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Synthesis and spectroscopic studies of stable aqueous dispersion of silver nanoparticles

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ABSTRACT

A facile approach for the synthesis of stable aqueous dispersion of silver nanoparticles (AgNPs) using glucose as the reducing agent in water/micelles system, in which cetyltrimethylammonium bromide (CTAB) was used as capping agent (stabilizer) is described. The evolution of plasmon band of AgNPs was monitored under different conditions such as (a) concentration of sodium hydroxide, (b) concentration of glucose, (c) concentration of silver nitrate (d) concentration of CTAB, and (e) reaction time. AgNPs were characterized by UV–visible spectroscopy, transmission electron microscopy (TEM), fluorescence spectroscopy and FT-IR spectroscopy. The results revealed an easy and viable strategy for obtaining stable aqueous dispersion of AgNPs with well controlled shape and size below 30 nm in diameter.

1. Introduction

Noble metal nanostructures such as AgNPs attract much interest because of their unique properties, including large optical field enhancements resulting in the strong scattering and absorption of light. This optical property arises from the coherent oscillation of the free electrons from one surface of the particle to the other and is called the surface plasmon absorption [1,2]. This plasmon resonance has generated great interest in their potential for a wide range of optical, photonic and medicinal applications [1,3]. Therefore, synthesis and characterization of AgNPs is being an important area of research [3,4].

Synthesis of nanoparticles generally involves the reduction of metal ions in solutions or in high temperature gaseous environments. The high surface energy of these particles makes them extremely reactive, and most systems undergo aggregation without protection or passivation of their surfaces [5–9]. It is essential to stabilize nanoparticles in the dispersing medium to prevent agglomeration. This can be achieved by either electrostatic or steric stabilization, or both. Many of the traditional routes to metal nanoparticle synthesis in an aqueous medium rely on electrostatic stabilization by the formation of an electrical double layer around the particles. This double layer is formed by the adsorption of negatively charged species, usually inorganic ions, onto the metal nanoparticle surface. This results in a Coulombic repulsion between particles that prevents them from coagulating. Steric stabilization normally involves the adsorption of molecules such as polymers, surfactants or ligands onto the particle surface providing a protective layer. The protecting agent must have good affinity to the particle surface as well as being easily dispersible in the desired solvent. Various stabilizing agents such as surfactants and functional polymers among others have proved useful for protecting and dispersing nanoparticles in aqueous solutions [3].

The green synthesis of AgNPs involves three main steps, which must be evaluated based on green chemistry perspectives, including (1) selection of solvent medium, (2) selection of environmentally benign reducing agent, and (3) selection of nontoxic substances for the AgNPs stability [3,4,10]. In the present approach, H_2O is utilized as the environmentally benign solvent throughout the preparation. The second concern in a green nanoparticle preparation method is the choice of the reducing agent. The majority of reducing chemicals used so far use agents such as hydrazine [11], sodium borohydride ($NaBH_4$) [12], and dimethyl formamide (DMF) [13,14]. All of these are highly reactive chemicals and pose potential environmental and biological risks. There have been few reports to replace such harsh chemicals with glucose as reducing agent for the production of AgNPs [10,15,16]. In this interest, the present work was designed so as to get insight into the viability of using glucose under different conditions for the formation of stable aqueous dispersion of AgNPs. With gentle heating and/or at room temperature, this system is a mild, renewable, inex-

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