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Electrochemical Synthesis of Copper Nanoparticles

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Abstract : A method for synthesizing copper nanoparticles through an electrochemical approach is proposed, employing surfactants to stabilize the size of the newly formed nanoparticles. The electrolyte was made up of a matrix of H_2SO_4 (190 g/L) having Cu^{2+} (from 3.2 to 9.5 g/L), sodium dodecyl sulfate -SDS- (from 0.5 to 1.0 g/L) and Tween 80 (from 0 to 7.5 mL/L). Tween 80 was used in a molar relation of 1 to 1 with SDS. A glass cell was used, which was in a thermostatic water bath to keep the system temperature, and the electrodes were cathodic copper as an anode and stainless steel 316-L as a cathode. This process was influenced by the control exerted through the initial copper concentration in the electrolyte and the applied current density. Copper nanoparticles of electrolytic purity, exhibiting a spherical morphology of varying sizes with low dispersion, were successfully produced, contingent upon the chemical composition of the electrolyte and current density. The minimum size achieved was 3.0 nm ± 0.9 nm, with an average standard deviation of 2.2 nm throughout the entire process. The deposited copper mass ranged from 0.394 g to 1.848 g per hour (over an area of 25 cm^2), accompanied by an average Faradaic efficiency of 30.8% and an average specific energy consumption of 4.4 kWh/kg. The chemical analysis of the product employed X-ray powder diffraction (XRD), while physical characteristics such as size and morphology were assessed using atomic force microscopy (AFM). It was identified that the initial concentration of copper and the current density are the variables defining the size and dispersion of the nanoparticles, as they serve as reactants in the cathodic half-reaction. The presence of surfactants stabilizes the nanoparticle size as their molecules adsorb onto the nanoparticle surface, forming a thick barrier that prevents mass transfer with the exterior and halts further growth.

Keywords : copper nanopowder, electrochemical synthesis, current density, surfactant stabilizer
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