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# SPECTROPHOTOMETRIC STUDIES OF SOME NOVEL CITRATE CAPPED GOLD NANOPARTICLES

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**ABSTRACT**

Gold Nanoparticles (GNPs) has been successfully developed by chemical reduction method (Turkevich method) using sodium citrate as reducing agent. The synthesized gold colloidal solution is characterized by using UV-VIS spectroscopy and transition electron microscope (TEM). The result of TEM shows that GNPs with sodium citrate have particle size of 20 nm (diameter) and have incipient stability. The Result of UV- VIS shows that GNPs with sodium citrate gives peak at 525 nm of 0.5% citrate using and red in colour. By changing parameters gold nanoparticles are different in colours and they have different absorbance.

**Keywords: gold nanoparticles, chemical reduction, sodium citrate, TEM, spectroscopy**

## INTRODUCTION

Nanotechnology is an anticipated manufacturing technology that allows the long-established trend toward lesser, quicker, inexpensive materials and bias. Chemistry of gold colloids and investigates was performed by Michael Faraday in the nineteenth century. Gold nanoparticles (GNPs) are the most companionable nanomaterial for provision of engineered nano platforms in smart sensing bias. Surface Plasmon resonance (SPR) property of GNP makes them most suitable engineered nanomaterial for bioimaging, biomedical rectifier and biodiagnostic tools **[1]**. When bulk gold is converted into nanoparticulate gold, change of colour observes from Yellow to ruby Red. "Surface plasmonics" theory explains that ruby red colour of AuNps. The frimness of gold to the nanometer range has dramatic consequences for its physical and chemical properties **[2]**. With the arrival of nanotechnology and the discovery of nanoparticles and the exploration of the physico-chemical properties of gold make it a supreme material for progress fields **[3]**. As applications for citrate-capped gold nanoparticles become ever more dependent on their precise surface chemistry, fully understanding the citrate coordination and most crucially time dependent rearrangements (termed “aging”) on the AuNP surfaces is now essential. These consequences are also well-established for other metals however, Gold is an outstanding example. In our work, we used gold because it has outstanding surface properties. These surface properties can be used in applications of biotechnological, optical and electrochemical. Previous studies of citrate on metallic nanoparticles use various spectroscopic techniques including attenuated total reflectance infrared (ATR-IR) **[4, 5]**, Fourier transform infrared (FTIR) **[6]**, X-ray photoelectron (XPS) **[7]**, solid-state NMR **[8]** and surface-enhanced Raman spectroscopy. There are various advantages of the gold nanoparticles like non-toxicity, strong scattering length, bio-conjugation and long-term stability. These features are fundamental for a secure and responsive biosensing policy. Gold nanoparticles (GNPs) are the well-matched nanomaterial for groundwork of engineered nano platforms in smart sensing bias. SPR properties of GNP make them useful nanomaterial in bioimaging, biomedical therapeutics and biodiagnostic tools **[9]**. GNPs are also called as gold colloids. There are huge global demands of gold colloids because of their significant requirement in many industrial and commercial applications. Biomolecule GNPs are used in the medicine and in cosmetic products as these have anti-aging components for skin protection **[10]**. GNPs are used for doing permanent coloration of wool or cotton fibres and also used for novel coatings and paintings. These are also used as catalysts **[11]**. Due to all above advantages, more attention should be paid on effective synthesis methods to match the enlarging demand of GNPs. In this paper, synthesis of 0.1mM gold nanoparticles with 0.5% sodium citrate are done by chemical reduction method (Turkevich method) and characterised by using UV-VIS spectroscopy and transition electron microscope TEM. The result of TEM shows that GNPs with sodium citrate have particle size of 20 nm (diameter) and have incipient stability. The result of UV-vis shows that GNPs with sodium citrate gives peak at 525 nm. We also synthesised AuNPs by changing parameters and characterized by using UV-vis spectroscopy.

## EXPERIMENTAL

### Materials

Chloroauric acid ($HAuCl_4$) (99%) and Trisodium citrate were purchased from Sigma-Aldrich. Aqueous solutions were prepared by using double distilled water. Stock solutions were also prepared in double distilled water too.

**Synthesis and characterization of Au NPs**

The citrate capped AuNPs were prepared through chemical reduction method in which $HAuCl_4$ is reduced by trisodium citrate where citrate is used as reducing agent, capping agent as well as stabilizing agent. The colour of AuNPs solution is observed from yellow to red. Here the citrate ions reduce the $Au^{+3}$ ions to neutral Au atoms. Due to dynamic stirring, the solution becomes super saturated, gold atoms collide to form a stable nucleus, growth starts and leads to the formation of mono disperse spherical gold nanoparticles after about ten minutes. The colour observed of solution after the procedure from transparent light yellow colour of the chloroauric acid to dark black to finally a characteristic ruby red colour which confirms the presence of gold nanoparticles.

**SYNTHESIS OF CITRATE CAPPED GOLD NANOPARTICLES WITH CHANGED PARAMETERS**

**Volume of Trisodium Citrate added**

In this experiment we only changed the volume of trisodium citrate added other parameters like temperature, gold concentration, concentration of trisodium citrate, mixing rate, etc. were kept constant throughout. Gold salt concentration was 0.1mM and 0.5% and 1% trisodium citrate was used. In this approach 1ml, 1.5ml, 2ml and 3ml of 0.5% citrate added **(Figure 1)** where 1ml, 2ml, 3ml and 4ml volume of 1% trisodium citrate was added **(Figure 2)** to a rapidly mixing heated solution of gold salt.

**Trisodium Citrate Concentration**

In this experiment only the concentration of trisodium citrate was changed other parameters were kept constant. 10ml0.1mMgold salt concentration was reduced by adding 2mlof trisodium citrate with different concentration/percentage. In our basic approach 0.5% of trisodium citrate was added, we used 1%, 1.5%, 2% and 3%.

**RESULTS AND DISCUSSION**

**Synthesis and characterization of functionalized Au NPs**

In our further work we used 100ml 0.1mM gold solution and 20 ml 0.5 % citrate to synthesised spherical gold nanoparticles. These synthesised gold nanoparticles were characterised by TEM **(Figure 5)** and UV-visible **(Figure 6)**. These gold nanoparticles have maximum absorption at 525 nm and by TEM analysis we considered their size was about 20 nm, spherical in shape. Characterisation of NPs by UV-Vis Spectroscopy was done at Chemistry Department, HNGU, Patan, Gujarat. Size and shape of nanoparticles were characterised by TEM at SICART, Anand, Gujarat.

**Parameter changed: volume of Citrate**

The amount of Trisodium Citrate was changed from 1 ml to 3 ml and other parameters were kept constant as data obtain is define **(Table 1)**.

The colours of the GNPs produced are seen to be varying from red to purple **(Figure 3)**. Purple colour indicates lager particles and red colour indicates smaller GNPs to get a better knowledge about the size and size distribution we need to analyse the UV-Vis spectroscopy data.

Absorbance of volume 1ml 0.5 % citrate is 2.973 more than other volumes, spectra was absorbed at 525 nm. From 1 ml to 2 ml the absorbance was decrease and wavelength not much became longer **(Figure 4)**. There was no peak observed in volume 3 ml from this we could say that gold nanoparticles were not properly made. In 1.5 ml of 0.5 % citrate absorbance was maximum 2.425 at 526 nm and in 2 ml it was maximum 2.261 at 528 nm. So here order of absorbance is 525(1 ml) <526(1.5 ml) <528(2 ml).

From 1 ml to 4 ml, volume was increased the absorbance was decreased and wavelength became longer and red shift was observed (except 4 ml 1 % citrate). 1ml 1 % citrate has more absorbance 2.250 at 536 nm than other volumes. Maximum absorbance of 2 ml, 3 ml and 4 ml is 2.122, 1.968 and 1.489 at 549 nm, 559 nm and 535 nm. Particle size order according to wavelength was 535 (4 ml) <537(1 ml) <549(2 ml) <559(3 ml) **(Table 2)**. Thus we can conclude that the amount of citrate added does have an effect on the size of the gold nanoparticles and also mono dispersity is slightly affected and increase in citrate volume shows the mono dispersity.

**Parameter changed: Concentration of Trisodium Citrate**

The concentration of Trisodium Citrate was changed from 0.5% to 3% and all other parameters were kept constant **(Table 3)**. GNPs produced the colours from red to purple **(Figure 7)**.

From 0.5% to 3 % of citrate the absorbance of citrate was decreased and wavelength was increased **(Figure 8)**. So the percentage or concentration of citrate was increase, the absorbance peak shifted to the right side mean longer wavelength obtained and size of nanoparticles also increased. Here the order of size of particles according to wavelength was 523 (0.5%) <531 (1%) < 535 (1.5%) <549 (2%) <557 (3%).

**Figure 1: Different volume of 0.5% Citrate (1ml, 1.5ml, 2ml, 3ml)**

**Figure 2: Different volume of 1% Citrate (1ml, 2ml, 3ml, 4ml)**

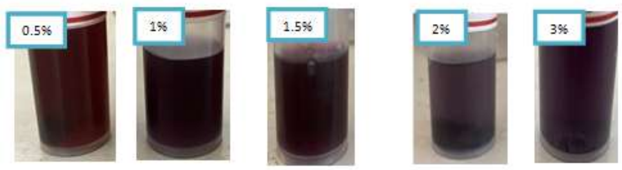


**Figure 3: Different concentrations of tri sodium Citrate with same volume of gold salt**

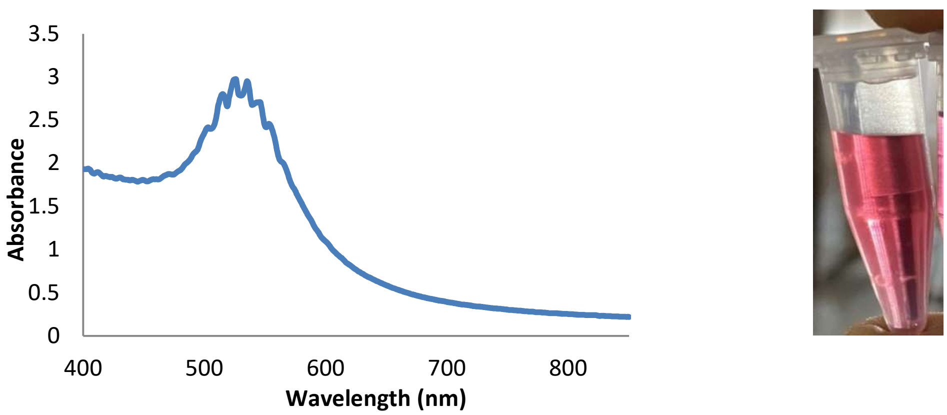


**Figure 4: Absorbance peak of 100ml 0.1mM gold chloride solution and 0.5% Citrate were used to synthesize gold nanoparticles**

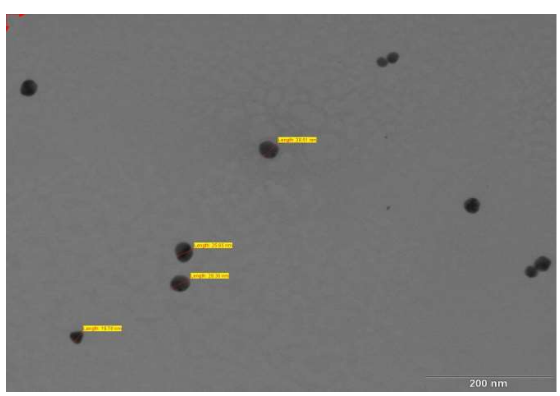


**Figure 5: TEM images of 20nm (diameter) Citrate capped gold nanoparticles**

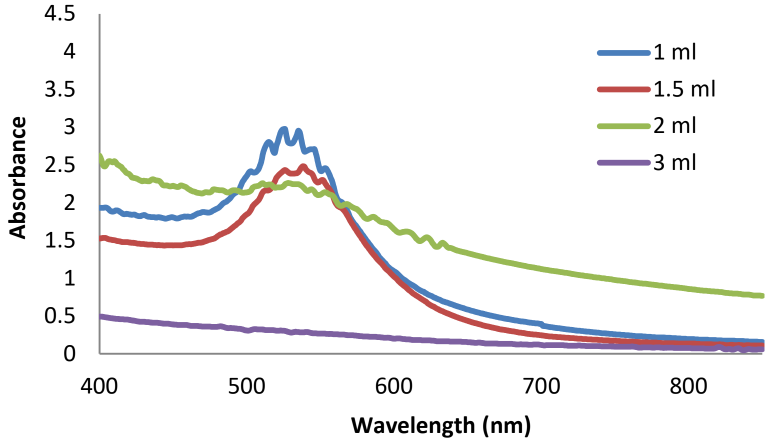


**Figure 6: Absorbance peak of 0.5% Citrate with different volume**

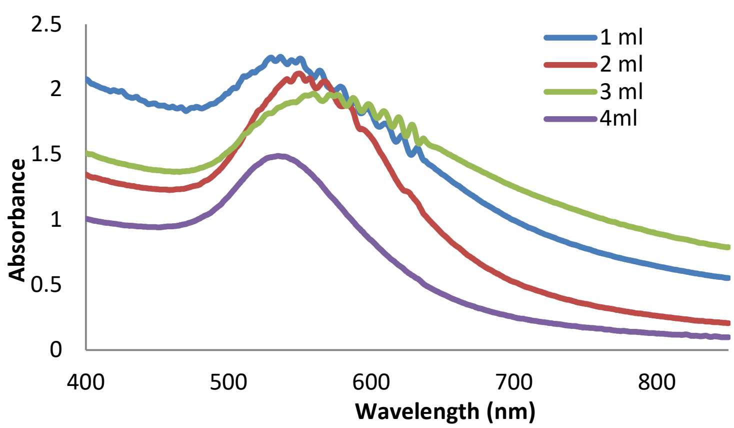


**Figure 7: Absorbance peak of 1% Citrate with different volume of Citrate**

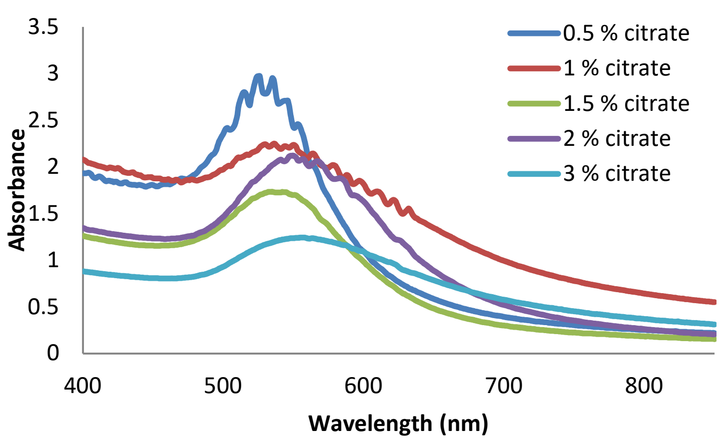


**Figure 8: Absorbance peak of different % of Citrate with same volume**

**Table 1: Observations for volume of 0.5 % Citrate changed**

| Gold Solution (mM) | Volume of citrate (mL) | Volume of Gold Solution (mL) | Percentage of citrate | GNP solution Color | Sediments |
|---|---|---|---|---|---|
| 0.1 | 1 | 5 | 0.5% | Dark Red | Yes |
| 0.1 | 1.5 | 5 | 0.5% | Red | Yes |
| 0.1 | 2 | 5 | 0.5% | Purple | Yes |
| 0.1 | 3 | 5 | 0.5% | Light purple | Yes |

**Table 2: Observations for volume of 1 % Citrate changed**

| Gold Solution (mM) | Volume of citrate (mL) | Amount of Gold Solution (mL) | Percentage of citrate | GNP solution Color | Sediments | Absorbance |
|---|---|---|---|---|---|---|
| 0.1 | 1 | 5 | 1% | Dark purple | Yes | 2.250 |
| 0.1 | 2 | 5 | 1% | Dark purple | Yes | 2.122 |
| 0.1 | 3 | 5 | 1% | Dark purple | Yes | 1.968 |
| 0.1 | 4 | 5 | 1% | Light Red | Yes | 1.489 |

**Table 3: Observations for % of Citrate changed**

| Gold Solution (mM) | Amount of citrate (mL) | Amount of Gold Solution (mL) | Percentage of citrate | GNP solution Color | Sediments |
|---|---|---|---|---|---|
| 0.1 | 2 | 10 | 0.5% | Dark Red | Yes |
| 0.1 | 2 | 10 | 1% | purple | No |
| 0.1 | 2 | 10 | 1.5% | Reddish pink | No |
| 0.1 | 2 | 10 | 2% | Purple | Yes |
| 0.1 | 2 | 10 | 3% | Dark purple | Yes |

## CONCLUSIONS

Gold nanoparticles in spherical shape were synthesized by the citrate reduction method. The effects of various experimental parameters (trisodium citrate concentration andtrisodium citrate concentration) on its size and size distribution were studied. The morphology, size and shape of citrate capped AuNPs were characterised using TEM and UV-visible spectrophotometer. The TEM shows diameter 20 nm and UV-visible give maximum absorbance at 525 nm of 0.1mM gold and 1 ml 0.5% citrate. Such environmental- friendly synthesis method for AuNPs have great potential in large scale manufacturing to match the increasing commercial and industrial demand.

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## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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