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Green synthesis and characterization of monodisperse gold nanoparticles using Ginkgo Biloba leaf extract

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ABSTRACT

A simple, straightforward and eco-friendly approach for synthesis of well dispersed nano gold particles was reported. In the process, Ginkgo Biloba leaf extract was used as both reducing and stabilizing agent without addition of any other reducing and capping agent. The characterization and properties of prepared gold nanoparticles were measured by transmission electron microscopy (TEM), Scanning electron microscope (SEM), energy dispersive X-ray spectroscopy (EDS), dynamic light scattering (DLS), powder X-ray diffraction (XRD), Fourier transform infrared (FT-IR) and UV–vis absorption spectroscopy (UV-vis). The formation of gold nanoparticles was confirmed by change of color from light yellow to red, which was further proved by absorbance peak at 544.5 nm in UV–vis spectroscopy. The particles were highly crystalline in nature, global in shape and small in size with a narrowly distribution from 10 nm to 40 nm. The gold nanoparticles were capped with extracts, preventing them from oxidation and agglomeration. The effect of reaction temperature, reaction time, amount of extracts and chloroauric acid solution was also investigated. The results reveal that these parameters play important roles in the formation of gold nanoparticles. The method exhibited in this study provides a very prospective process to prepare other noble nanoparticles, such as Pd, using renewable and environmentally materials.

1. Introduction

Now days, due to the provision of various approaches to regulate a wide variety of nanomaterials, nanotechnology have been known as one of the most promising and popular fields of scientific research [1–11]. Many nanomaterials, such as nanoparticles, nanowire, nanodisk, have been prepared by a number of methods [12–16]. Among nanomaterials, metallic nanoparticles have been extensive investigated due to their unique properties which may lead to a wide range of application in medicine, optoelectronics or composites [17–22]. Recently, there is an increasing interest to prepare gold nanoparticles not only for the expansion of synthetic advancement, but also for the assessment of their remarkable physical and chemical properties [23–27]. Metallic gold nanoparticles have been employed in many fields, such as catalysts for numerous environmental progressions, antimicrobial agents against a wide range of microorganisms, and so on [20,28,29]. Usually,

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these applications are associated with the size, shape and surface morphology of particles, which can be adjusted to suit the desired particular application [30,31]. Hence, the controlled fabrication of gold nanoparticles in terms of size and shape can augment biological, optical, catalytic and electronic of gold nanoparticles that can have broader applications [32–35]. Numerous procedures, including physical method, electrochemical method, photochemical method and liquid chemical reduction method, have been developed to synthesize gold nanoparticles [21,36–40]. In the above mentioned means, liquid chemical reduction method offered the advantages of large scale and more controllable synthesis [24,27,37,41]. The most intensively used protocol for the preparation of gold nanoparticles in liquid chemical method is the reduction of gold ion by suitable reducing agents and capping agents [26,40,42]. Various reducing agents and capping agents are employed to prepare gold nanoparticles [26,29,43–47]. Unfortunately, some of these reducing agents or capping agents used in above method are toxic to biotic communities and pollute the environment, which may limit the application of gold nanoparticles [46,48–50]. In order to reduce the effects of toxic chemicals on the environment, there is a trend to explore alternative process for gold nanoparticles preparation which avoids the use of toxic reducing or capping agents [26]. Recently, the green preparation of metallic nanopartilces was evolved into an important branch of nanotechnology. The synthesis of gold nanoparticles using various plants and microbes has been viewed as eco-friendly alternatives to chemical and physical methods due to its cost effectiveness and environmental compatibility [49–54]. However, the microbes approach for gold nanoparticles synthesis requires complicated process such as the purification and adherence of bacteria on the particle surface, which may increase the potential danger to public environmental hygiene and human health [26]. Compare with microbial process, the plant extract mediated synthesis was more preferable due to its simplicity, low toxicity and easy biodegradability [26]. A large number of plants extract have been employed to preparation of gold nanoparticles, such as geranium leaf,Murraya Koenigii leaf, Mangifera indica leaf, Sesbania grandiflora leaf [37,55–57].

Recently, we have developed an original approach using wolfberry fruit (Lycium barbarum) and Osmanthus fragrans extract as capping agents as well as reducing agent for preparation of small silver nanoparticles [58,59]. In present research, Ginkgo biloba leaf extract were used as reducing and capping agents for the bio-synthesis of gold nanoparticles. Ginkgo biloba, have survived on the earth for 200 million years, which is the only living species in the large plant division Ginkgophyta [60]. This plant is widely planted in China, Korea, Japan, Europe and USA. Ginkgo biloba leaf is common used in medicine, health-care food and cosmetics [61]. The leaf consists of many bioactive components, such as sterols, polyprenols, flavonoids, terpene lactones and carboxylic acids, which can acted as reducing or capping agent to prepare metallic nanoparticles [62,63]. To the best of our knowledge, there is no report about the use of Ginkgo biloba leaf to synthesize gold nanoparticles.

2. Experimental methods

2.1. Reagents

Chloroauric acid (analytical grade) used during the experiment was obtained from Sinopharm Chemical Reagent Co. Ltd., acted as the precursor for the synthesis of gold nanoparticles. Fresh ginkgo biloba leaf was collected from Hubei Polytechnic University, Hubei, China. All chemicals and solvents were used as received without further purification and doubly distilled water was used in all experiments.

2.2. Preparation of chloroauric acid solution

To prepare 0.2% chloroauric acid solution (w/v), 0.1 g of chloroauric acid was dissolve in 50 mL distilled water. The solution was kept in dark for further use.

2.3. Preparation of leaf extract

For a typical extract, the freshly collected ginkgo biloba leaf were washed thoroughly with tap water and then rinsed with distilled water to remove any dirt attached. The cleaned ginkgo biloba leaf were kept overnight for drying at room temperature. Thereafter, fifty grams of dried fresh leaf were placed in a 250 mL flask with 150 mL distilled water, and refluxed at 100 °C for 30 min. The ginkgo biloba leaf extract were cooled and filtered through Whatman filter paper no. 1. The total volume of extract was adjusted to 150 mL by adding distilled water and stored at 4 °C. The extract was used further studies within 3 days.

2.4. Synthesis of gold nanoparticles

The synthesis of gold nanoparticles was simply obtained by the reduction of chloroauric acid in solution using ginkgo biloba leaf extract as reducing agent and capping agent. In a typical experiments, 2 mL chloroauric acid solution and 5 mL ginkgo biloba leaf extract were mixed. The volume of mixture was tuned to 25 mL by adding appropriate amount of distilled water. The solution were stirred at room temperature and allowed to react for 2 h. The color of the reaction mixture was gradually changed from pale yellow to red, which indicates the formation of gold nanoparticles. Finally, the gold nanoparticles were separated and purified from the solution by repeated centrifugation, and further dried in vacuum at 40 °C for 12 h.