

Effect of Applied Potentials and Deposition Time on Electrodeposition on Stainless Steel

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Structured Abstract

Background: Copper is widely recognized for its excellent antimicrobial properties and has been historically used to limit the spread of pathogens on high-contact surfaces. However, coating stainless steel with copper by electrodeposition presents challenges, including poor adhesion, porosity, and non-uniform layers if deposition conditions are not well controlled. This study investigates the effects of applied potentials and deposition times on copper electrodeposition to develop high-quality antimicrobial copper coatings for stainless steel surfaces, with potential applications in healthcare.

Methods: Stainless steel substrates were mechanically polished and cleaned before electrodeposition using a three-electrode cell with a stainless-steel working electrode, a platinum counter electrode, and an Ag/AgCl reference electrode. A 0.01 M CuSO₄ solution was used as the electrolyte. Cyclic voltammetry (CV) was first conducted to identify suitable deposition potentials. Chronoamperometry (CA) was then performed at -0.5 V, -1.0 V, and -1.5 V for deposition times of 900 s, 1800 s, and 3600 s to study nucleation and growth behaviour. Coatings were characterized using FESEM for surface morphology and EDX for elemental composition. Adhesion was assessed using a tape test.

Results: Higher applied potentials increased current density but also promoted hydrogen evolution, thereby affecting coating quality. At -1.0 V, copper coatings exhibited better uniformity and coverage than at -0.5 V. Increasing the deposition time from 900 s to 3600 s increased coating thickness but also introduced internal stress, which reduced adhesion strength. FESEM images confirmed smoother, denser coatings at -1.0 V for 1800 s, but excessive hydrogen evolution at -1.5 V caused surface roughness and porosity. EDX confirmed an increase in copper content at higher potentials.

Conclusion: Controlling applied potential and deposition time is crucial for optimizing copper electrodeposition on stainless steel. An applied potential of -1.0 V with moderate deposition time produced the most uniform coatings, but further improvements in adhesion are needed. Future work should consider pulse electrodeposition or surface treatments to enhance coating quality for practical antimicrobial applications.

Keywords: Copper Coating; Electrodeposition; Stainless Steel; Applied Potential; Antimicrobial Surface.

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