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Green Synthesis of Gold Nanoparticle using Nutmeg Fruit Extract

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Abstract: ***Nanotechnology is an interdisciplinary branch of science which deals with the synthesis, processing and application of nanomaterials. Nanomaterials are particles in the range of 1-100nm. Researchers have keen interest in finding a green synthetic method for the production of gold nanoparticles due to its distinctive properties and technological application. In this article, the biosynthesis of gold nanoparticle by chloroauric acid using nutmeg (Myristica fragrans) fruit extract was reported. This method is simple, low cost and environment friendly. Nutmeg fruit extract acts as the reducing and stabilizing agent. Water is used as the solvent and chloroauric acid as the metal precursor. This method is a chemical reduction method by bottom-up approach. Different concentrations of nutmeg fruit extract were prepared for this experiment. The reduction of Au (III) to Au (0) was confirmed by UV-Visible spectroscopy. The characteristic strong absorption band at 530nm reveals the presence of gold nanoparticle.***

Keywords: nanomaterials, chloroauric acid, nutmeg, chemical reduction, gold nanoparticle

1. Introduction

Nanotechnology is an interdisciplinary science that allows developing cheaper and smaller materials which possess wide application in many fields mainly in electronics and medicine. The Greek word 'nanos' means 'small', from where the term originates. Prof. Norio Tanigushi of Tokyo University coined the term nanotechnology. Nanoparticles are particles with size in the range of 1-100nm. Nanoparticles can be classified into organic nanoparticles and inorganic nanoparticles. Organic nanoparticles consists of carbon nanoparticles especially fullerene whereas inorganic nanoparticles contains metal nanoparticles like gold, silver, TiO_2, ZnO etc. Inorganic nanoparticles possess vibrant material properties therefore Scientists are fond of inorganic nanoparticles [1].

The applications of gold nanoparticles were known since 16^{th} century, used as medicine and for staining purposes. The interaction of gold nanoparticles with visible light produces vibrant colours. The properties of gold nanoparticle are different from bulk [2]. For example, gold is yellow in colour whereas gold colloid is wine red. During the synthesis of gold nanoparticle, it could be in any shape like spherical, triangular, rod like, nanoprism, multiple twinned, octahedral, tetrahedral, hexagonal etc. A triangular gold nanoparticle shows excellent optical properties than spherical. Gold nanoparticles are stable, biocompatible, nontoxic, binding ability to proteins, DNA, nucleic acids, enzymes and other biomolecules. They have large surface to volume ratio, optical, electrical and chemical properties which enhanced their technological benefits [3]. The commonly used techniques for the characterization of gold nanoparticle include UV-Visible spectroscopy, FTIR, TEM, SEM and XRD. UV-Visible spectroscopy for the identification of gold nanoparticle of different shape and size, FTIR used to recognize the biogroups that are bound to the surface of the nanoparticle, SEM and TEM for the analysis of chemical composition and morphology, XRD for identification and quantitative analysis of various crystalline samples [4].

Generally they are prepared by the chemical reduction of chloroauric acid. The reaction medium contains reducing and stabilizing agents which proceeds to the product formation. The reducing agents reduce the Au (III) to Au (0) and stabilizing agents prevents after the formation of small gold nucleus. Turkevich method is the simplest method for the synthesis of gold nanoparticles [5]. The development of novel green synthetic route has become an interesting topic of research in this field. This method is simple, low cost, environment friendly and nontoxic [6]. The hazardous reducing agents like DMF, sodium borohydride, hydrazine can be eliminated here, provided the plant extracts used should contain both reducing and stabilizing agents [7]. The choice of the plant depends on the presence of phenolic compounds. Phenolic compounds are good reducing agents the synthesis of nanoparticle using plant extracts is based on two steps- nucleation and growth. In the nucleation step, small gold nuclei are formed by the reduction of chloroauric acid and the coalescence of small adjacent gold nucleus into bigger particles occurs in the growth step [8].

Nutmeg is a spice found mostly in Indonesia and some parts of Kerala. It is a yellow colored fruit which cracks to give red color mace and seed as shown in Fig.1. It is found in essential oil [9]. It is used in puddings, cakes as a flavor. It is used to relieve pain, insomnia, brain health, treat liver disorders etc. It has antidepressant, anticonvulsant and antioxidant properties [10]. In the present study, nutmeg fruit extract is used for the synthesis of gold nanoparticles.

Figure 1: Nutmeg fruit

2. Experimental

2.1 Materials

Nutmeg fruit was collected from Alappuzha district, Kerala. Chloroauric acid was purchased from Sigma Aldrich chemie, USA. Experiments were performed in double distilled water. All glasswares were properly washed with water and dried in oven.

2.2 Preparation of nutmeg fruit extract

A fresh nutmeg fruit was taken, washed thoroughly with water and chopped into small pieces. It was ground into powder in a grinder. Aqueous extract were prepared with distilled water. The solution was filtered and kept in the refrigerator at 4°C for further experiments.

2.3 Biosynthesis of gold nanoparticle

A 100% solution of nutmeg fruit extract was prepared and from this, various composition like 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% were prepared in a 100ml beaker. 5ml of each of these extract was taken and mixed with 2.5ml of chloroauric acid and 2.5ml of distilled water in a 50ml beaker. It is then stirred in a magnetic stirrer for half an hour. It was observed that the colour of the solution becomes red wine due to surface Plasmon resonance. The gold nanoparticle solution of composition from 10% to100% is shown in Fig. 2. This shows the presence of gold nanoparticles in the solution which was further characterized by UV-Visible spectroscopy.

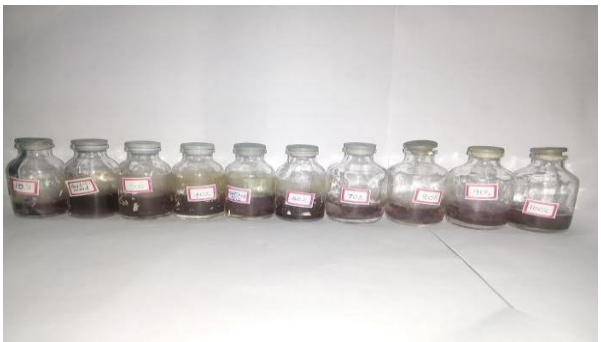

Figure 2: Gold nanoparticle solution of various composition

2.4 UV-Visible spectral analysis

It is the most widely used technique for the structural characterization of gold nanoparticle. This analysis was carried out on “Shimadzu UV 2450”.

3. Result and Discussion

In the solution, the gold nanoparticles were formed when complete reduction of chloroauric acid takes place in the presence of nutmeg fruit extract within half an hour. When these were formed, the solution becomes wine red in colour. A characteristic peak in the UV-Visible spectrum at 530nm is due to the phenomenon of surface Plasmon resonance. The absorption band in the UV-Visible spectrum is shown in Fig.3. From the spectra, it was revealed that the peak obtained for the solution from 10% to60% are at 540nm and those from 70% to100% are at 560nm. This is because as the size of the particle increases, the absorption shifts to longer wavelength. The size of the nanoparticles can be tuned by the change in concentration of the nutmeg fruit extract. At low concentration of the extract, mostly spherical nanostructures are obtained. On increasing the percentage concentration of the extract in the reaction medium, the size of the spherical nanostructures decreases which leads to the formation of clusters.

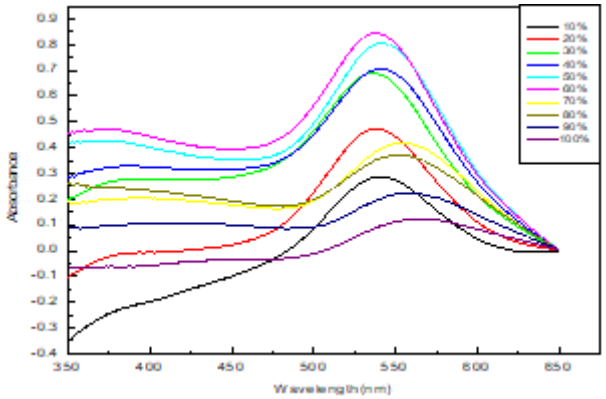

Figure 3: UV-Visible spectrum of gold nanoparticle from 10 % to 100%

4. Conclusion

In conclusion, the biological activity of nutmeg fruit extract for the reduction of Au (III) in choloroauric acid to Au (0) was investigated. This method is simple, low cost and environment friendly. This novel green method for the synthesis of gold nanoparticle may offers wide application in environment, biotechnological and biomedical field.

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Author Profile

Sarah John received the B.Sc. and M.Sc. degrees in Chemistry from Mahatma Gandhi University in 2013 and 2015, respectively. Now works as a lecturer in Kerala Civil Service Academy.