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Synthesis of Silver-Copper Nanocolloids using *Escherichia coli*

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Abstract

The Ag-Cu bimetallic colloidal nanoparticles were prepared by an environmentally friendly method. We used to synthesize Ag-Cu alloy nanoparticles from the culture supernatant of *E. coli*. Aqueous solutions of Cu^{2+} and Ag^{+} ions were mixed with the culture supernatant for the formation of Ag–Cu alloy nanoparticles. The alloy nanoparticles were characterized by dynamic light scattering (DLS) UV–Vis spectroscopy and transmission electron microscopy (TEM). The size of Ag-Cu alloy nanoparticles, analyzed by dynamic light scattering method, were determined to be about 45 nm.

Keywords: Ag-Cu alloy, *Escherichia coli*, Synthesis, Nanoparticles,

Bimetallic nanoparticles are the combination of two metals in the nanoscale size range. The manufacture of materials with controllable properties and structures on the nanometer scale coupled with the flexibility paid by intermetallic materials, which is referred as nanoalloys[2]. This area of nanoscience is gaining mounting attention in the field of catalysis due to synergistic effects. The properties of alloy nanoparticles can be very unlike from the properties of the component monometallic nanoparticles[1]. Bimetallic nanoparticles have excelled monometallic nanocrystals owing to their improved electronic, optical and catalytic performances[9,10]. They often improve the selectivity of metal catalyzed reactions. Additionally, the change in composition of metals provides another dimension in tailoring the properties of bimetallic nanoparticles besides the usual size and shape manipulation. Kobayashi et al. have synthesized Ag–Cu alloy nanoparticles by chemical method. They used from hydrazine as reducing agent and citric acid as stabilizer at room temperature[2]. In another work, Ag–Cu nanocolloids were produced by solvothermal method[6]. In 2014, Zobac *et al*. reported synthesis and characterization Ag–Cu nanoparticles using sodium borohydride as reducing agent in polar solvent[8].

It seems microorganisms and extracts of plants are used for synthesizing bimetallic nanoparticles. In this study, a green chemistry method using *E. coli* is employed to synthesize the Ag"Cu alloy nanoparticles. In this work, the size of the nanoparticles was measured by dynamic light scattering (DLS) and the morphology of nanoparticles was observed using transmission electron microscopy (TEM).

Escherichia coli was obtained from Microbiology Laboratory, Tehran University, Iran. The bacterium after growth was maintained on an agar plate (Macconkey agar) at 4ºC temperature. The Muller-Hinton broth (MHB) was used for bacterial culture. E.coli was inoculated into flasks containing sterile Muller-Hinton broth and the flasks were incubated at 37 °C for 24 h.

The materials used for the biosynthesis of nanoparticles are silver nitrate and copper sulphate. Polyvinylpyrrolidone (PVP) was used as a dispersing agent in preparation of nanoparticles. The two metal salt solutions (0.01 M silver nitrate and 0.01 M copper sulphate) containing PVP were mixed in a flask. The reaction mixture was stirred for 10 min using magnetic stirrer. The culture was centrifuged at 5000 rpm for 20 minutes and the supernatant was used for the synthesis of Ag–Cu alloy nanoparticles. 5 ml of supernatant was added to the reaction vessel containing 100 ml metal salt solution. The reaction between this supernatant and Ag^+: Cu^{2+} mixtures ions were carried out for 45 minutes at room temperature. The dark green precipitate was obtained and separated by filtration. The obtained precipitate was washed with ethanol water mixture. The colloids of the synthetized nanoparticles were characterized by different techniques: UV-Vis spectroscopy, dynamic light scattering (DLS), and transmission electron microscopy (TEM). The aim was to measure size and shape of the produced nanoparticles in solution.

UV-vis spectra of Ag–Cu colloidal solution are shown in Fig. 1. As illustrated, a strong absorption peak shows at about 506 nm attributed to the surface plasmon resonance band (SPR) of the Ag–Cu alloy nanoparticles. In previous papers, it was understood that pure Ag and pure Cu should display absorption peaks at 422 nm and 582 nm, respectively[3-5].

The size of the Ag-Cu colloidal nanoparticles was measured by dynamic light scattering (DLS) method. As shown in figure 2, the size distribution of the Ag-Cu bimetallic nanoparticles ranged between 45±18 nm.

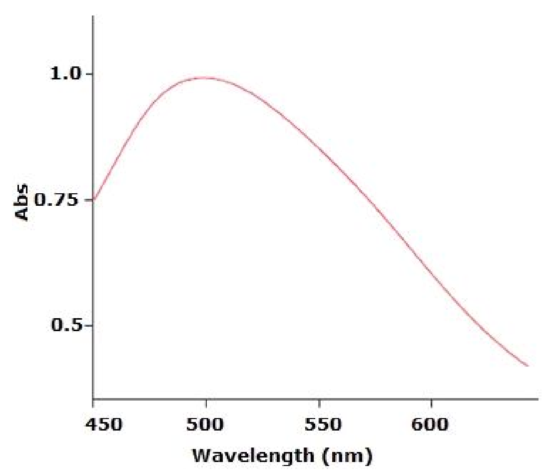

Fig 1. Uv–vis spectra of Ag–Cu alloy colloids

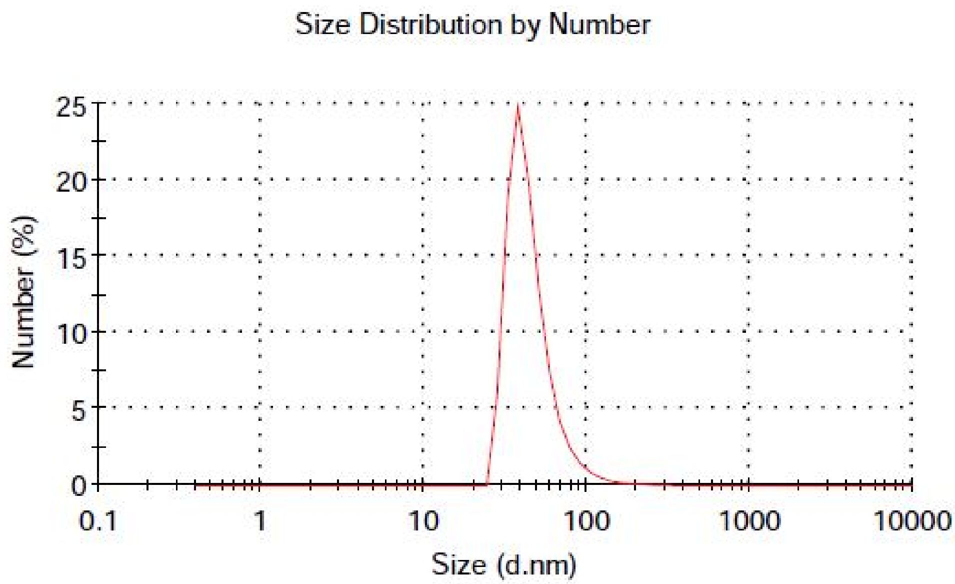

Fig. 2. The curve of size distribution (Ag-Cu nanoparticles) by number

To prepare samples for TEM, a drop of dilute Ag-Cu colloid suspension was placed on a carbon-coated grid and allowed to dry by evaporation at ambient temperature. TEM images of the Ag-Cu bimetallic nanoparticles are shown in Fig 3. It confirm nanoparticles production at nano-size.

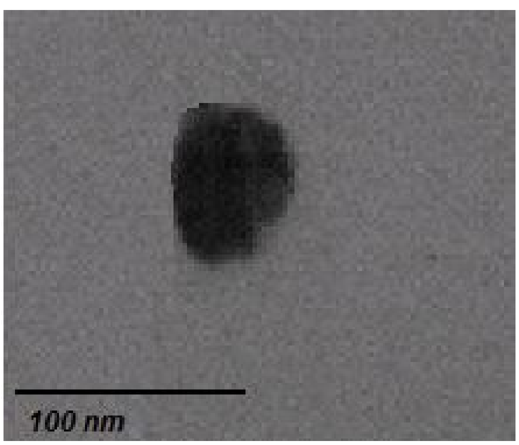

Fig. 3. TEM of Ag-Cu nanoparticles synthesized by Escherichia coli

The Ag-Cu bimetallic colloidal nanoparticles were prepared by biological synthesis and using E.coli as reducing agent. The size of the Ag-Cu nanoparticles was 45±18 nm. The Ag-Cu alloy nanoparticles were characterized using dynamic light scattering (DLS) UV–Vis spectroscopy and transmission electron microscopy (TEM) techniques. According to previous reports, the reductase enzymes released by the bacteria play the most important role in the reduction of metal ions. This is an economical, efficient, eco-friendly and simple process.

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