

The Corrosion Inspection of Wood-iron Assemblies from an Old Ship Hulk based on Morphology and Structure Analysis

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Abstract Underwater ancient shipwrecks usually contain numerous wood/iron assemblies, which will face a high risk of further deterioration after excavation as environmental conditions change. It is necessary to evaluate the long-term corrosion behavior of iron in wood/iron assemblies for further study of restoration and conservation. In this paper, an iron spike, embedded in wood from a 70-year-old ship hulk, was chosen for morphology and structure investigation. This study employed multiple analytical techniques: Ultra-Depth 3D Microscope for morphology analysis, SEM-EDS for elemental distribution, XRD for crystalline phase identification, and Raman microspectroscopy for phase identification, distribution, and quantification. The morphological analysis revealed a multi-layered corrosion structure composed of three distinct layers characterized by different textures and colors, and the surrounding wood fibers gradually degraded until being entirely replaced by corrosion products. Phase identification and elemental analysis indicated that the corrosion rusts formed multi-phase mixed layers, which include (1) Internal chloride-rich layer (300–500 μm), which is non-continuous and contains $\beta\text{-Fe}_2(\text{OH})_3\text{Cl}$, Ferrihydrite, and $\beta\text{-FeOOH}$. (2) Intermediate layer (400–600 μm), which is thicker and composed of α -, β -, and $\gamma\text{-FeOOH}$, $\gamma\text{-Fe}_2\text{O}_3$, and Fe_3O_4 . (3) External sulfur-containing layer (20–50 μm), which is continuous and primarily consists of $\alpha\text{-FeOOH}$ and $\alpha\text{-Fe}_2\text{O}_3$. Phase distribution and quantification demonstrated that all layers are heterogeneous, with a significant presence of highly reactive phases like iron(III) (oxyhydr)oxides. This interface corrosion evaluation of the wood/iron assembly serves as a reference for future research on the conservation and restoration of salvaged ancient shipwrecks.

Keywords Wood-iron assemblies; Raman spectroscopy; SEM-EDS; Corrosion

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