J. Mat. NanoSci. 2016, 3(1), 8-10 Article

Journal of
Materials NanoScience

Green synthesis of Gold Nanoparticles and their characterization

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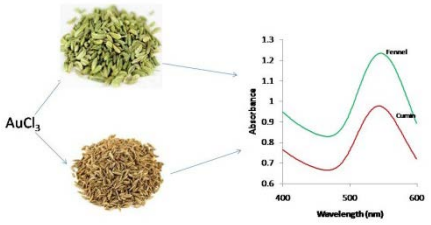
Submitted on: 1-Jan-2016 Accepted and Published on: 8-Feb-2016

ABSTRACT



Biocompatible gold nanoparticles have gained considerable attention in recent years for potential applications in different fields such as medicine, catalysis, electronics and biotechnology. This work is aimed at exploring the green synthesis of gold nanoparticles using cumin and fennel seeds as simple, non-toxic, eco-friendly 'green materials'. The growth of nanoparticles was monitored by UV-Vis spectrophotometer. The UV-Vis spectrum of cumin and fennel-gold nanoparticles showed a peak in the region of 535and 540 nm respectively corresponding to the surface Plasmon resonance band (SPR) of gold nanoparticles.

Keywords: Gold nanoparticles, cumin, fennel, UV-vis spectroscopy

INTRODUCTION

The application of nanoscale materials and structures, usually ranging from 1 to 100 nanometers (nm), is an emerging area of nanoscience and nanotechnology. Nanomaterials may provide solutions to technological and environmental challenges in the areas of solar energy conversion, catalysis, medicine, and water treatment.[1-3] The metallic nanoparticles (NPs) exhibit unique physical and chemical properties that are not observed either in the individual molecules or in the bulk materials because of their high surface to volume ratio. Among the metallic NPs, gold nanoparticles (AuNPs) in particular are known for their versatile biological applications in the fields of medicine and biotechnology.

AuNPs can be synthesized by physical and chemical methods.[4-6] The chemical synthesis of AuNPs may lead to the presence of some toxic chemicals adsorbed on the surface that may have adverse effects in its application and also the chemical used in the synthesis may pollute the environment. Biological materials have the potential to reduce the metal ions into metal NPs. Biosynthesis of Au NPs gained considerable attention in the past decade because of their vast applications. Moreover, it has been proposed as a less toxic, cost-effective, environmentally friendly alternative to chemical and physical methods. Accordingly, AuNPs have been synthesized using microorganisms[7,8] and plant extracts.[9,10] The proteins present in the biological materials are involved in the reduction and stabilization of NPs. Plants such as Coriander leaf, Alfalfa, Aloe vera, Neem, Tulsi, Amla, Lemon grass and Tamarind have been reported as potent biological materials for synthesis of AuNPs and continuing with this work, we have used Cumin *(Cuminum cyminum*) and Fennel (*Foeniculum vulgare*) seeds for biosynthesis of AuNPs. Cuminand fennelare herbaceous plant grown in Mediterranean climate and are known for their

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Cite as: *J. Mat. NanoSci., 2016, 3(1), 8-10.*

 ISSN 2394-0867 http://pubs.iscience.in/jmns

stimulant, antispasmodic, anti-inflammatory, antioxidant and carminative properties and help in digestion and maintain blood pressure. Cumin and fennel's distinctive flavor and strong aroma are due to their essential oil content. The biocomponents present in these not only reduce the gold ions to NPs but also stabilize it.

The objective of present study is to prepare green AuNPs using cheap, easy available and ecofriendly reducing agents. The experimental work for this project was done by student authors Ayushi Chand, Geetika Dhanda, Neha Abbasi and Gunjan Panchal as part of their summer internship project during the months of May to July at DS Kothari Centre for Research and Innovation in Science Education at Miranda House under the guidance of Malti Sharma, Mallika Pathak and Bani Roy.

MATERIALS AND METHODS

The spices were procured from local market. Auric chloride (Fisher Scientific) of99.8% purity was used for gold nanoparticle preparation. The water used for the synthesis was 18 Mega ohm MilliQ grade water derived from Millipore water system (Elix 3, Millipore Corp USA). Cary 100 (BIO UV-Vis spectrophotometer, Varian, Australia) was used for characterization of prepared NPs.

Preparation of Spice Extract

Spices were washed thoroughly with Milli Q water and then oven dried. The dried spices were finely powdered using mortar and pestle. 1% extract of spices powder were prepared by boiling for 10 min in Milli Q water. The extracts were filtered with Whatman filter paper Number 1 and the residual material was discarded. The filtered extracts were stored in the refrigerator at 4 $^{\circ}$C for use as reducing agent in the synthesis of Au NPs.

Green synthesis of gold nanoparticles

10 mL of 1mM Auric chloride aqueous solution and 30 mL Milli Q water was taken in a conical flask and placed on the hot plate with magnetic stirrer at a temperature of around 50ºC. After around 3 minutes, 5 mL of 1% extract of cumin was added slowly to the gold (III) chloride solution. The progress in conversion of gold ions to AuNP was monitored by observing the color change and UV-vis spectroscopy. The time taken for conversion to AuNPs was also noted. Similar procedure was applied for the preparation of AuNPs using 1% fennel aqueous extract.

RESULTS AND DISCUSSION

AuNPs exhibit a distinct optical feature commonly referred to as surface plasmon resonance (SPR), that is, the collective oscillation of electrons in the conduction band of gold AuNPs in resonance with a specific wavelength of incident light. SPR of AuNPs results in a strong absorbance band[11,12] in the visible region (500-600 nm), which can be measured by UV-Vis spectroscopy. The SPR spectrum is dependent both on the size and shape of AuNPs. The peak wavelength increases with particle diameter, and for uneven shaped particles such as gold nanourchins, the absorbance spectrum shifts significantly into the far-red region of the spectrum when compared to a spherical particle of the same diameter. UV-vis spectra (Figure 1) of AuNPs prepared using cumin and fennel exhibit SPR band in the region of 535 and 540 nm, respectively. Tyndall effect was also observed in the synthesized NPs solution which was not found in gold chloride solution.

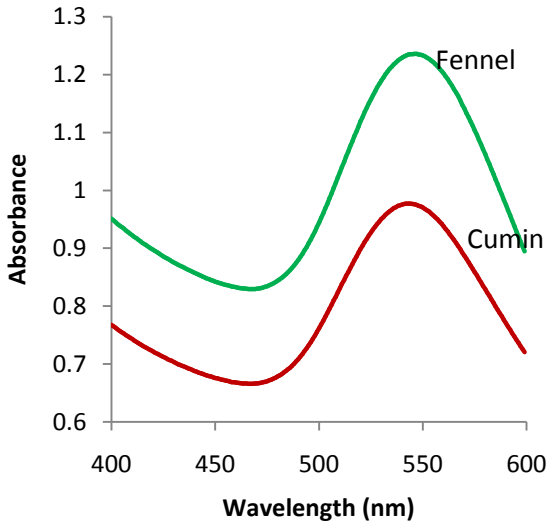

Figure 1. UV-vis spectra of AuNPs prepared using cumin and fennel extracts

We have prepared AuNPs using aqueous extracts of spices such as cumin and fennelby adding certain volume of spice extracts to auric chloride solution with stirring at 50 °C. The colour change from light yellow to violet and finally to red was observed within 40 min which confirm the formation of AuNPs (Fig.2). Spice mediated synthesis of NPs is due to the presence of amino acids, essential oils, carbohydrate derivatives, resins, glycosides, phenylpropanoids etc. present in the spices as their phytochemicals.[13]

Figure 2. AuNPs prepared using fennel extract

It was also noted that as temperature increases, rate of reaction also increases. Furthermore, stability of prepared nanoparticles was monitored by collecting UV-vis spectra of the same solution after every 7-8 hrs. for 20 days. Studies indicated that there was no change in the position of their wavelength. This proved that the prepared NPs were quite stable and biomolecules present in species not only played a role in reducing the ions to the nanosize, but also play an important role by preventing the agglomeration of NPs.[14,15]

ACKNOWLEDGEMENTS

Authors acknowledge the support given to the project by the DS Kothari Centre for Research and Innovation in Science Education (DSKC) at Miranda House.

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