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Colloidal Synthesis of Silver Nano Particles

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Silver nanoparticles exhibit new optical properties, which are observed neither in molecules nor in bulk metals. One example is presence of absorption band in visible light region. A class of materials in which two or more phases (solid, liquid or gas) of same or different materials co exists with at least one dimension less than a micrometer is known as colloids. Nanomaterials are a subclass of colloids, in which one of the dimensions of colloids is about 1 to 100 nanometer range. In the present work, Ag nanoparticles were synthesized by silver salt ($AgNO_3$) reduction with sodium citrate and then characterized using UV-Visible spectroscopy and SEM. UV-Visible absorption results confirmed formation of silver particles prepared and SEM indicates the size in nanometer (nm) range.

Key Words: Silver, Nanoparticles, Characterization, U.V-Visible

INTRODUCTION

Nanoparticles possess a very high surface to volume ratio. This can be utilized in areas where high surface areas are critical for success. This could for example be in the catalytic industry. Some nanoparticles actually have proven to be good catalysts. Some nanoparticles also show bactericidal effects and hence a high surface to volume ratio is also important. In biology and biochemistry nanoparticles have attracted much attention. Nanoparticles are often in the range 10-100 nm and this is the size as that of human proteins. Scientists from the Chinese Academy of Science have even suggested using gold nanoparticles to improve Polymerase Chain Reaction (PCR). In the production of anti-reflective optical coatings, nanoparticles have also proven valuable. Using metal oxides to coat polymeric films, antireflective surfaces have been created. Nanoparticles do exhibit many interesting properties. it is just a matter of time until more of these properties will be exploited[1-3].

Colloidal particles are increasingly receiving attention as important starting points for the generation of micro and nanostructures. These particles are under active research because they posses interesting physical properties differing considerably from that of the bulk phase. It comes from small sizes and high surface/volume ratio. Manufacturing entire objects from pure silver metal or coating them with silver is prohibitively expensive for consumer items but research has found that impregnating other materials with silver nanoparticles is a practical way to exploit the germ fighting properties of silver.

The extremely small size of nanoparticles means they exhibit enhanced or different properties when compared with the bulk material. In the case of silver nanoparticles this allows them to easily interact with other particles and increases their antibacterial efficiency. This effect can be so great that one gram of silver nanoparticles is all that is required to give antibacterial properties to hundred of square meters of substrate material. Ag nanoparticles can be synthesized using various methods: chemical, electrochemical, γ-radiation photochemical, laser ablation etc. The most popular preparation of Ag colloids is chemical reduction of silver salts by sodium borohydride or sodium citrate. This preparation is simple, but the great care must be exercised to make stable and reproducible colloid[2].

EXPERIMENTAL

Silver nitrate $AgNO_3$ and trisodium citrate $C_6H_5O_7Na_3$ of analytical grade purity were used as starting materials without further purification. The silver colloid was prepared by using chemical reduction method[4]. All solutions of reacting materials were prepared in distilled water. In typical experiment 50 ml of .001 M $AgNO_3$ was heated to boiling. To this solution 5 ml of 1 % trisodium citrate was added drop by drop. During the process solution was mixed vigorously. Solution was heated until color's change is evident (pale yellow). Then it was removed from the heating element and stirred until cooled to room temperature.

Mechanism of reaction could be expressed as follows[5-6]:

$$4Ag^+ + C_6H_5O_7Na_3 + 2H_2O \rightarrow 4Ag^0 + C_6H_5O_7H_3 + 3Na^+ + + H^+ + O_2\uparrow$$

Also 0.002 M Silver Nitrate and 0.02 M Trisodium Citrate used in another method[6].

The instrument was a UV-Vis spectrophotometer. It measures the intensity of light passing through a sample (I), and compares it to the intensity of light before it passes through the sample (I_o). The ratio I / I_0 is called the transmittance, and is usually expressed as a percentage (%T). The absorbance, A, is based on the transmittance: $A = -\log (\%T)$. A Field-Emission Scanning Electron Microscope using a beam of electron to scan the surface of nanoparticles is used to determine the particle size. It provides narrower probing beams at low as well as high electron energy, resulting in both improved spatial resolution and minimized sample charging and damage.

RESULTS AND DISCUSSION

As the particles increase in size, the absorption peak usually shifts toward the red wavelengths. Increase of absorption indicates that amount of silver nanoparticles increases. The stable position of absorbance peak indicates that new particles do not aggregate. One can understand that since the silver colloidal particles possessed a negative charge due to the adsorbed citrate ions, a repulsive force worked along particles and prevented aggregation. Absorption peak of silver nanoparticles at 421 nm (Fig-1). As NaCl was added and solution was allowed to stand for 48 hrs aggregation of silver nanoparticles and increase in absorbance is observed (Fig-2).Absorbance peak after 1 hr and after 1 month shows increase in absorbance and shift towards longer wavelength (Fig-3). Silver particles produced are of 10-20 nm size (Fig-4) and aggregation occurs if allowed to settle after 1 month (Fig-5).

UV-VIS absorption results confirmed formation of silver nanoparticles prepared in liquid by chemical reduction method (silver nitrate $AgNO_3$ reduced by sodium citrate $C_6H_5O_7Na_3$). There was no obvious change in peak position for three weeks, except for the increase of absorbance. Nanoparticles produced are of 10-20 nm size as indicated by Scanning Electron Microscope. Electrostatic repulsion between silver nanoparticles takes place as each silver particle surrounded by molecules of citrate and because of which negative charge is generated. Absorption peak shifted from 421 nm to 425 nm after 1 month this change is due to aggregation of silver nanoparticles with time and larger particles require lesser energy and hence longer wavelength. Moreover as NaCl is added aggregation occur, this result in more absorption.

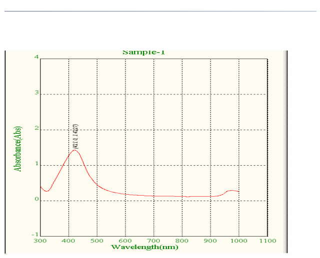

Fig-1: Absorption peak of silver nanoparticles at 421 nm

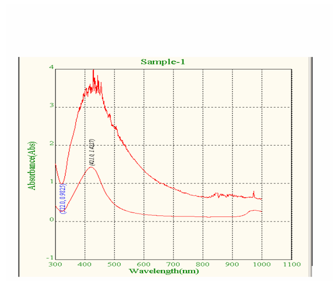

Fig-2: Aggregation of silver nanoparticles and increase in absorbance on adding NaCl

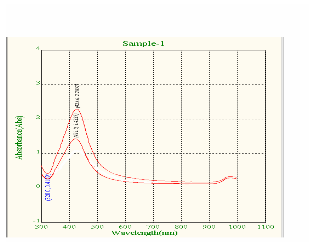

Fig-3: Absorbance peak after 1 hr and after 1 month shows increase in absorbance and shift towards longer wavelength.

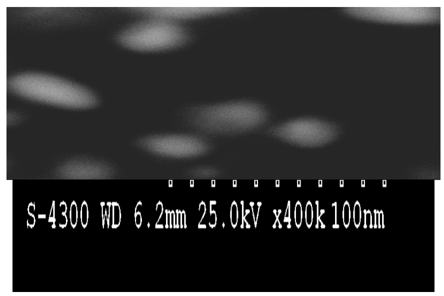

Fig-4 showing SEM image of nanoparticles produced.

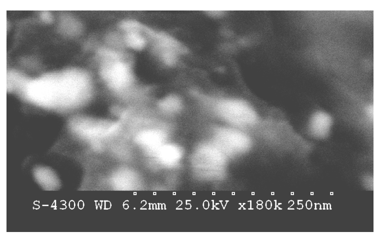

Fig-5 Showing SEM image of silver nanoparticles after 1 month of synthesis.

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