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Green Synthesis of Charcoal Based Silver Nanoparticles - Characterization and Inorganic Arsenic Absorption Properties

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Abstract: ***Charcoal based Silver nanoparticles (C/AgNPs) have been prepared by reduction of Tollen's reagent (ammonicalsilver nitrate, a complex of Ag^+ ion)with biomolecule Dextrose under warmed conditions in the presence of ethanol treated charcoal. The C/AgNPs are characterized by Energy Dispersive Spectroscopy (EDS) and UV-Vis. spectroscopy. The morphological studies are carried out by SEM. Inorganic arsenic absorption properties have been studied by using 100ppm sodium arsenite solution. It has been observed that these C/AgNPs have good inorganic absorption properties.***

Keywords: Silver nanoparticles, Chemical reduction, Energy Dispersion Spectroscopy (EDS), Scanning Electron microscopy (SEM), UV-Vis. Spectroscopy, Arsenic absorption.

1. Introduction

Nano-science is a new interdisciplinary field of research which has drawn attention of Chemists, Physicists and Technologists. Nanoparticles (particles in the dimension of 10^{-9}m) have several unique physical, chemical and biological properties compared to their macro scaled counterparts due to their high surfaceto volume ratio. Metallic nanoparticles exhibit size and shape dependent properties that are of interest for application ranging from catalysts and sensing to optics, antibacterial activity and data storage[1,3].

Metal nanoparticles can be prepared by two routes: First one is the physical approach which involves evaporation-condensation or laser ablation techniques. The second one is the chemical approach which involves the reduction of metal ions in solution under suitable conditions favoring the of small metal clusters or aggregates[4,5].

Like other metal nanoparticles, silver nanoparticles have several important properties such as antibacterial properties [(6-8)], electrochemical properties[(9,10)], catalytic activities[(11,12)] and optical properties[(13,14)] which have drawn attention of Chemists and Technologists over the past few decades. Silver nanoparticles are also prepared in two methods: Physical methods related to the evaporation–condensation technique [(15,16)], while chemical reduction is the soft technique which is applied to the synthesis of silver nanoparticles(AgNPs)[(17,18)].

Recently, trace level gas sensing characteristics of Nano-crystalline silver decamolybdobate has been studied by Misraet al[19]. Amine coated silver nanoparticles has also been prepared and characterized by Ramajiet al.[20]. Silver nanoparticles with different particle sizes for low temperature sintering have also been prepared by Steve Lien-Chung Hsu et al[21]. Silver nanoparticles are also prepared by green approach. CharusheelaRamtekeet al[22] uses aqueous extract of leaves of ocimum sanctum for the synthesis of silver nanoparticles with enhaced antibacterial activity. Several other reports on biological and green synthesis of silver nano-particles are available in the literature such as using microorganisms[23-24], enzymes[25], fungi[26], plants and plant extracts[27,28].

In present work, green synthesis of silver nanoparticles with cores of active charcoal has been carried out by reducing Tollen's reagent with dextrose (a biomolecule) and polyacrylamide as nanoparticle stabilizer. The charcoal based silver nanoparticles (C/AgNPs) have been characterized by EDS, SEM and UV-Vis. spectroscopy and their inorganic arsenic absorption characteristics have been studied by UV-Vis spectroscopy.

2. Experimental

Analytical grade of silver nitrate (purchased from Merck) is used in the preparation of 0.01 (M) silver nitrate solution. Tollen's reagent is prepared by using 0.01(M) silver nitrate solution. Sodium hydroxide is added to the silver nitrate solution to get the precipitate of silver hydroxide, which is then filtered and precipitate is dissolved in ammonium hydroxide. The clear solution of ammonical silver nitrate is called Tollen's reagent and used in the preparation silver nanoparticles.

Analytical grade of dextrose(purchased from Merck) is used as reducing agent. A solution of 0.01M dextrose is used for the reduction of Ag^+ to Ag^0. Glucose (Dextrose) on oxidation yieldsgluconic acid. The active charcoal is treated with ethanol followed by dried in hot air oven to constant mass, which is called here treated charcoal and used for synthesis of C/AgNPs.
Silver nanoparticles are synthesized under three different conditions as described below:

I]5 gm of treated charcoalisadded toa 100 ml Tollen's reagent (conc. Ag^+ = 0.01 M) solution is taken in 250 ml conical flask and stirred well with magnetic stirrer. Then 10 ml 5% (w/v) polyacrylamide is added to the mixture as nanoparticle stabilizer. The solution is warmed at 60-80ºC and under warmed condition dextrose is added dropwise. The solution becomes black to yellowish-browncolor and the reduction of Ag^+ is completed by adding calculated amount of dextrose solution. The solution is allowed to cool for 30 minutes. The precipitate is filter under suction pump and dried hot air oven. This sample is designated as C/AgNPs(1).

II] To a 100 mlTollen's reagent [conc. Ag^+ = 0.02 (M)] 5 gm of treated charcoal is added and solution is stirred well by using magnetic stirrer. Then 10 ml 5% (w/v) polyacrylamide is added to the mixture as nanoparticle stabilizer. The solution is warmed at 60-80^{o}C and under warmed condition dextrose solution is addeddropwise. The solution becomes black to yellowish-browncolor and the reduction is completed by adding calculated amount of dextrose solution. The mixture is allowed to cooled and filter after 30 minutes at the suction pump and dried in hot air oven. The sample is designated as C/AgNPs(2).

III] The loading of silver on charcoal further increases by taking 100 ml 0.03 (M)Tollen'sreagent and keeping the percentage of charcoal (5 gm) in the solution same. Then 10 ml 5% polyacrylamide is added to the mixture as nanoparticle stabilizer.The reduction of Tollen's reagent by dextrose is carried out by keeping all other physical parameters constant. The change of color from black to yellowish-brown confirms the formation of AgNPs. The sample is designated as C/AgNPs(3).

The UV-spectroscopic studies were carried out using a Hitachi U-2001 UV-Vis spectrophotometer using quartz cells. Energy Dispersive Spectrometer (EDS) pattern C/AgNPswere carried out with a JEOL JEM 1200EX transmission electron microscope operating at 120 KV. Scanning Electron Microscopy (SEM) of the sampleswas carried out with Philips XL-30.

The inorganic arsenic absorption properties of C/AgNPs (2) have been studied by the same UV-Vis spectrophotometer. When 1.0L of 100 ppm sodium arsenite (Na_3AsO_3) sample is treated with 0.25mg to 2.0 mg of C/AgNPs(2) and filtered through Whatsman 41 filter paper. UV-spectroscopy of the filtrate is carried out using theHitachi U-2001 UV-Vis pectrophometer using quartz cells. The peak area of 556 nm for inorganic arsetite is monitored against the concentration (gm/L) of the sample C/AgNPs (2).

3. Results and Discussion

Figure-1 shows EDS of the C/AgNPs. The EDS spectrum shows the presence of Ag which confirms the formation ofAg nanoparticles over the charcoal cores. The presence of Cuis attributed to the copper grid. All the samplesshow similar pattern of EDS-spectra.

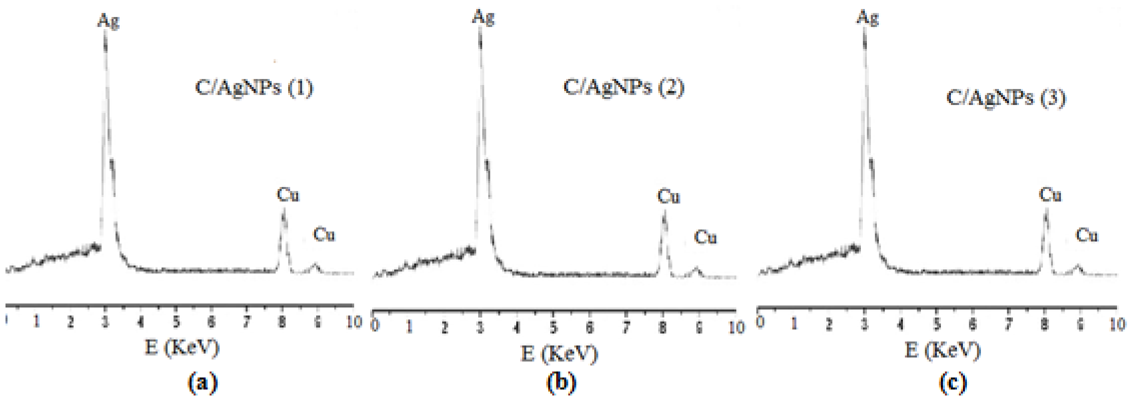

Figure 1: EDS spectra of a)C/AgNPs(1), b) C/AgNPs(2) and c) C/AgNPs(3).

The morphological features of the silver nanoparticles were studied by scanning electron microscopy. **Figure-2** shows SEM micrographs of the samples C/AgNPs (1), C/AgNPs (2) and C/AgNPs (3). It is evident that silver nanoparticles havebeen developed on the surface of carbon black. As the percentage of Ag-atom loading increases the particle size increases and morphology changes. The average particle size for C/AgNPs (1) is 20-25 nm, C/AgNPs (2) is 25-30 and C/AgNPs is 30-50 nm, which confirms the formation of silver nanoparticles.

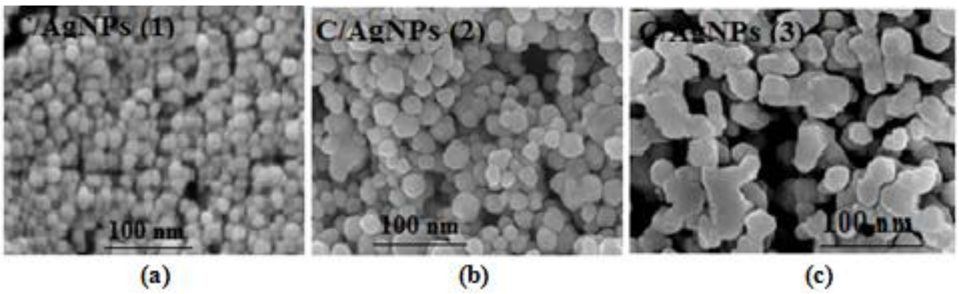

Figure 2: SEM micrographs of a)C/AgNPs(1), b) C/AgNPs(2) and c) C/AgNPs(3).

Figure-3 shows the UV-Vis. absorption spectra of silver nanoparticles prepared over treated charcoal using polyacrylamideas nanoparticle stabilizerat different concentrations of silver ion (Ag^+)in solution,i.e. at different % of Ag loading on charcoal cores.

All the spectra have the characteristic absorption bands with maxima at λ = 420-430 nm which due to the surface Plasmon resonance and indicate the formation of silver nanoparticles[29]. The spectral position and intensity of absorption depends on the particle size and dielectric constant of the medium. As the particle size increases, the polydispersity of the particle increases consequently peak position is slightly shifted towards lower values which occurs at the higher percentage of the Ag loading.

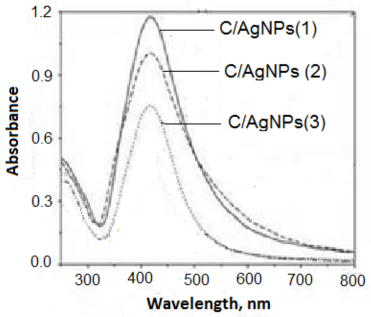

Figure 3: *UV-spectroscopy of a)C/AgNPs(1), b) C/AgNPs(2) and c) C/AgNPs(3).*

The inorganic arsenic absorption properties of the charcoal based silver nanoparticles have been studied with C/AgNPs (2). **Figure 4** shows the peak area of absorbance versus mass (mg/L)of C/AgNPs (2), plot of peak at 556 nm in UV-Vis spectroscopy. It is evident that C/AgNPs absorbs inorganic arsenic remarkably. The inorganic arsenic absorption increases with increase in the concentration/mass of C/AgNPs (2)/L and it reaches a plateau at the concentration of 1.0 mg/L of C/AgNP(2). The lower intensity of absorptionof the peak at 556 nm indicates inorganic arsenic is removed from water to a safe level.

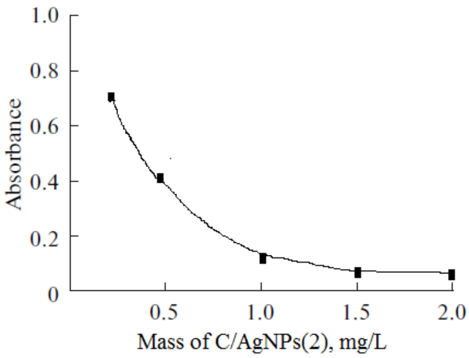

Figure 4: *Arsenic absorption properties of C/AgNPs.*

4. Conclusions

Carbon based silver nanoparticles (C/AgNPs) are formed when reduction of Ag^+ to Ag^0 by dextrose is carried out in the presence treated charcoal and polyacrylamide as nanoparticle stabilizer. On increasing the Ag loading particle size increases. Carbon based C/AgNPs have inorganic arsenic absorption properties. The overall the method is a green synthesis of C/AgNPs since no toxic chemicals/solvents are used in the synthesis of C/AgNPs.

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