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Growth of Ag-nanoparticles using aspartic acid in aqueous solutions

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ABSTRACT

Spectrophotometric, kinetic, and transmission electron microscopic (TEM) data for the formation of Ag-nanoparticles using aspartic acid (Asp) as reductant are reported for the first time. In the formation of transparent silver sols, an alkaline medium is required. The silver nanoparticles are spherical, uniform particle size, and strongly depend on the [Asp]. The apparent rate constant decreases with [Asp] (from 4.0 to $24.0 \times 10^{-4} \text{ mol dm}^{-3}$, the rate constants decreased from 2.6×10^{-4} to $0.3 \times 10^{-4} \text{ s}^{-1}$). For a certain reaction time, i.e., 30 min, the absorbance of the silver sol first increased until it reached a maximum, and then decreased with [Asp]. Kinetic and TEM results indicate that the size of the Ag-nanoparticles depends on the [Asp]. It is proposed that the oxidation of Asp occurs by the adsorbed Ag^+ ions on the surface of Ag_2O particles.

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1. Introduction

Proteins in the serum are critical to maintaining the pH balance in the body; it is largely the charged amino acids that are involved in the buffering properties of proteins. Biomolecules (proteins, amino acids, polysaccharides and vitamins) are used as reducing-, capping-, stabilizing- and crossing-agents for the production of advanced silver nanomaterials [1]. Chang and his coworkers reported an easy procedure for the preparation of different shaped and sized gold–silver nanocomposites from gold nanorod seeds in various amino acid solutions (arginine, cysteine, glycine, glutamate, glutamine, histidine, lysine and methionine) [2]. Zhong et al. [3] reported the surface chemistry of gold colloids in presence of different amino acids and suggested that basic side chain amino acids (glutamine, arginine, lysine, histidine, cysteine, methionine, and tyrosine) acts as cross-linking agents for pairs of gold particles where as non-polar (alanine) and acidic (aspartic and, glutamic) amino acids have no effect in the spectra of gold nanoparticles. Single-crystal nanoplates have also been prepared in large quantities through the aspartate-mediated reduction of gold [4]. Bakshi and coworkers have synthesized the Au–Ag bimetallic conjugate materials by seed-growth method using phospholipids and ascorbic acid as capping- and weak reducing agents, respectively [5].

The chemical literature contains abundant reports aimed towards understanding the role of normal surfactants, gemini surfactants, polymers and triblock polymers in the synthesis and

characterization of different shaped and sized Au–Ag bimetallic nanocomposites and their nanoparticles [6]. The principal interest in the redox chemistry of silver stems from the fact that silver nanoparticles have surface plasmon resonance absorption band in the UV–visible region [7], particle size, chemical surrounding, adsorbed species on the surface and dielectric constant of the medium are responsible for the band shift. Functionalized, biocompatible and inert nanomaterials are found to be effective for photography, biological labeling, diagnosis and therapy of cancer [8a]. Various radiation-, chemical-, photo-, and electro-chemical methods and theories are most widely used for the preparation and characterization of advanced silver nanomaterials [9,10].

It has been accepted that the morphology and properties of these materials are strongly influenced by the reaction conditions (acidity of the medium, nature of the reducing agent, and rate of the reduction of Ag^+) [11]. In addition, smaller particles will grow faster, by reduction and combination reactions, than larger particles and Ag^+ ions were spontaneously reduced by reaction with the solvents in basic solutions saturated with air [12]. Alkaline solution is essential for the synthesis of silver nanoparticles in aqueous solution of sugar-persubstituted poly(amidoamine) dendrimers (hydroxyl groups of glucose residues of sugar ball operate as reduction sites for Ag^+ ions) [13]. Mehta et al. [14] synthesized of silver nanoparticles in homogeneous aqueous-alkaline solutions of silver nitrate and saccharides (glucose, fructose and sucrose) in presence of sodium dodecyl sulphate.

Lee and his coworkers described the synthesis of single-crystalline silver nanoplates using the extract of unicellular green alga *Chlorella vulgaris* at room temperature and reported that proteins in the extract was responsible to the reduction of silver ions and

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