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Tansy fruit mediated greener synthesis of silver and gold nanoparticles

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ABSTRACT

In this paper we have reported the green synthesis of silver (AgNPs) and gold (AuNPs) nanoparticles by reduction of silver nitrate and chloroauric acid solutions, respectively, using fruit extract of *Tanacetum vulgare*; commonly found plant in Finland. The process for the synthesis of AgNPs and AuNPs is rapid, novel and ecofriendly. Formation of the AgNPs and AuNPs were confirmed by surface plasmon spectra using UV–Vis spectrophotometer and absorbance peaks at 452 and 546 nm. Different tansy fruit extract concentration (TFE), silver and gold ion concentration, temperature and contact times were experimented in the synthesis of AgNPs and AuNPs. The properties of prepared nanoparticles were characterized by TEM, XRD, EDX and FTIR. Finally zeta potential values at various pH were analyzed along with corresponding SPR spectra.

1. Introduction

Science of the nanotechnology is supposed to have started by the lecture of Richard Feyman on “There is Plenty of Room at the Bottom” at the annual meeting of the American Physical Society at the California Institute of Technology in 1959. Due to the optical, magnetic and electrical properties [1,2], nanomaterials have a long list of applicability in improving the human life and its environment. The first relation between human life and nanoscale was developed naturally in ayurveda, which is 5000-year-old Indian system of medicine. It had some knowledge of nanoscience and technology before the term ‘nano’ was even formed, which modern science has just started exploring in the 21st century [3]. Several physical and chemical processes [4–6] for synthesis of metal nanoparticles were developed considering the real life application of nanoparticles in the area of medicine [7], catalysis [8], detection [9], etc. Recently the studies started under green chemistry for the search of benign methods for the development nanoparticles and searching antibacterial, antioxidant, and antitumor activity of natural products. Biosynthetic processes have received much attention as a viable alternative for the development of metal nanoparticles where plant extract is used for the synthesis of nanoparticles without any chemical ingredients [10–14]. Leaf extracts of neem, geranium, hibiscus, cinnamon, tamarind and coriander have also found suitable for the biosynthesis of silver and gold nanoparticles [15–20]. Among various metal nanoparticles, AgNPs and AuNPs have several effective applications as antibacterial, sensors and detectors besides their biomedical applications [21–25].

Tanacetum vulgare (tansy), a perennial herb is also known as Common Tansy, Bitter Buttons, Cow Bitter, Mugwort, or Golden Buttons. Around 1525, it was listed (by the spelling “Tansey”) as “necessary for a garden” in Britain [26]. Tansy was considered a cure for intestinal worms, rheumatism, digestive problems, fevers, sores, measles and less commonly it was used to treat menstrual irregularities and induce menstrual bleeding [27–30]. During the Middle Ages and later, high doses were used to induce abortions [28,31,32]. Contradictorily, tansy was also used to help women conceive and to prevent miscarriages [27,28,33].

Inflorescence of *T. vulgare*

The principal chemical constituent of the herb is the volatile oil or *oil of tansy*. In addition, a bitter, amorphous principle, tanacetin ($C_{11}H_{16}O_4$), is present [34] mainly in the flowers. Besides tanacetin,

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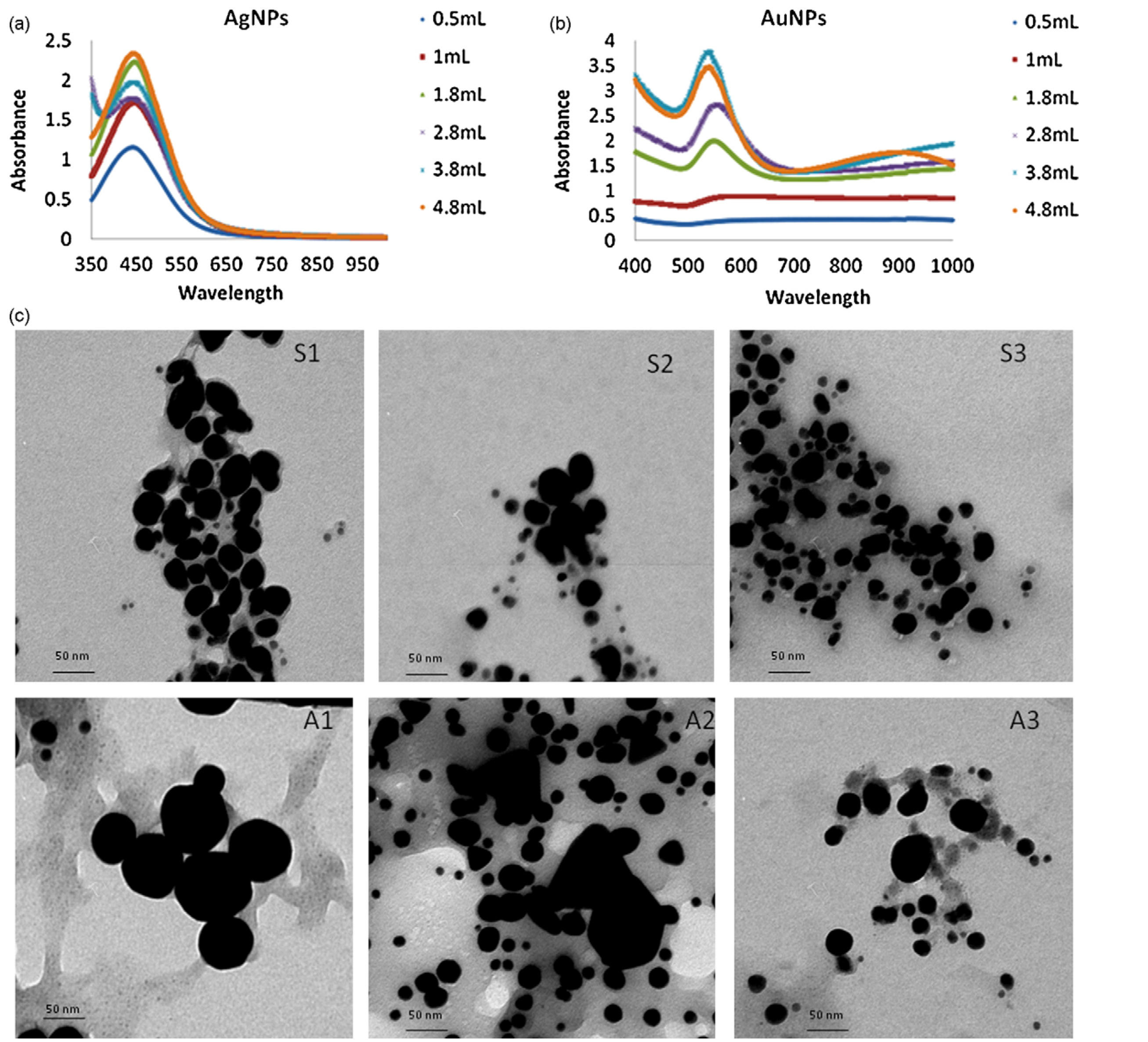

Fig. 1. Effect of Tansy fruit extract (TFE) quantity. (a) In silver nanoparticle (AgNPs) synthesis. (b) In gold nanoparticle (AuNPs) synthesis. (c) TEM images of silver and nanoparticles at different leaf extract quantity. (I) S1 AgNPs at 1.8 mL TFE. (II) S2 AgNPs at 2.8 mL TFE. (III) S3 AgNPs at 4.8 mL TFE. (IV) A1 AuNPs at 1.8 mL TFE. (V) A2 AuNPs at 2.8 mL TFE. (VI) A3 AuNPs at 4.8 mL TFE.

flower may contain several monoterpenoids [35]. The essential oil content of tansy flowers is about twice as much as in the leaves [36]. According to Leppig [37], the herb also contain the following constituents: tanacetin, tannic acid (tanacetum–tannic acid), traces of gallic acid, volatile oil, a wax-like substance, albuminoids, tartaric, citric, and malic acids, traces of oxalic acid, a laevogyrate sugar, resin, metarabic acid, parabin, and woody fiber.

Here we have explored an inventive contribution for synthesis of silver and gold nanoparticles using fruit extract of *T. vulgare*. The procedure for the development of stable AgNPs and AuNPs is rapid, simple and viable. Synthesized nanoparticles were characterized by various methods, such as TEM, XRD, EDX, UV–Vis and FTIR.

2. Materials and methods

Fresh fruits of *T. vulgare* were collected from Mikkeli city. Silver nitrate and auric acid were obtained from Sigma Aldrich chemicals. All glasswares were properly washed with water and dried in oven.

Tansy fruits extract (TFE) was used as a reducing agent for the development of silver and gold nanoparticles. Properly washed 50 g of fresh tansy fruits were added in 250 mL ultrapure water in 500 mL Erlenmeyer flask and boiled for 10–15 min. Whatman filter paper (No. 40) was used for the filtration of boiled material to prepare the aqueous fruit extract, which was used as such for metal nanoparticle synthesis.

Aqueous solution (1 mM) of silver nitrate and auric acid were prepared and 50 mL of those metal ion solutions were reduced using 1.8 mL of TFE at room temperature for 10 min. Below than this TFE quantity, the solution takes more than 20 min to get a significant SPR for both the metal nanoparticles. As a result brown–yellow and pink–red solutions were formed, indicating the formation of silver and gold nanoparticles, respectively [38,39]. The effects of reaction conditions such as the TFE amount, metal ion concentration, reaction temperature and contact time were also studied.

Spectral analysis for the development of nanoparticles at different reaction conditions were observed by UV–Vis spectroscopy (Perkin-Elmer Lamda-45 spectrophotometer). AgNPs and AuNPs gave sharp peak in the range of visible region of the electromagnetic spectrum. Transmission Electron Microscope (TEM) JEM-1200EX, JEOL was used for the analysis of size and shape of developed nanoparticles. 3 μL of the sample was placed on copper grid making a thin film of sample on the grid and kept for drying at room temperature for 15 min, then extra sample was removed using the cone of a blotting paper and reserved in grid box. The presence of elemental silver and gold was determined using energy dispersive X-ray analysis (EDX) with Zeiss Evo 50 instrument. Zetasizer (Malvern) instrumentation was used to analyze the surface charge and stability of synthesized nanoparticles at pH (2–10). The pH of the solution was maintained by 1N HCl and 1N NaOH.

Resulting solutions of the developed nanoparticles of silver and gold were dried at 80 °C for X-ray powder diffraction measurements. The X-ray powder diffrac-