

1. ABSTRACT

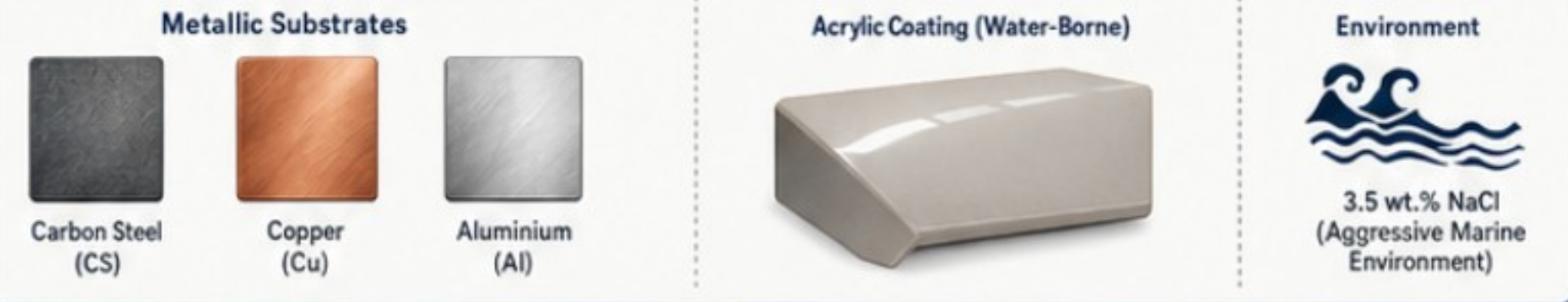
Corrosion of structural metals presents a significant challenge to material durability, particularly for infrastructure exposed to chloride-rich environments. This study investigates the performance of a water-borne acrylic coating formulated as a sustainable alternative to traditional solvent-borne systems. Carbon steel, copper, and aluminium substrates were evaluated through an integrated framework combining electrochemical testing, tensile analysis, and finite-element method (FEM) simulations. Mechanical testing suggests that the coating helps mitigate the onset of surface pitting and associated mechanical degradation. FEM simulations, utilizing elastic-plastic constitutive laws in ANSYS and COMSOL, reproduced the observed stress-strain behaviors. These models provide a framework for analyzing stress redistribution in protected systems, showing more uniform von Mises stress fields compared to degraded, uncoated specimens. Surface characterization via SEM and EDS confirmed coating uniformity and limited crack propagation at the interface. This study demonstrates the potential of combining electrochemical resistance with numerical modeling to assist in the service-life assessment of coated metallic infrastructure.

Comprehensive electrochemical analyses, including Open-Circuit Potential (OCP) and Electrochemical Impedance Spectroscopy (EIS), were conducted in a 3.5 wt.% NaCl solution to simulate aggressive marine conditions. Under these controlled conditions, the coating demonstrated high barrier performance, with calculated inhibition efficiencies reaching 99.9% for carbon steel and aluminium. Complementary weight-loss measurements indicated a substantial reduction in corrosion rates, supporting the electrochemical data.

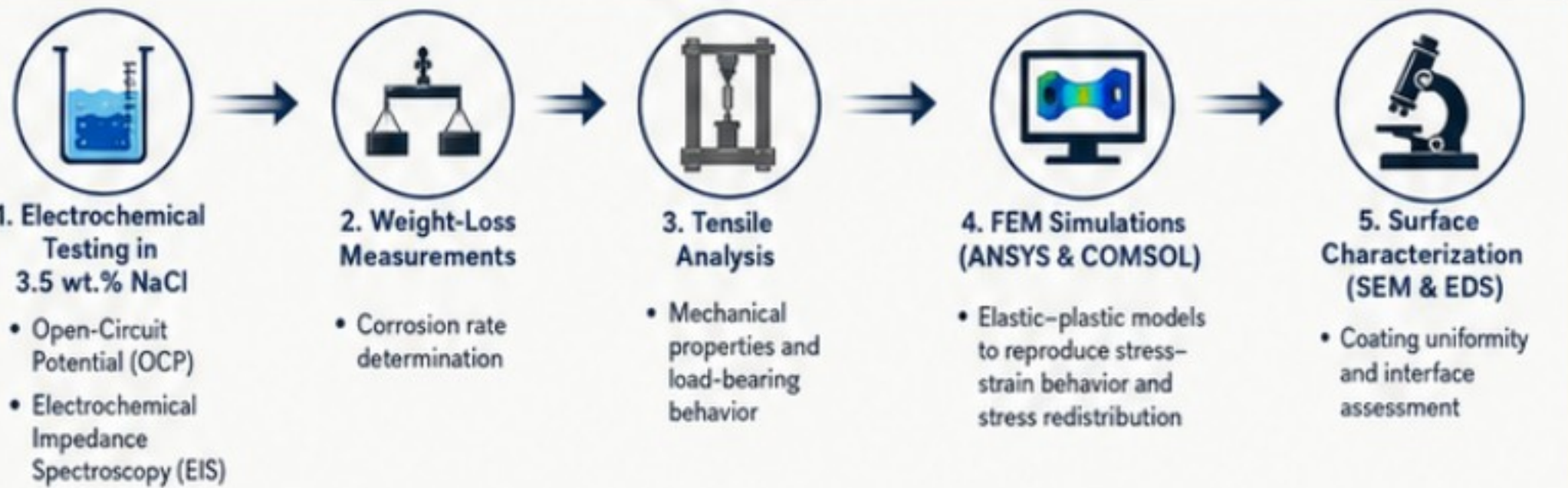
2. KEYWORDS

Eco-acrylic coating; corrosion resistance; sustainable materials; FEM modeling; electro-mechanical analysis; water-borne polymer; durability; stress redistribution

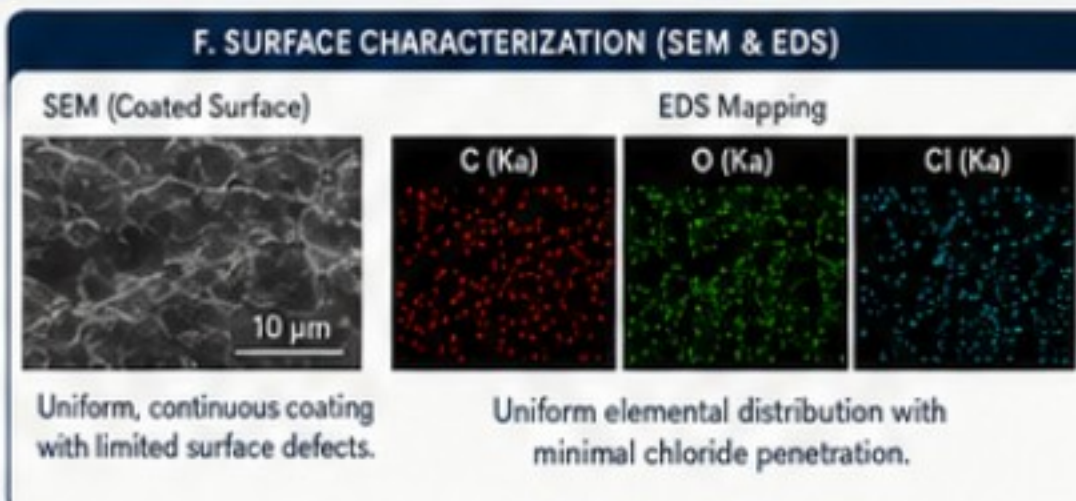
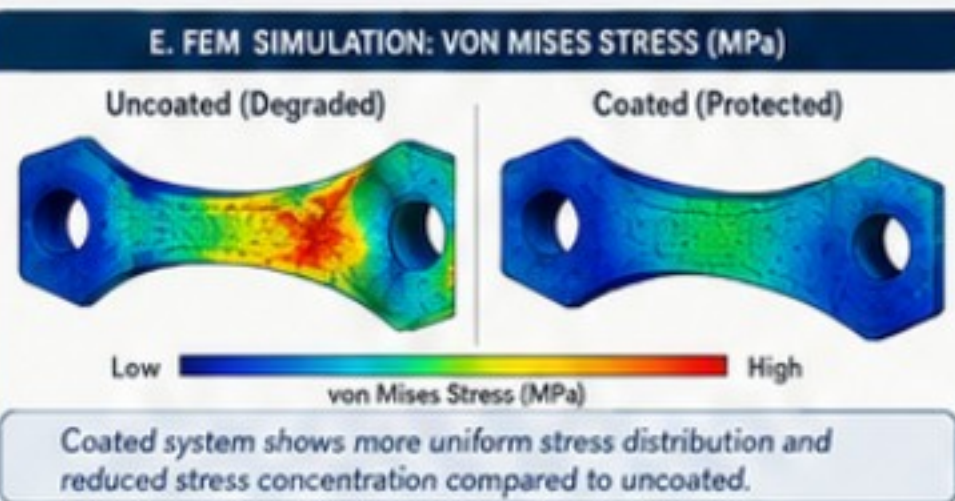
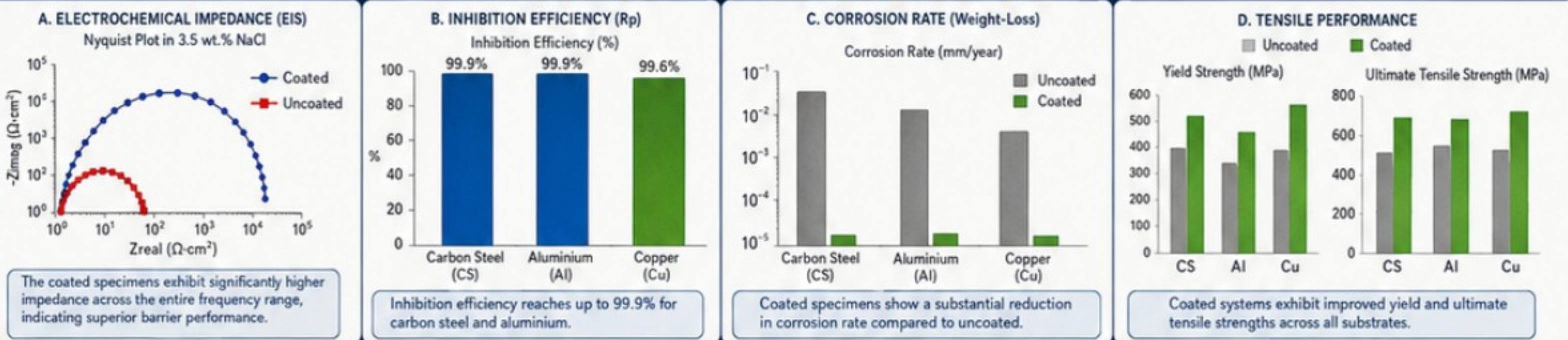
3. STUDY OVERVIEW / MATERIALS



4. METHODOLOGY



5. KEY EXPERIMENTAL FINDINGS & RESULTS



- ### G. KEY OBSERVATIONS
- ✓ High barrier performance in chloride solution.
 - ✓ Inhibition efficiency up to 99.9% for carbon steel and aluminium.
 - ✓ Substantial reduction in corrosion rate from weight-loss data.
 - ✓ Mitigation of pitting onset and reduced crack propagation.
 - ✓ Coated systems show improved load-bearing behavior.
 - ✓ Stress redistribution more uniform in coated specimens.

6. CONCLUSIONS

- Water-borne acrylic coating provides excellent corrosion protection in chloride environments.
- The coating preserves mechanical integrity by reducing pitting-related degradation.
- FEM reproduces experimental behavior and supports service-life prediction.
- Integrated electrochemical and numerical assessment is effective for evaluating protective coatings.
- The approach supports sustainable protection of metallic infrastructure.

SUSTAINABLE COATING
Eco-friendly water-borne polymer

CORROSION PROTECTION
High barrier performance in chloride environments

IMPROVED MECHANICAL PERFORMANCE
Higher strength & durability of coated systems

NUMERICAL VALIDATION
FEM models validate and explain experimental data

INFRASTRUCTURE DURABILITY
Extending service life of metallic infrastructure