

Research on Physicochemical Characteristics and Typical Disease Mechanism during Corrosion and Degradation of Ancient Fragile Bronzes

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Abstract This Research aims to systematically elucidate the corrosion mechanisms and pathogenesis of ancient bronze materials. Building upon a comprehensive analysis of the corrosion characteristics observed in bronze archaeological samples from various regions, we conducted a series of simulated corrosion experiments under soil burial conditions to elucidate the corrosion characteristics and rates of bronze materials, as well as their quantitative relationships with environmental indicators. Additionally, we established a preliminary evaluation model for assessing the impacts of corrosion. The mixture of copper, tin, and lead powders was exposed to a gaseous environment, and the exposure results were characterized by mass spectrometry analysis. The results indicate that the oxidation rates of components within the copper-tin and copper-lead systems are maximized when the content of tin or lead reaches 15%; for the copper-tin-lead system, the peak oxidation rate is observed when both tin and lead contents are maintained at 20%. Furthermore, relative humidity levels at 40% and oxygen concentrations exceeding 11% emerged as critical thresholds influencing changes in oxidation rates. Through theoretical calculations, the impact of alloy element ratios on the corrosion behavior of low tin bronze material was elucidated, and the adsorption patterns of oxygen atoms on both the surface and subsurface layers of the alloy were characterized. Finally, we concentrated on the typical issue “bronze disease”, investigating the corrosion behavior of four distinct types of tin bronze alloys and ancient bronze coins under various conditions, including soil environments, continuous immersion, and acidic or alkaline atmospheres. A model for segregation corrosion in low tin bronze associated with “bronze disease” was subsequently developed.

Keywords Bronze Artifact; Corrosion Characteristics; Buried environment; Gaseous Environment; Corrosion Model; Theoretical Calculation