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Synthesis and Characterization of Silver-oxide Nanoparticles by Sol-Gel Method

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ABSTRACT

Silver oxide (Ag_2O) nanoparticles were synthesized via modified Sol-gel method. Sol-gel technique is very simple and low cost synthesis technique. In this modified method, oxalic acid was replaced with citric acid which was mixed with ethylene glycol to form a homogenous gel. Here we replaced ethyl alcohol with ethylene glycol. Ethylene glycol here acted as a sol stabilizer. The metal nanoparticles were characterized by XRD, UV-Visible and FT-IR spectroscopy. The results obtained from XRD, UV-Visible and FT-IR spectral analysis confirms the formation of silver oxide nanoparticles. Thermal and optical study of metal nanoparticles was also carried out using TGA/DTA and Tauc plot methods.

Keywords:* Ag_2O *nanoparticles, Citric acid, Ethylene glycol, FTIR, Sol-gel method, XRD.

I.INTRODUCTION

Nanoparticles have attracted much interest as they exhibit unique properties that differ significantly from their bulk counterparts. Metal nanoparticles have many potential applications, including use in biomedical [1], optoelectronic [2] and catalysis systems [3] which relate to their size-dependent properties. Silver and its salts as nanoparticles are of particular interest due to their potential applications in fuel cells [4], heterogeneous catalysts [5, 6], coating of medical devices [7], sterilization of sanitary napkins [8], anti-tumour [9] and antimicrobial chemotherapeutic agents [10], etc. Silver nanoparticles possess unique physical, chemical and biological properties and so are the most extensively used nanoparticles in wound dressings, antimicrobial coatings, anti-cancer chemotherapy and cosmetics [11]. Silver exhibits multiple modes of inhibitory action against microorganisms. Silver nanoparticles are common antimicrobial agents because their production costs are low [12].

Noble nanomaterials have been synthesized by various methods such as hard template, bio-reduction and solution phase synthesis. Some commonly used chemical approaches used for the synthesis of silver nanoparticles (NPs), includes chemical reduction using a variety of organic and inorganic reducing agents, electrochemical techniques, physicochemical reduction, and radiolysis. But most of these methods are still in development stage and the experienced problems are the stability and aggregation of NPs, control of crystal growth, morphology, size and size distribution. Moreover, extraction and purification of synthesized NPs for further applications are also important issues [13-15].

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In continuation to our earlier study [16-24], present study is focussed on developing a novel synthesis technique to synthesize Ag_2O nanoparticles using modified sol-gel technique by using $AgNO_3$ as the inorganic precursor. This method has many advantages also, which includes operational simplicity, high purity and high yield of product and no special equipment required. Samples were characterized by FTIR, UV-VIS and XRD. Thermal and optical study of metal nanoparticles was also carried out using TGA/DTA and Tauc plot methods.

II.EXPERIMENTAL

2.1. Chemicals and Apparatus

All chemicals used in experiment were of analytical grade. The chemicals used in the synthesis were$AgNO_3$, citric acid and ethylene glycol. All the solutions were prepared in double distilled water.

2.2. Synthesis of Ag_2O Nanoparticles

Metal salt solution was mixed in double distilled water. In another beaker citric acid solution was prepared in double distilled water and then two solutions prepared separately were mixed and continuously stirred for 15 minutes. Ethylene glycol was then mixed into it drop wise with continuous stirring for three hours. The resultant precipitates thus obtained were washed with double distilled water and then dried at 100.0 °C in oven for 2.0 hours. Finally, these metal nanoparticles were put into the muffle furnace maintained at a constant temperature of 400.0°C for 3.0 hours. Silver coloured Ag_2O nanoparticles were thus obtained.

2.3. Characterization techniques

The size, structure and morphology of metal oxide nanoparticles were characterised by FTIR (Thermo-USA, FTIR-380) in the wavelength range 400-4000 cm^{-1}, UV-Visible spectroscopy (Shimadzu 1800) in the wavelength range 200-1000 cm^{-1} and XRD (Rikagu mini-2 using Cuα1, λ=0.15406 nm radiations). Thermal and optical study of metal nanoparticles was also carried out using TGA/DTA and Tauc plot methods.

III.RESULTS AND DISCUSSIONS

3.1 X-Ray Diffraction Study

"Fig.1" represents X-ray diffraction pattern of metal oxide nanoparticles. The X-ray diffraction pattern revealed major peaks at 2θ values of 38.08 (111), 44.26 (200), 64.39 (220), 77.36 (311), 81.52 (222), respectively. All diffraction peaks of sample correspond to the characteristic face centered cubic structure of silver oxide which are confirmed by JCPDS card no. 04-0783 [110]

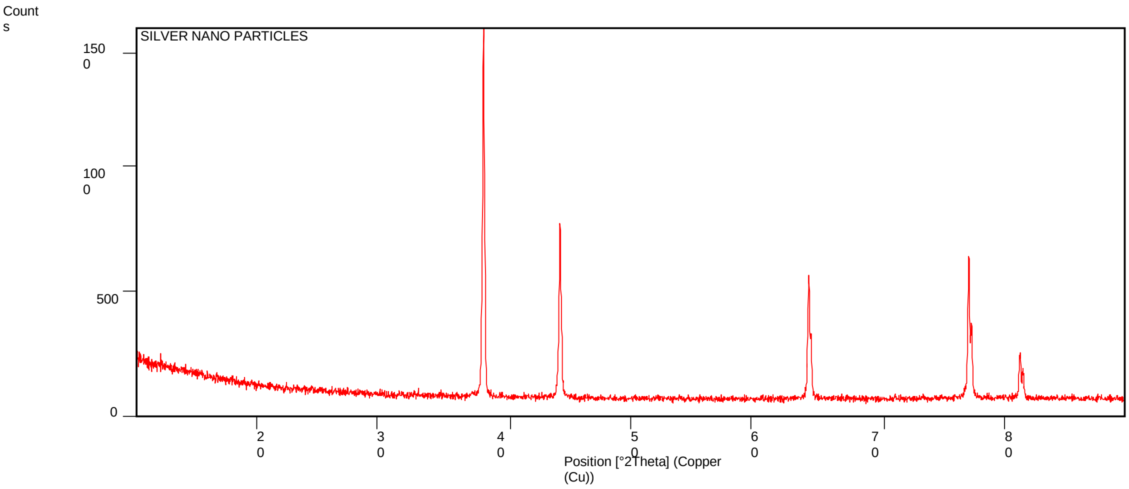

Figure 1. XRD spectra of Silver oxide nanoparticles.

3.2 FTIR Spectroscopy

"Fig 2" presents the FTIR spectra in the range 4000-400 cm^{-1}. The characteristic absorption bands are 935 and 677 cm^{-1} correspond to the Ag-O stretching and bending vibration mode respectively. The peaks observed around 3500 cm^{-1} and 1740 cm^{-1} corresponds to stretching and bending vibration of –OH bond.

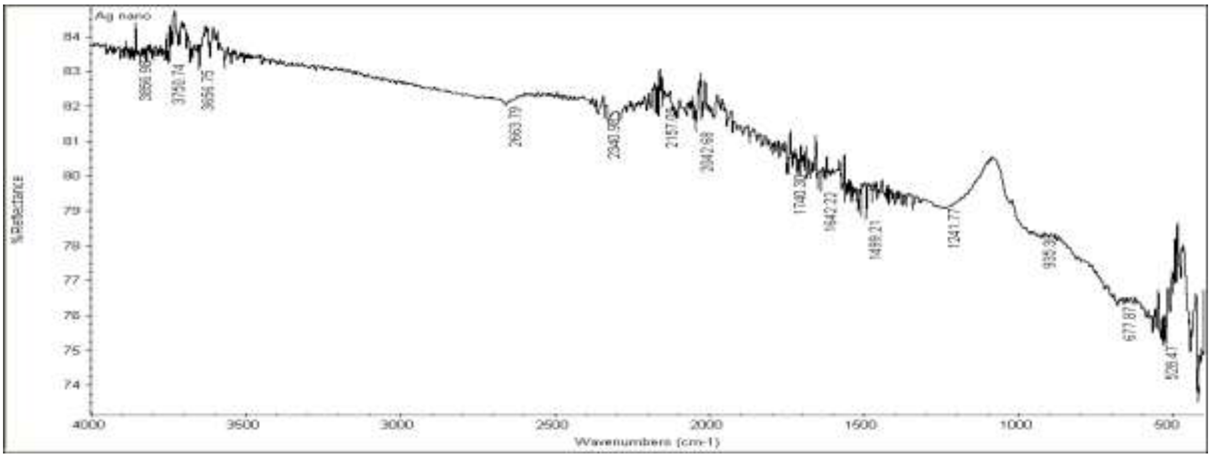

Figure 2. FTIR Spectra of Silver oxide nanoparticles.

3.3 UV-Visible Spectroscopy

"Fig.3" represents the absorbance spectra of the Ag_2O nanoparticles. The UV absorption spectra of Ag_2O nanoparticles show a characteristics peak at a wavelength of 340 nm. The peak corresponds to the formation of Silver oxide nanoparticles. "Fig. 3(a)" is the Tauc plot showing variation of $(\alpha h\nu)^{½}$ vs. hν and "Fig. 3(b)" is the Tauc plot showing variation of $(\alpha h\nu)^2$ vs. hν. These plots were drawn from the data of UV-Visible absorption

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spectra of silver oxide nanoparticles. The direct and indirect band gap (Eg) of silver oxide nanoparticles corresponding to absorption peak at 340 nm was found to be 2.4 and 2.4 eV, respectively. It is clear from band gap that synthesized nanoparticles are of semiconductor type.

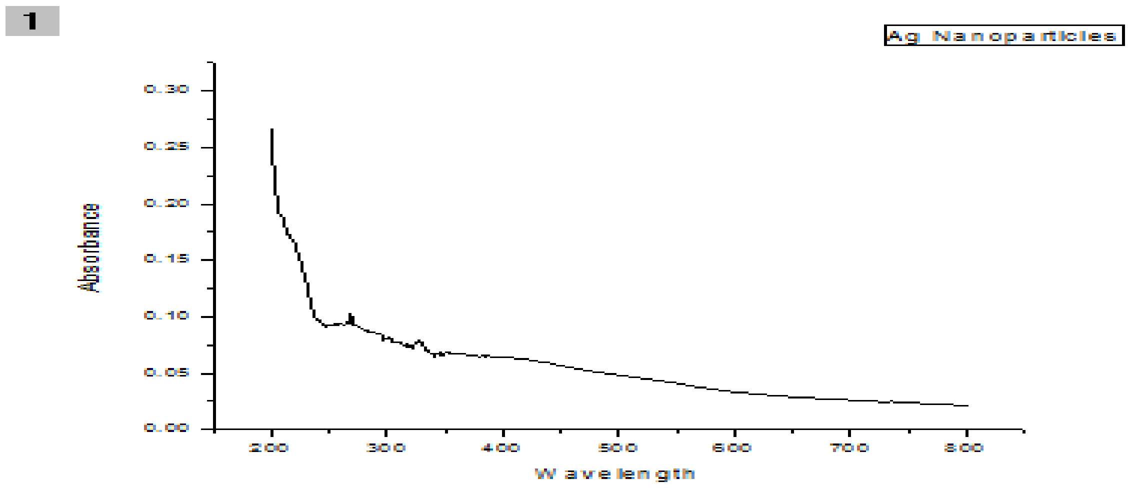

Figure 3. UV-Visible spectra of Silver-oxide nanoparticles.

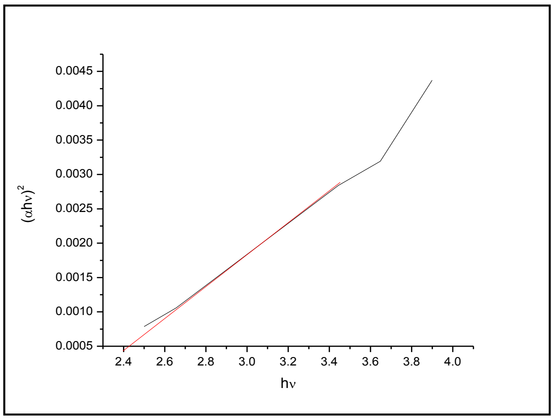

Figure 3(a) Tauc plot of $(\alpha h\nu)^{1/2}$ vs. hν

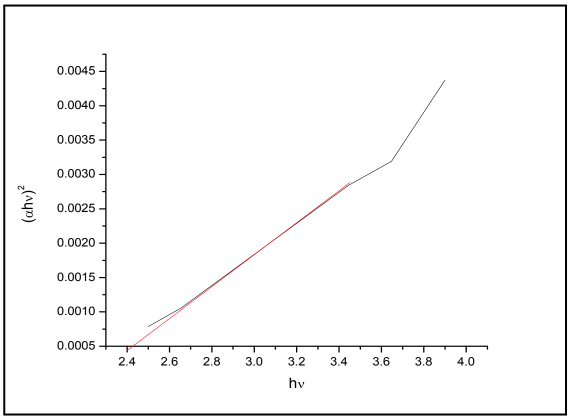

Figure 3(b) Tauc plot of $(\alpha h\nu)^2$ vs. hν

3.4 TGA and DTA Analysis:

"Fig.4" represents the TGA and DTA spectra of the Ag_2O nanoparticles. Thermogravimetric studies were carried out under nitrogen atmosphere with a heating rate of 10 ºC/ min, to check the stability of Ag_2O nanoparticles. Weight takes place first around 100 ºC (due to loss of moisture) and then in the temperature region 400–600 °C (due to loss of CO_2 and H_2O).

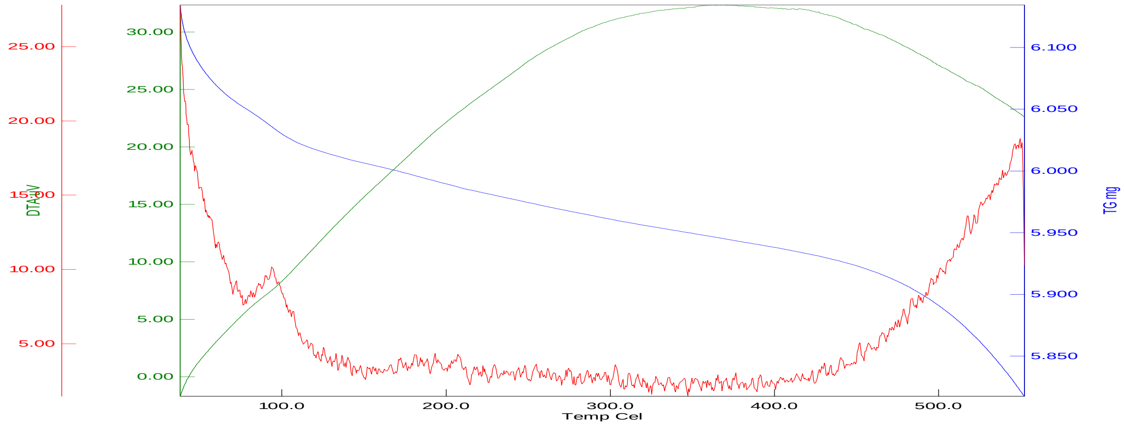

Figure 4 TGA/DTA thermal analysis curves of Silver oxide nanoparticles.

IV.CONCLUSIONS

Ag_2O metal nanoparticles synthesized by modified sol-gel technique are typical fcc in structure. The results of UV-VIS, FTIR and XRD, indicates the formation of Ag_2O nanoparticles and TGA/DTA results indicate the stability of silver oxide nanoparticles. The optical absorption spectrum of Silver oxide nanoparticles was studied by UV-Visible spectroscopy. The Tauc Plots shows the good conductivity of synthesized nanoparticles. The absorption band in finger print region of FTIR spectra i.e. 935 and 677 cm^{-1} indicated metal oxide stretching vibrations. This modified sol-gel method is one of the simplest, environment friendly, cost effective and less time consuming method of synthesis of nanoparticles.

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