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EFFECT OF REDUCING AGENT ON PARTICLE SIZE OF GOLD NANOPARTICLES: SYNTHESIS AND CHARACTERIZATION

Ankita U. Patel[a]*, Girish K. Jani[b], Ketan Ranch[c], Kapil Patil[a], Abhay Dharamsi[a]

Parul Institute of Pharmacy, Parul University, P.O. Limda, Ta. Waghodia, Dist. Vadodara – 391760, Gujarat, India

[a] Parul Institute of Pharmacy, Parul University, P.O. Limda, Ta. Waghodia, Dist. Vadodara – 391760, Gujarat, India

[b] K. B. Raval College of Pharmacy, Gandhinagar, Gujarat - 382423. INDIA

[c] Maliba Pharmacy College, Uka Tarsadia University, Gopal Vidyanagar, Bardoli-Mahuva Road, Dist: Surat, Gujarat 394 350, India

***Corresponding Author Email: ankitapatel0910@gmail.com**

ABSTRACT

Gold nanoparticles are emerging as a novel platform that could simultaneously be utilized for both, cancer targeted drug delivery and imaging, commonly referred to as theranostic application. The present research work includes synthesis of gold nanoparticles using different reducing agents in various concentrations. Gold nanoparticles were prepared by chemical reduction method. A prepared gold nanoparticle was evaluated for particle size, zeta potential, poly dispersity index and UV visible spectrophotometry. Experimental data showed that The size of Gold nanoparticles varies as the concentration and type of reducing agent changes. Small size of gold nanoparticles was obtained with 1% trisodium citrate (24.20 nm) which was used as a reducing agent as well as stabilizing agent.

KEY WORDS

Chemical reduction, Gold nanoparticles, Reducing agent, Trisodium citrate.

INTRODUCTION

Nanoparticles refer to the small size (dimensions about 100 nm) having application in science and engineering [1]. Many nanoparticle-based drug delivery systems have been designed in order to fulfil the ever-growing need of the science in both medical as well as in pharmaceutical fields [2]. The most well-studied nanoparticles include quantum dots, carbon nanotubes, paramagnetic nanoparticles, liposomes, metallic nanoparticles, and many others. Compared with other nanoparticles, metallic nanopartcles have proven to be the most flexible nanostructures owing to the synthesis control of their size, shape, structure, surface plasmon resonance, composition as well as resulting tunability of optical activity [3].

In recent years, gold nanoparticles have attracted much attention. They are agents with numerous applications in biomedicine like cancer research, diagnostic assay [4-6], thermal ablation, gene and drug delivery [7-10], etc. Nano gold have several unique properties, for example they are inert and nontoxic, and have good anti-bacterial, anti-angiogenesis properties [11]. GNPs have been prepared by both “physical” and “chemical” methods. For the “physical” preparation method, Au bulk is broken down by a strong attack force, for example, ion irradiation in air or arc discharge in water, to generate GNPs. Chemical method including chemical reduction of Au salts, electrochemical pathways and

decomposition of organometallic compounds. Among them, the chemical reduction method is simple and controllable to prepare various sizes and shapes of GNPs [12-13].

In this study, gold nanoparticles were prepared by chemical reduction in which reduction of chloride precursor carried out by using reducing agent [14]. To prepare gold nanoparticles various reducing agents which are act as stabilizing agents too, such as, Chitosan, Gelatin, Gellan gum, Guar gum, Trisodium citrate, and Xantan gum were selected. The effect of the reducing agent on the size and charge of gold nanoparticles were investigated. The UV-vis spectrophotometry was employed in the characterization of the prepared gold nanoparticles.

MATERIAL AND METHODS

Material

Hydrogen tetrachloroaurate (III) hydrate ($HAuCl_4$) (99.9%) was obtained from Indian Platinum Pvt Ltd, Mumbai. Trisodium citrate dihydrate (TSC), Gellan gum, Xanthan gum, Guar gum, Gelatine, and Chitosan were obtained from S.D. Fine Chemicals Ltd, Mumbai. All the chemicals were used as received. All the samples were prepared in deionized water.

Method

Synthesis of Gold nanoparticles

All glassware was rinsed with deionized water before preparation. 20 mL of 1.0 mM HAuCl4 added to a 50 mL conical flask on a stirring hot plate. It was heated up to its boiling condition (100°C). To the rapidly-stirred boiling solution, 5 mL of a reducing agent was added. The gold sol gradually forms as the citrate reduces the gold (III). Remove from heat when the solution has turned deep red or 10 minutes has elapsed. Various concentrations of reducing agents were used to check the effect on size of gold nanoparticles. Different reducing agents along with concentration are shown in Table 1.

Table 1: Preparation of gold nanoparticles by using different reducing agent

Sr. No.	Reducing agent	Sample name	Concentration	Taken quantity	Particle size	PDI	Zeta Potential	Wavelength (nm)
1	Chitosan	Sample A	1%	5ml	460.9	0.99	-21.1	550.22
			1.5%		427.6	0.42	-17.3	555.34
			2%		495.5	1.00	-26.9	559.33
2	Gelatin	Sample B	1%	5ml	131.4	0.482	-16.5	531.63
			1.5%		168.3	0.749	-10.4	535.40
			2%		417.4	0.849	-12.5	552.32
3	Gellan gum	Sample C	1%	5ml	3536	0.537	-14.4	595.98
			1.5%		751.4	0.809	-14.3	567.56
			2%		178.6	0.328	-31.3	535.67
4	Guar gum	Sample D	0.2%	5ml	1613	0.417	-3.17	574.88
			0.4%		229.9	0.581	-5.09	535.56
			0.6%		241.9	0.507	-5.56	545.12
5	Trisodium citrate	Sample E	1%	5ml	24.20	0.391	-31.4	519.18
			1.5%		104.0	0.395	-32.6	528.45
			2%		250.0	0.254	-33.3	548.49
6	Xanthan gum	Sample F	0.2%	5ml	111.5	0.474	-19.1	529.53
			0.4%		137.8	0.525	-21.5	532.72
			0.6%		167.8	0.467	-23.6	534.69

Evaluations of Gold nanoparticles

Physical observation

Gold nanoparticles appears in brilliant color that depends on the size and shape of the particles. The color change of resulted gold nanoparticle formulations is observed. Colloidal gold suspension is typically either an intense red color for particles less than 100 nm or a dirty yellowish to blue color for larger particles.

UV-Absorbance

US-Absorbance was checked against deionized water using UV-visible spectrophotometer (UV-1800 double beam spectrophotometer, Shimadzu, Japan) by diluting with deionized water.

Particle size measurement

Particle size and particle size distribution of gold nanoparticles were determined using Malvern Zetasizer (Malvern ZS90) by filling the sample in an insulating sample cell [15]. Particle size distribution is determined from the velocity distribution of particles suspended in dispersing medium, using the principle of dynamic light scattering. The measurement is based on the particle diffusion due to brownian motion, which is related to particle size. Particle size was then calculated from the translational diffusion coefficient using the Strokes-Einstein equation by in-built software.

Polydispersity index (PDI)

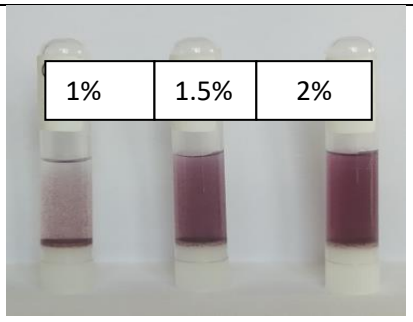
Polydispersity index (PDI) or heterogeneity index, is a measure of the distribution of molecular mass in a given sample. It determines size range of particles in the system. Polydispersity index was determined using Malvern Zetasizer (Malvern ZS90).

Zeta Potential

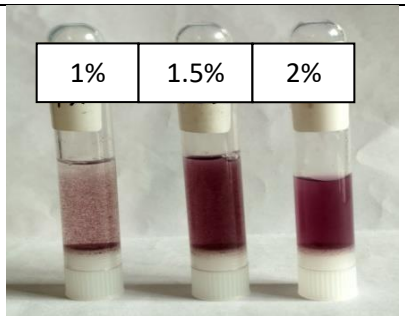
Zeta potential can calculate by measuring the response of charged particles to an electric field. Zeta potential was determined using Malvern Zetasizer (Malvern ZS90). The zeta potential gives an indication of the potential stability of colloidal system. Malvern Zetasizer measures the potential ranged from -120 to 120 mV. For measurement of zeta potential 1 ml of each formulations were diluted with deionized water (10 ml).

RESULT AND DISCUSSION

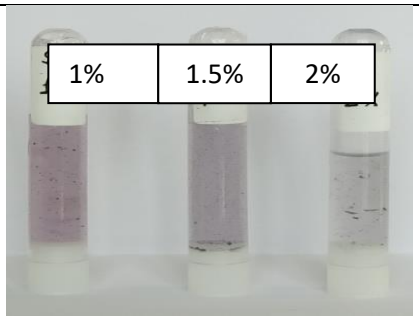
The color change of resulted formulations of gold nanoparticles reduced and stabilized by chitosan, gelatin, gellan gum, guar gum, trisodium citrate, and xanthan gum were observed and are shown in Fig. 1 (a), (b), (c) (d),(e), and (f) respectively. It was observed that AuNPs contatin 1% trisodium citrate observed in ruby red colour while other formulations observed in purple color, brown color or transparent.



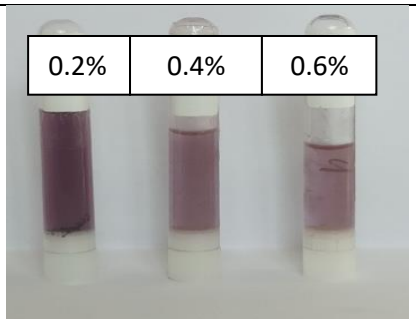
(A) Gold nanoparticle (Chitosan)



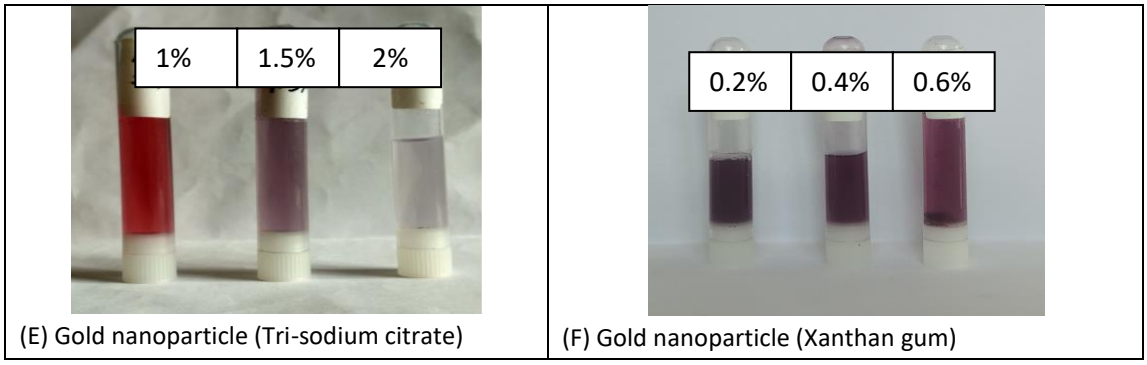
(B) Gold nanoparticle (Gelatin)



(C) Gold nanoparticle (Gellan gum)



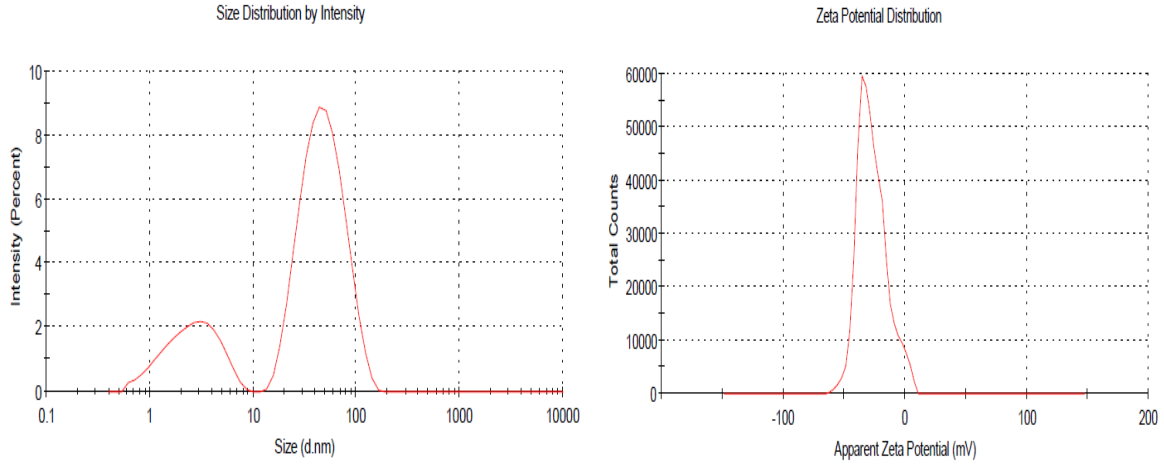
(D) Gold nanoparticle (Guar gum)



(E) Gold nanoparticle (Tri-sodium citrate) (F) Gold nanoparticle (Xanthan gum)

Figure 1: Color of prepared gold nanoparticles.

Particle size: In the present study different concentration of Reducing agents were used. As the concentration of trisodium citrate and xanthan gum increases, particle size increases. In case of other reducing agent particle size varies with change in concentration. Result of Sample E (1%) is shown in Fig. 2 (a).



(a) **(b)**

Figure 2: (a) Particle size of AuNPs contains 1% TSC. (b) Zeta potential of AuNPs contains 1% TSC.

Polydispersity index (PDI): PDI of prepared batches ranges from 0.254 to 1.000. Formulations containing trisodium citrate have less PDI (less than 0.4) as compare to other formulation.

Zeta potential: Zeta potential of prepared batches was found in between -3.17 to -38.3. From the result it was observed that AuNPs containing trisodium citrate have high zeta potential as compare to other formulations. Result of Sample E (1%) is shown in Fig. 2 (b).

UV –Wavelength: UV –Wavelength of prepared batches was found in between 520 nm to 560 nm.

From the obtained result, it was concluded that, 1% trisodium citrate as a reducing agent gives the good result of particle size, PDI, zeta potential as well as UV wavelength. Particle size, PDI, zeta potential and wavelength of 1% trisoudiun citrate was found to be 24.20 nm, 0.391, -31.4, and 519.18 nm respectively.

CONCLUSION

In the present study, formulation and characterization of gold nanoparticles were synthesized using chemical reduction method. In this method, trisodium citrate, was found to be good reducing agent to reduce chloroauric acid. The results showed that it is possible to formulate gold nanoparticles with very small size using trisodium citrate. The developed technology platform is proposed to be promising alternative for targeted drug delivery because of small size.

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***Corresponding Author:**
Ankita U. Patel*
Email: ankitapatel0910@gmail.com