombotic disorders.

As a continuation of our ongoing research [11–13] on biosynthesis of nanomaterials, we herein, wish to report biosynthesis of Au NPs using leaf powder of *Momordica cochinchinensis(Lour.) Spreng.* The species named *cochinchinensis* belongs to the melon family (Cucurbitaceae). It is found in the northern part of Vietnam, as well as many Asian countries, including India [14]. Extract from the plant parts of *Momordica cochinchinensis(Lour.) Spreng.* has been tested successfully in carotenoid biosynthesis and as antimicrobial agent. To the best our knowledge, use of *Momordica cochinchinensis(Lour.) Spreng.* in the synthesis of Au NPs has not been reported till date.

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2. Experimental

2.1. Biosynthesis of Au NPs

For the synthesis of Au NPs, approximately 1 g of dry leaf powder was mixed with 100 ml (10^{-3} M) aqueous solution of $HAuCl_4$ and stirred magnetically at room temperature for 12 h. The progress of the reaction was routinely monitored by observing color change as well as by recording UV–visible spectrum of small aliquot of mixture at regular interval. The initial light yellow solution turned to deep red, indicating formation of colloidal gold. The supernatant containing Au NPs was collected by centrifugation at 10,000 rpm. The settled green biomass loaded with gold nanoparticles was washed repeatedly with doubled distilled water and dried.

2.2. Catalytic performance test

In the typical run, 2 ml of freshly prepared sodium borohydride (SB) solution (0.2 M) was mixed with 50 ml (10 mg L^{-1}) aqueous solution of dye. In this solution 1 mg of catalyst was added and the reactant was mixed quickly. At a regular interval of time, 4 ml of the suspension was withdrawn and centrifuged immediately. The absorbance of the supernatant was then measured using UV–visible spectrophotometer. The reaction is also monitored without catalyst. The reactions were carried out at room temperature (30 ± 1 °C).

2.3. Anticoagulant activity

In this study, blood plasma was received from a few human healthy male and female in the age range of 25–45 years. Two different test tubes 'a' and 'b' were used to receive the blood plasma. Test tube 'a' received the blood without any anticoagulant, whereas test tube 'b' received 10 ml blood along with 1 ml Au NPs, respectively. The ability of Au NPs to inhibit the coagulation of blood plasma was examined.

3. Results and discussion

Au NPs were synthesized via bioreduction of aqueous $HAuCl_4$ solution with dry leaves powder of *Momordica cochinchinensis (Lour.) Spreng.* Within a few minutes of adding the dry leaves powder to the aqueous solution of $HAuCl_4$ biosynthesis reaction started as indicated by the slow change of light yellow color of $HAuCl_4$ solution to deep red. The protein molecules present in the leaf powder served both as reductant and stabilizer. The time-dependent UV–visible spectra (Fig. 1(a)) of Au NPs synthesized by *Momordica cochinchinensis(Lour.) Spreng* showed SPR band around

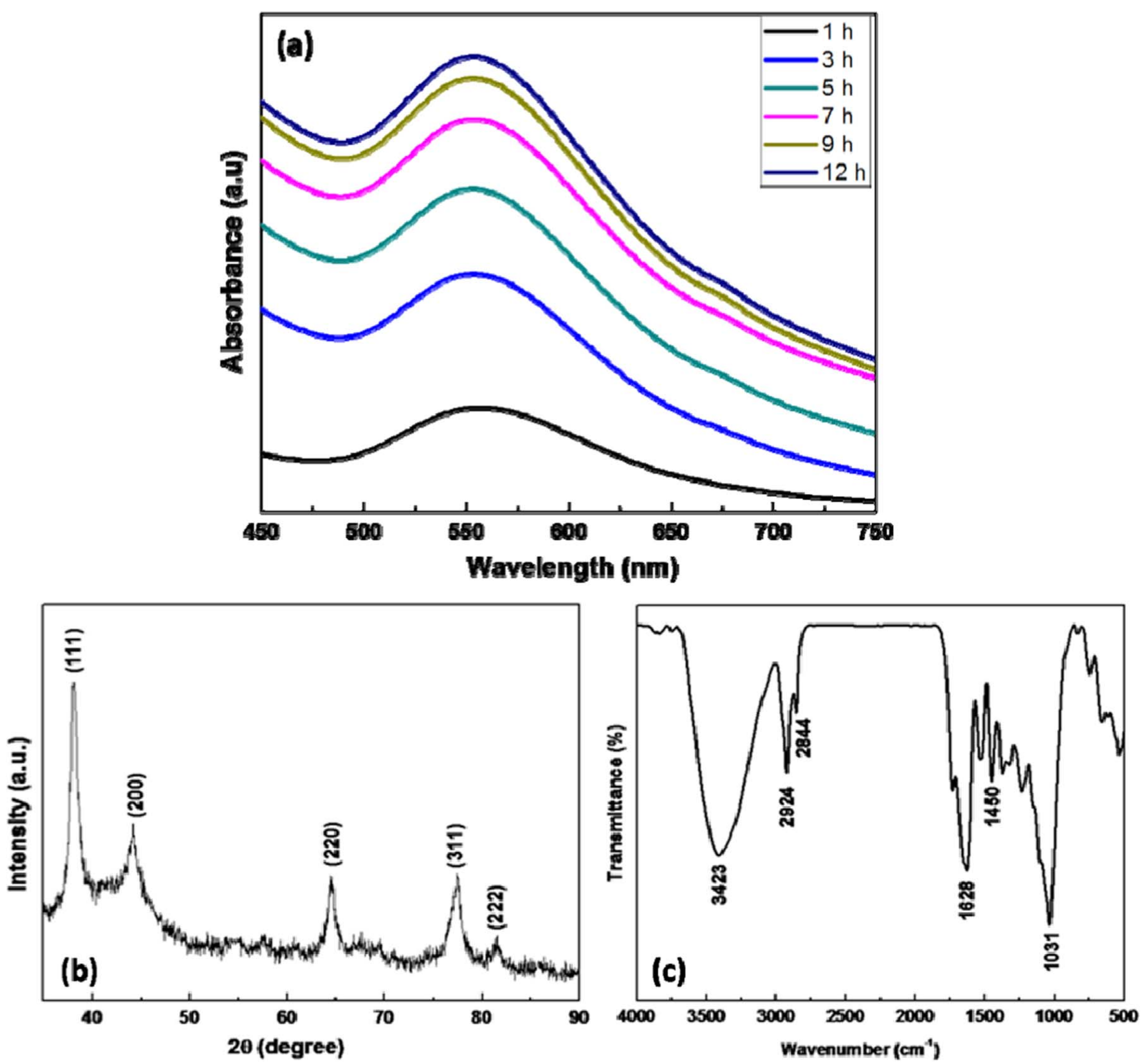

Fig. 1. (a) The time-dependent UV–visible spectra (b) X-ray diffraction pattern and (c) FT-IR spectrum of synthesized Au NPs.