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Structural and Optical Properties of Copper Nanoparticles Synthesized via Wet Chemical Route

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Abstract. Copper nanoparticles (Cu NPs) have inherent optical and electronic properties and hence they find potential applications in the fields of printed electronic technologies, electronic device fabrication, sensors and conductive ink based electronic devices. Synthesis of pure Cu NPs through bottom up wet chemical route is a tough task because copper is highly prone to the surface oxidation and copper oxide is a very stable form at ambient conditions. In this work, crystalline metallic Cu NPs are synthesized in a one-step, eco-friendly route with L-ascorbic acid as both stabilizing and antioxidant agent and sodium borohydride as the reducing agent at the room temperature, without any inert atmosphere conditions. The structural properties of Cu NPs are studied using XRD, FTIR, FE-SEM etc. Optical properties of Cu NPs are probed through UV-Visible and fluorescent spectra.

INTRODUCTION

In the recent years, nanotechnology and nanoengineering has been widely applied in many fields, due to it's the size and growth morphology dependent structure and properties of materials when it goes from bulk to atomic level1,2. Generally, metal nanoparticles exhibit superior optical, electronic, thermal, magnetic and sensing properties than that of their bulk structure. Among metal nanoparticles, Copper nanoparticles (Cu NPs) have lots of attention in the field of biosensing, gas sensing, printed electronics3 and photochemical catalysis4,5. Copper is a viable alternative for silver and gold as far as optical applications are concerned, because it is less expensive, and contains almost similar optical and electronic properties like these noble metals4,6. Chemical reduction7,8, polyol method9, thermal decomposition and electron beam irradiation techniques are the main techniques that are widely followed for the synthesis of Cu NPs7. But synthesis of Cu NPs is difficult because of the formation of copper oxide nanoparticles during the preparation4,10. Copper oxide nanoparticles are more stable than pure Cu NPs in ambient conditions especially in the nanoform11.

Here, in the present study, a one-step synthesis method for the fabrication of pure Cu NPs with minimal precursors is developed using ascorbic acid without any inert conditions. Effect of factors like concentration of ascorbic acid and the role of reducing agent on the formation of nanoparticles are studied here and the optical and structural properties of Cu NPs are also studied.

EXPERIMENTAL DETAILS

Copper sulphate ($CuSO_4.5H_2O$) with molecular weight 159.6g/mol, L-Ascorbic acid($C_6H_8O_6$) with molecular weight 176.1 g/mol purchased from Sigma Aldrich and Sodium borohydride ($NaBH_4$) are used as the precursor. A solution of copper (II) sulphate pentahydrate $CuSO_4.5H_2O$ (0.5M) is made by 20ml of deionized water kept under stirring for 10 minutes. Aqueous solution of ascorbic acid (1 M) of 20ml is added to the solution while stirring. The colour of the mixture changed from blue to green. The strong reducing agent, Sodium borohydride ($NaBH_4$) (5M) is added few dropwise and vigorous reaction take place with quick colour change from green to reddish brown. This indicates the formation of Cu NPs. The steps of formation of Cu NPs shown in the Fig. 1. It is kept 10 more minutes for stirring. The precipitate is centrifuged and dried for 1 hour at 150^0C. The experiment was conducted in three molar ratio combinations of $CuSO_4$: Ascorbic acid: $NaBH_4$ 1:0.5:10, 1:2:2.5 and 1:2:10.

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