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Effect of pH on the Size of Gold Nanoparticles

K. Jayalakshmi[1], Mohammed Ibrahim[2] and K. Venkateswar Rao[3]

[1]Center for Nano Science and Technology, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad–500085
[2]Nizam Institute of Pharmacy, Deshmukhi Near Ramoji Film City, Greater Hyderabad-508284
[3]Center for Nano Science and Technology, Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad–500085

Abstract

The effect of pH on the size of gold nanoparticles was observed in this paper. We synthesized biocompatiable gold nanoparticles by reducing gold chloride with ascorbic acid. Colloidal gold nanoparticles produced in this method were stabilized by non toxic gum arabic. Formation of gold nanoparticles was confirmed with the help of UV-visible spectrophotometer. Peak wavelength was observed between 530 and 540 nm. We achieved size variations between 10 and 23 nm when the concentration of ascorbic acid was varied. Morphology and mean diameter of the particles were observed with the help of Scanning electron microscope and particle size analyzer respectively. Capping of gum arabic on gold naoparticles was confirmed with the help of FTIR spectroscopy.

Keywords: Gold nanoparticles, Surface Plasmon Resonance and Scanning electron microscope.

1. Introduction

Gold nanoparticles, also known as colloidal gold are small spheres of gold. The use of colloidal gold was well explained in a book on soluble gold[1]. Physical and chemical properties[2-5] of nanomaterials are different from their counterparts, for example, bulk gold is yellow in color and gold in nano level appears red. Gold is widely used in ornaments as well as in medical applications. Gold nanoparticles are highly stable against oxidation and therefore they play very important role in diagnostic and therapeutic nanomedicene. Gold Nanoparticles can be modified to impart various functionalities and they are biocompatible. They exhibit unique optical properties and these unique properties allow gold nanoparticles in the applications of catalysts, biosensors and in biomedical field.

2. Experimental Section

2.1 Materials

Hydrogen tetrachlorourate (III) trihydrate [6], was purchased from Aldrich. Ascorbic acid and Gum arabic, were purchased from Hi media chemicals. Deionized water was used for the preparation of solutions to prevent aggregation [7]. HNO_3 and HCl were used for aqua regia preparation.

2.2. Protocol

Chloroauric acid or gold chloride was used as a precursor for the preparation of gold nanoparticles. Ascorbic acid was used for the reduction of gold chloride. Chemical formulae of gold chloride and ascorbic acid are $HAuCl_4$ $3H_2O$ and $C_6H_8O_6$ respectively. Aqua regia was prepared by using HCl and HNO_3 (3:1 ratio). Gold chloride (mM), ascorbic acid (mM) and gum arabic (1% w/v) solutions were prepared. Magnetic stirrer, beaker and glassware were washed with aqua regia. Glassware was cleaned thoroughly with deionized water.

2.3. Synthesis of gold nanoparticles

Initially 3ml of gold chloride solution was boiled at 80^{o}C, stirred continuously with magnetic stirrer and hot plate combination. At this stage hot solution of 5ml ascorbic acid was added. Gold solution was yellow in color at the beginning. After the reduction of Gold chloride with ascorbic acid, yellow colored gold solution became colorless and after few minutes wine red color solution was observed. Synthesis parameters are given in the ***Table. 1***. Non toxic gum arabic was added to prevent the agglomeration of gold nanoparticles. The experiment was repeated by changing the amount of ascorbic acid.

Table 1: Synthesis parameters.

Sample	1mM Gold chloride [ml]	1mM Ascorbic acid [ml]	1%(w/V) Gum arabic
A	3	5	-
B	3	10	5
C	3	20	5
D	3	25	5

3. Characterization

UV-Visible plasma absorption measurements [8,9] were carried out at room temperature on Shimadzu 1800 UV-Visible spectrophotometer using a quartz cell with 1 cm path length. The particle size distribution of the colloidal gold nanoparticles was determined by Horiba SZ-100. Zeta potential was measured at 37^{o}C. Capping of gum arabic was confirmed from SHIMADZU 8400S FTIR spectroscopy in the range 400-4000cm^{-1}. Polymeric chains of gum arabic protect gold nanoparticles with intramolecular and intermolecular H-bonds [10].

4. Results and Discussion

4.1. UV studies

Optical properties [8, 9] of gum arabic stabilized gold nanoparticles were characterized by Shimadzu-1800 UV spectrophotometer with 10mm quartz cuvette. We have observed the blue shift of UV –Visible spectrum when particle size is reduced from 151.8 nm to 10.2 nm.

Table 2: Experimental results showing particle size and peak wavelength.

Sample	λ_{max} [nm]	Ab [a.u.]	Particle size [nm]	pH
A	548	1.117	151.8	4.5
B	537	0.852	23.5	4.4

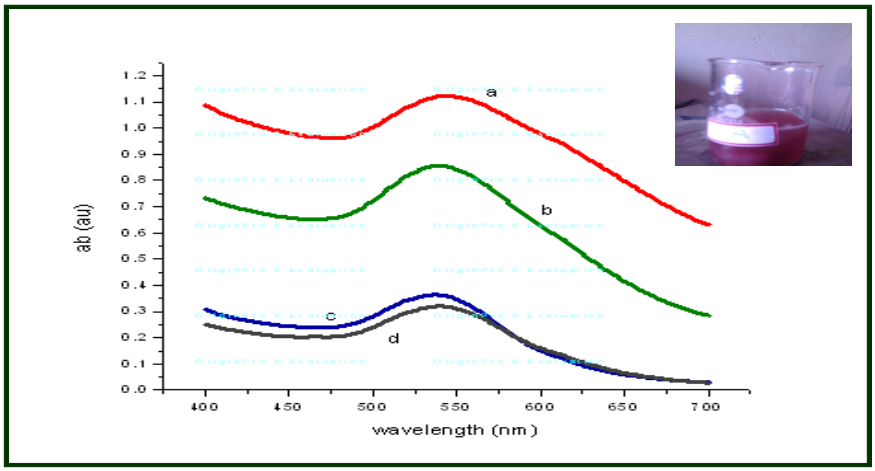

Fig. 1: UV-visible spectra of gold nanoparticles reduced by ascorbic acid.

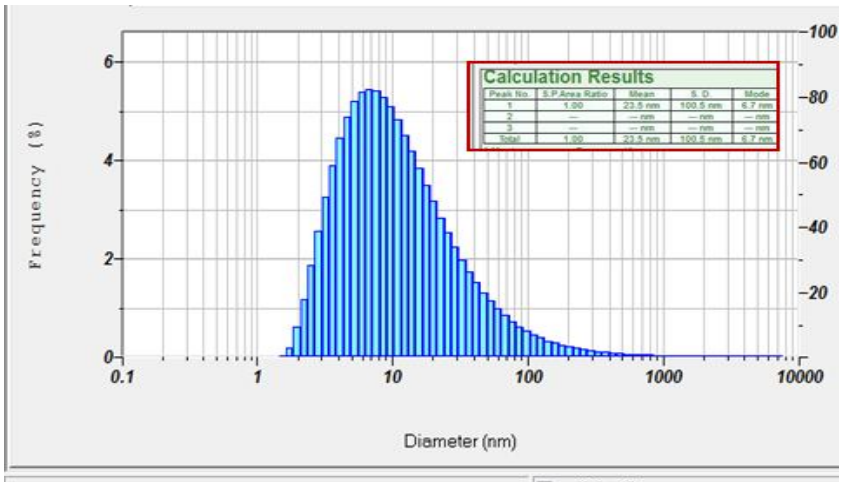

Fig. 3: Particle size distribution of Sample B4.2. Particle size analysis.

Curve 'a' is the UV- Visible spectrum of gold nanoparticles reduced by ascorbic acid at pH 4.5 (sample A). particle size at this pH is 151.8 nm with λ_{max} at 548 nm and absorbance value is 1.117 a.u. We have observed that when gold nanoparticles are reduced with ascorbic acid, without any stabilizer, the size of the particle is large. In sample B, gum arabic was used as a stabilizer to prevent particle agglomeration (curve'b'). The size of the particle in sample B is reduced to 23.5 nm with λ_{max} at 537 nm. The particle size of the sample B is shown in the **Fig. 3**. As the amount of ascorbic acid was increased, the size of the particle is reduced as shown in the **Table. 2.**

From the above table we can infer that when pH of the solution is reduced, particle size is reduced from 151.8 nm to 10.2 nm. The amount of ascorbic acid plays very important role in determining the size of the gold nanoparticles. It can be explained from the graph (Fig. ***2)***. In this present work, we have increased the amount of ascorbic acid from 5ml to 25 ml keeping the volume of gum arabic at a constant value.

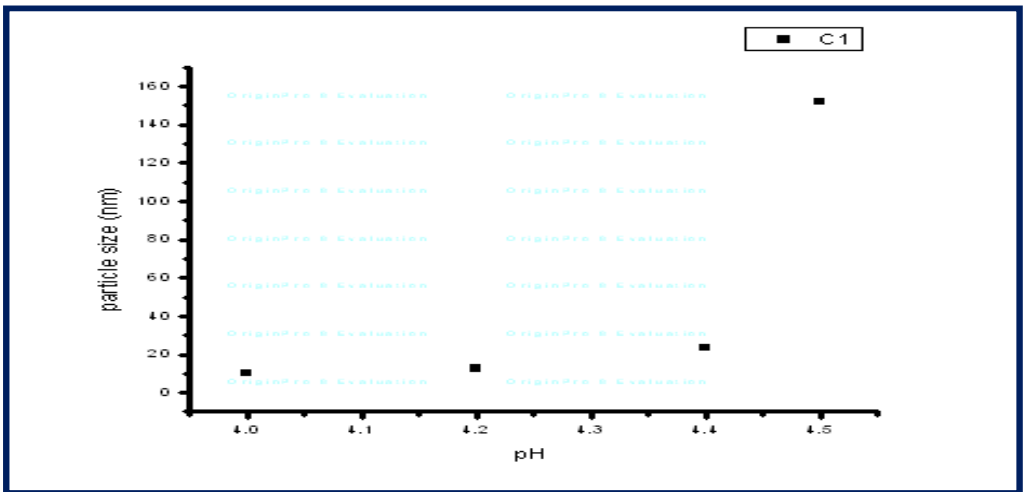

Fig. 2: Variation of particle size along with pH of the solution.

5. Conclusion

In our present work we reduced gold precursor by ascorbic acid and the resulted gold nanoparticles were stabilized with gum arabic which is nontoxic, used as a stabilizer in food industry. As the chemicals which are used in this study are biocompatiable, gold nanoparticles synthesized from the above method can be used in biomedicine for drug delivery applications.

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