Corrosion and Discoloration Behavior of Five Coinage Copper Alloys in Six Atmospheric Environments: Experimental Analysis and DFT-Based Mechanism Insights

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Abstract: This study analyzes the corrosion behavior of five copper alloys exposed to outdoor environments at six locations, which employed CIE-Lab colorimetry and UV-VIS absorption spectroscopy to assess the extent of discoloration and the rate of corrosion. The results revealed that among the silver-like copper alloys, zinc white copper exhibited a significantly slower darkening rate compared to nickel white copper, highlighting its superior resistance to atmospheric tarnishing. For gold-like copper alloys, the darkening rates generally followed the order: aluminum bronze < nickel brass < tin brass. However, under the unique environmental conditions of Dunhuang, aluminum bronze demonstrated a markedly higher darkening rate. Additionally, to elucidate the mechanisms behind these observations, the study incorporated scanning electron microscopy (SEM), scanning Kelvin probe (SKP) analysis, and density functional theory (DFT) calculations. These methods provided insights into the morphology and distribution of corrosion products, highlighting differences in corrosion resistance. The work function of corrosion products and material migration capabilities were found to be critical factors influencing corrosion resistance. The findings provide valuable guidance for the development of more corrosion-resistant copper-based materials, with implications for their use in diverse atmospheric environments.

Keywords: Atmospheric corrosion; Copper alloys; Discoloration; DFT