Synthesis and Characterization of PEGylated Gold Nanoparticles

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ABSTRACT

PEGylation is one of the most commonly used functionalisation methods for gold nanoparticles. A layer of PEG (Polyethylene glycol) coated gold nanoparticles were synthesized and characterized. We followed the reaction between gold chloride and trisodium citrate. Colloidal gold nanoparticles were stabilized with Polyethylene glycol. Wine red color colloidal gold solution was formed. Particle size measurement, UV-VIS spectrophotometer conformed the formation of nano sized gold particles. Mean diameters of the spherical gold nanoparticles with various trisodium citrate concentrations were 88.3 and 91.2 nanometers. Spherical shapes of the colloidal gold nanoparticles were confirmed by Scanning Electron Microscope. Colloidal gold nanoparticles were also characterized by FTIR spectroscopy.

Keywords: ***Nanoparticles, Gold Colloidal Solution, Scanning electron microscopy, Zeta potential, surface Plasmon resonance and functionalization.***

1. INTRODUCTION

Nanoparticle systems play very important role in the field of Sensors, Medicine and Biotechnology. Metal nanoparticles exhibit size dependant electronic, catalytic and optical properties. Gold in pure form melts at 1063^{o} C and boils at 2966^{o}C with density 19.32 g/cm^3. Gold is inert in bulk stage and becomes highly reactive at nanoscale range. As gold nanoparticles can adsorb a variety of functional groups, they can be used to bind various biomolecules such as DNA and Carbohydrates. PEGylation is a very important functionalization method for the drug delivery applications of gold nanoparticles [1-3]. In this paper synthesis and characterization of PEGylated [4-8] gold nanoparticles was carried out and effect of trisodium citrate on the size of gold nanoparticles was observed.

2. EXPERIMENTAL

2.1 Materials. Hydrogen tetrachlorourate (III) trihydrate, was purchased from Aldrich. Polyethylene glycol (PEG), trisodium citrate was purchased from Merck. Deionized water was used for the preparation of solutions. HNO_3 and HCl were used for aqua regia preparation.

2.2 Synthesis of Gold nanoparticles. Chloroauric acid or gold chloride was used as precursor for the preparation of gold nanoparticles. Trisodium citrate was used for the reduction of gold chloride [9-12]. Chemical formulae of gold chloride and trisodium citrate are HAucl4 $3H_2O$ and $Na_3C_6H_5O_7.2H_2O$ respectively.

Magnetic stirrer, beaker and glassware were washed with aqua regia. Glassware was cleaned thoroughly with deionized water. Gold chloride and trisodium citrate solutions (mM) were prepared. Initially 2 ml of gold chloride solution was boiled at 95^{o}C, stirred continuously with magnetic stirrer and hot plate combination. At this stage hot solution of trisodium citrate was added without the use of stabilizer (sample C). Gold solution was yellow in color at the beginning. After the reduction of Gold chloride with trisodium citrate, yellow colored gold solution became colorless and after few minutes wine red color was observed. Later 2 ml of gold chloride solution containing polyethylene glycol was boiled and 10 ml trisodium citrate was added quickly. Solution turned into wine red color confirming the formation of gold nanoparticles. The solution was allowed to cool at room temperature. The experiment was repeated by changing the amount of trisodium citrate. The colloidal gold nanoparticles were stored and used for further characterization.

$2HAuCl_43H_2O + 4Na_3C_6H_5O_7 \rightarrow 2AU + 4CO_2 + 4NaC_5H_5O_5 + 8NaCl + 4H_2$ [1]

S.No	Sample	1mM Gold chloride (ml)	1mM Trisodiumcitrate (ml)	PEG (µl)
1	A	2	10	10
2	B	2	12	10
3	C	2	10	-

Table1. Synthesis parameters

Fig. 1: Synthesized gold nanoparticles

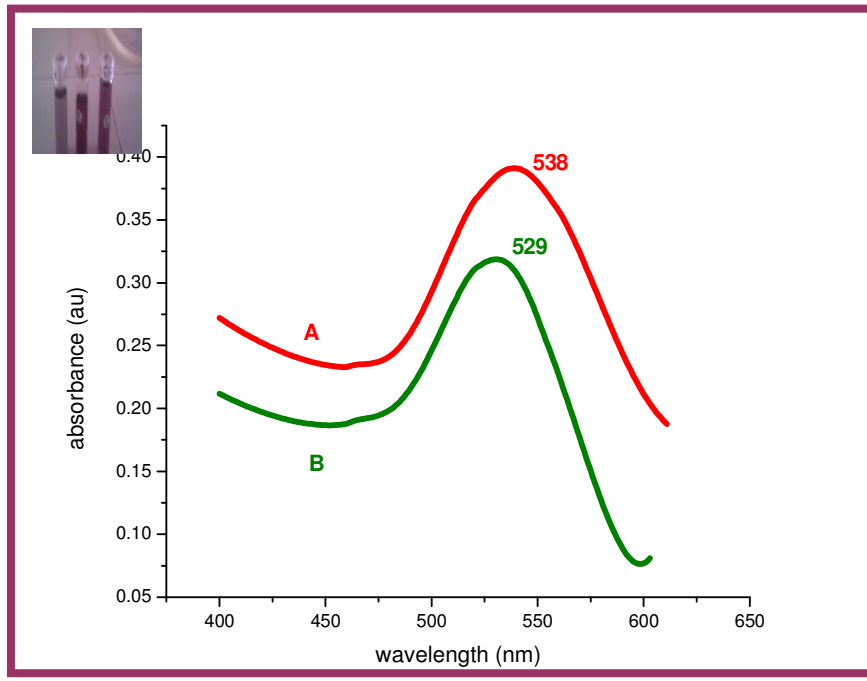


Fig.2: UV-visible spectra of PEGylated gold nanoparticles

2.3 Characterization

Surface Plasmon resonance. Incident light creates oscillations in conduction electrons on the surface of the nanoparticles. Collective oscillations of free electrons are called Plasmons. These electrons interact with visibile light under certain conditions and electromagnetic radiation is absorbed. Particles synthesized by trisodium citrate are nearly monodisperse spheres. They have negative surface charge. They can be easily characterized by Plasmon absorption band [13-15]. The colloidal gold solutions were characterized with Shimadzu-1800 UV-vis spectrophotometer.

Spherical morphology and average particle size of gold nanoparticles were investigated by Scanning Electron Microscope (S-3700) and Horiba SZ-100. PEG-gold nanoparticle combination was analyzed by FTIR spectroscopy in the range of 600 cm^{-1} to 3,500 cm^{-1}

3. RESULTS

From the above experiment we can say that using appropriate reducing agent and dispersing agent play very important role in the formation of gold nanoparticles without the formation of clusters, i.e in the absence of stabilizer agglomeration takes place. Fig.2 shows the UV- Visible spectra of synthesized gold nanoparticles. The peak wavelength of the sample A is (λ_{max}) 538nm and for the sample B is 529nm. As the third sample C was without the stabilizer, agglomeration of particles

was observed. The speherical shape of Pegylated gold nanoparticles was observed from the images of Scanning electron microscope (fig.3).

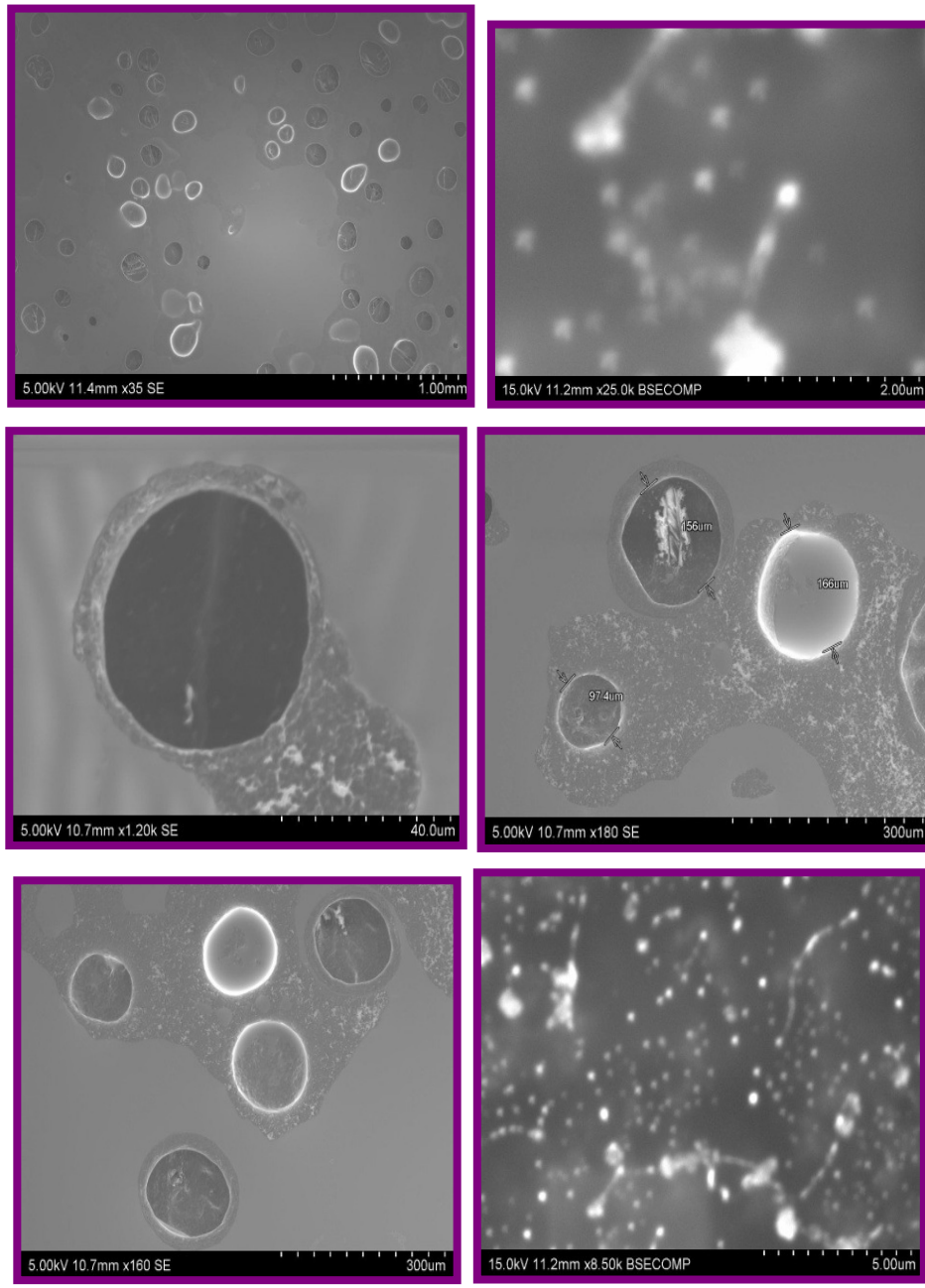


Figure.3: SEM photographs of PEGlyated gold nanoparticles

Dynamic light scattering [13-15] and zeta potential measurements are given by fig 4(a) and 4(b). Accordingly the mean diameters of sample A and B are 91.2nm and 88.3nm respectively.

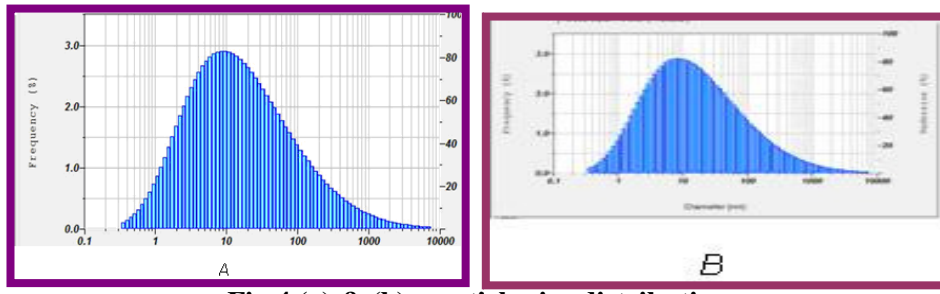
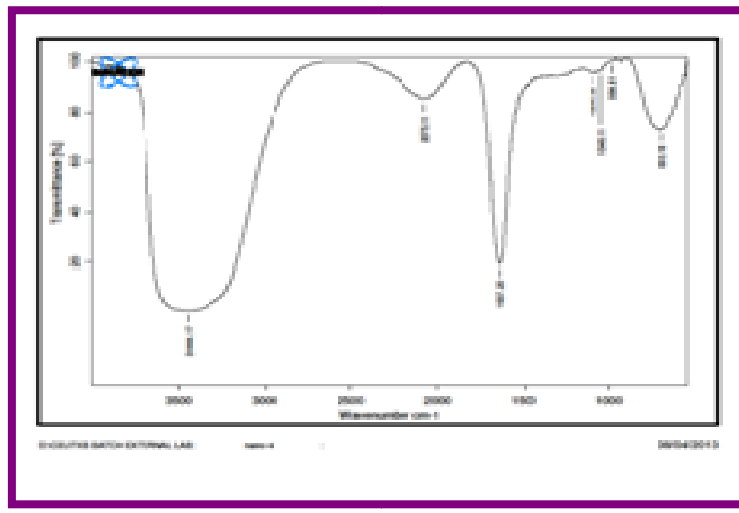


Fig.4 (a) & (b): particle size distribution

Table.2. particle size and λ_{max} for the peglyated gold nanoparticles

S.No	Sample	Particle size [nm]	λ_{max} [nm]
1	A	91.2	538
2	B	88.3	529

4. DISCUSSION



Fig(5): FTIR Spectrum of PEGylated GNP

Synthesis and characterization of PEGlyated gold nanoparticles were presented in this work. Peglyated gold nanoparticles were synthesized by reducing gold chloride with trisodium citrate chemically. Polyethylene Glycol was selected as an effective stabilizer and was used to stabilize

gold nanoparticles. UV-Vis spectra indicate the formation of gold nanoparticles. Absorption intensity increases with increasing particle size. Gold nanoparticles displayed single absorption peak in the visible range. When particle size is increased, absorption peak was shifted to a larger wavelength. When trisodium citrate was less, particles aggregate and bigger particles were formed. FTIR analysis confirmed Polyethylene glycol capping on gold nanoparticles fig(5). Accordingly 3444.17cm^{-1} assigned to O-H, 1095 cm^{-1} to C-O-C stretching and 1637 cm^{-1} to C=O stretching.

5. CONCLUSION

PEGlyated gold nanoparticles were successfully prepared by the reduction of hydrogen tetrachloroaurate aqueous solution with tri sodium citrate. SEM results show the morphology of spherical gold nanoparticles. The coating of polyethylene glycol in gold nanoparticles was confirmed by FTIR spectrum.

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