Chemically Bonded, Porcelain Enamel Coated Pipe for Corrosion Protection and Flow Efficiency

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Main Objective

The aims of this project are to explore chemically-bonded porcelain enamel coating for corrosion protection and safety of metallic pipes, and to develop a rapid field-applicable coating process for flow efficiency and cost reduction in the operation of metallic pipelines.

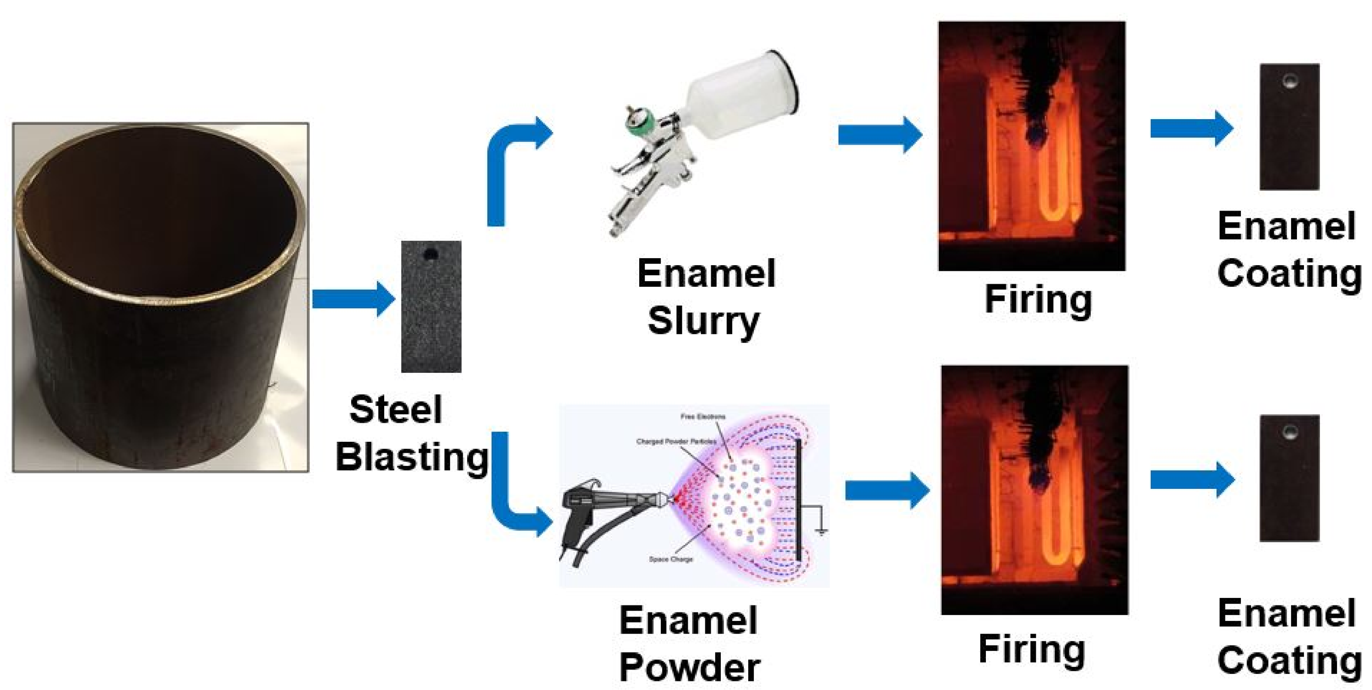

Figure 1. Enameling: wet vs. dry process.

Project Approach/Scope

- Optimization of enamel materials for durability and thermal compatibility with steel
- Enameling process for coating uniformity, low surface roughness, and efficiency
- Characterization of enamel coated pipes for microstructure, chemical adhesion on steel, and corrosion resistance
- Corrosion resistance of pipeline steel with damaged enamel coating and cathodic protection
- System performance of in-situ enamel coated pipelines - stress distribution under thermal effect, external and internal pressure
- Effect of cathodic polarization on the stress corrosion cracking (SCC) of enamel coated API X65 pipeline steel

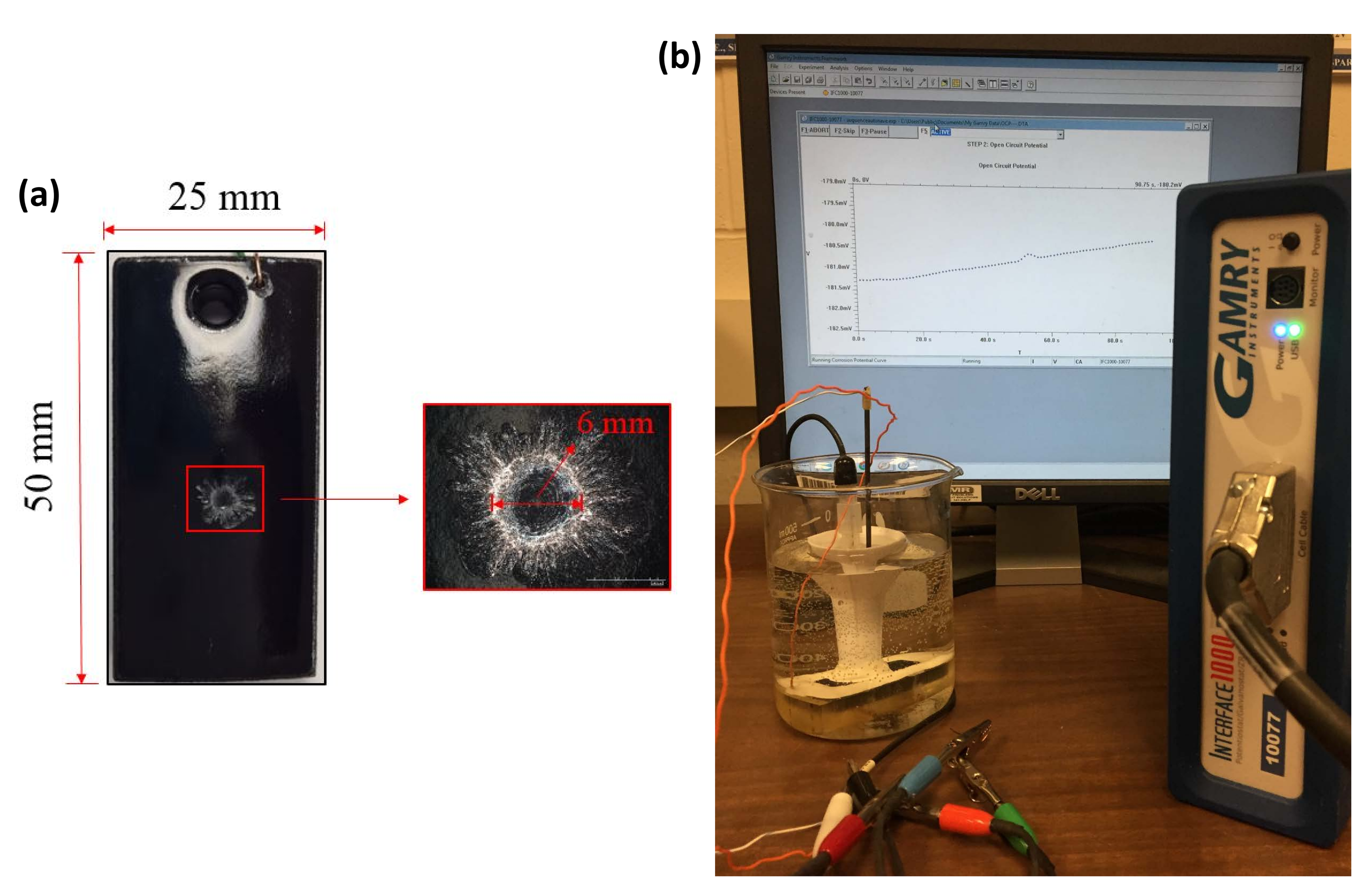

Figure 2. (a) Impact induced coating damage and (b) electrochemical tests with a two-cell set-up.

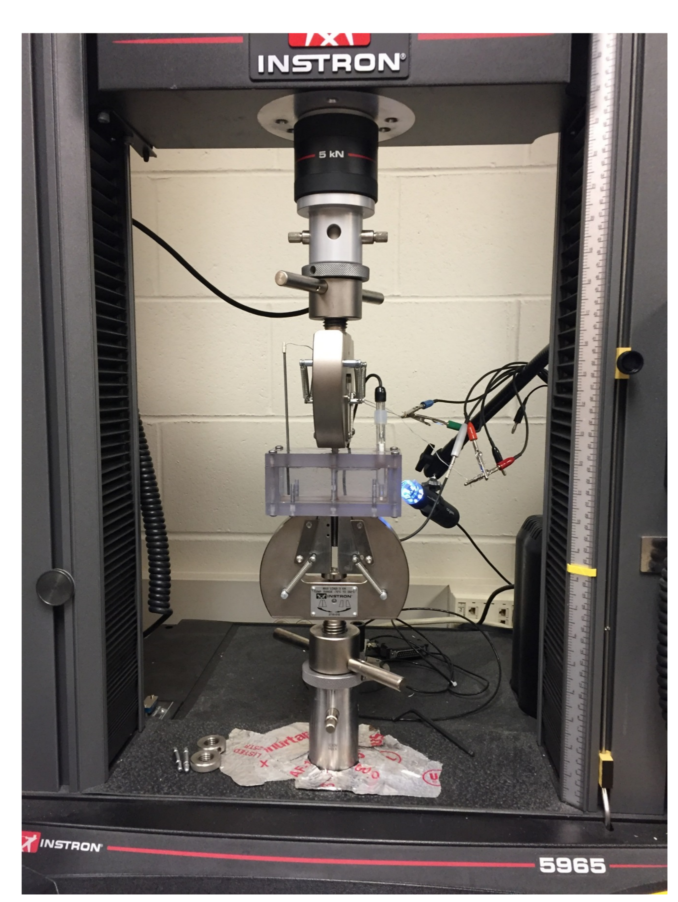

Figure 3. Glass autoclave and INSTRON tensile instrument used to perform slow strain rate tests.

Results to Date

- Cathodic protection (CP), when applied to decelerate the degradation process of enamel coating, does not compromise the integrity of bonding between the enamel coating and its substrate steel. Once the coating is damaged, however, CP does not improve the coating performance.
- The more negative the applied potential, the more susceptible the steel to SCC in the NS4 solution.
- The fracture surfaces of specimens tested in air include small dimples and micro voids, experiencing apparent necking and ductile failure. When tested at CP-1200 mV, the fracture surfaces do not show apparent necking, indicating cleavage fractures.

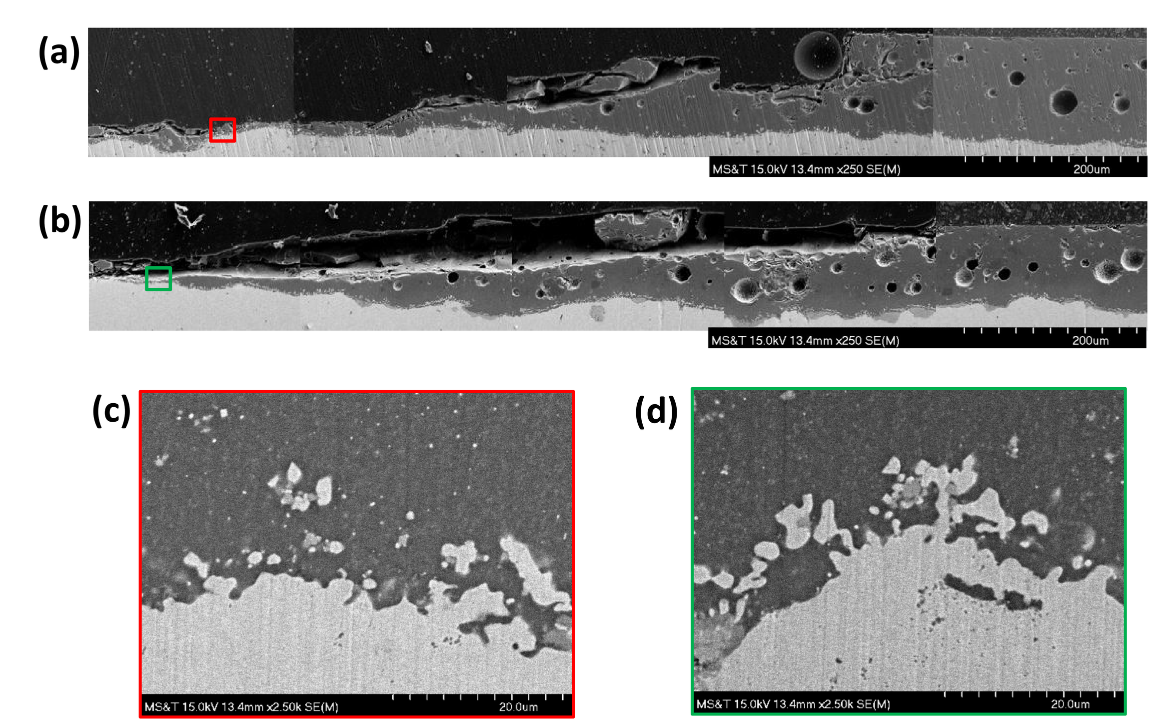

Figure 4. Cross-sectional SEM images of enamel coated samples under the OCP (a and c) and -1.15 V/SCE (b and d).

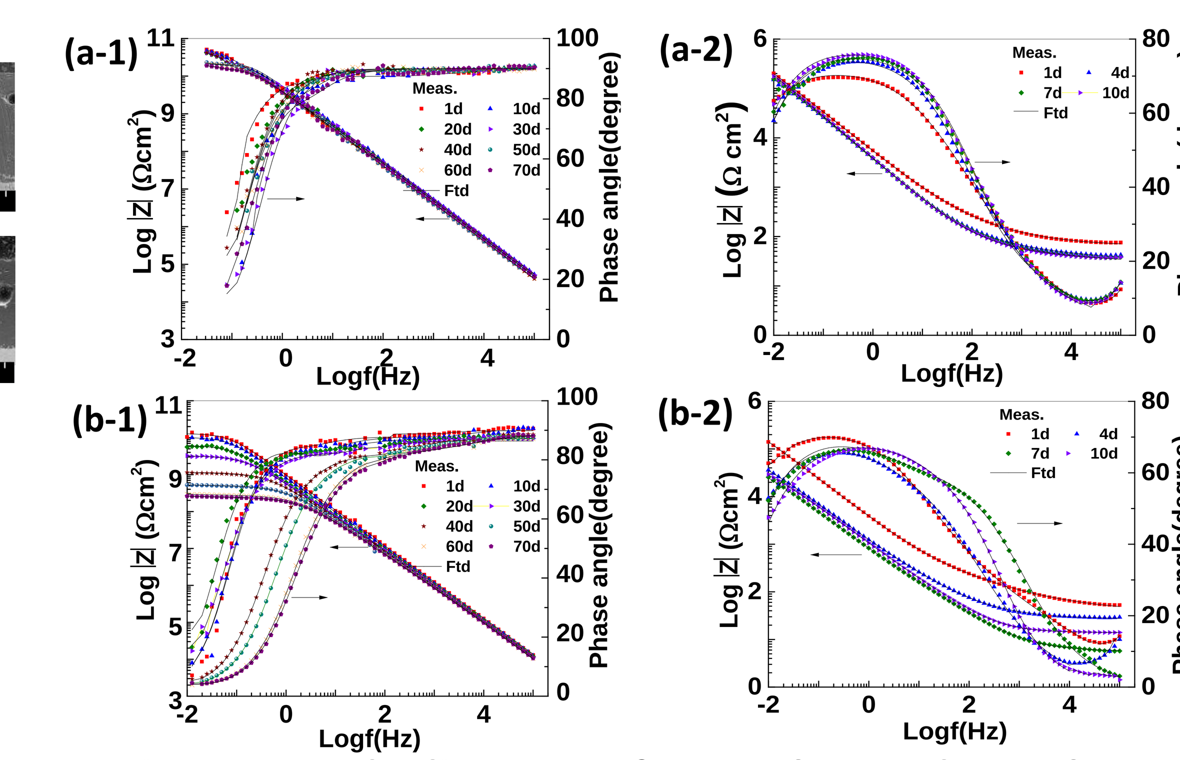

Figure 5. Bode diagrams of enamel coated samples at (1) intact coating zone, and (2) damaged coating zone under (a) CP -1.15 vs. SCE/V and (b) the OCP.

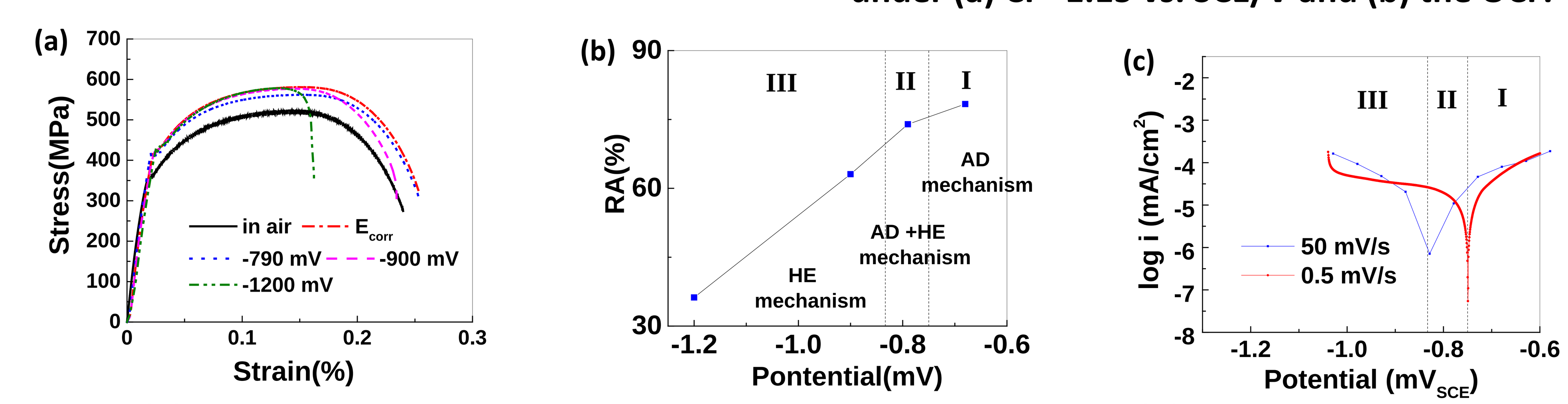

Figure 6. (a) Stress vs. strain curves obtained from slow strain rate tests, (b) reduction in cross-sectional area as a function of the cathodic potential, (c) polarization curves of the steel measured at high (50 mV/s) and low (0.5 mV/s) potential scanning rates in the NS4 solution.

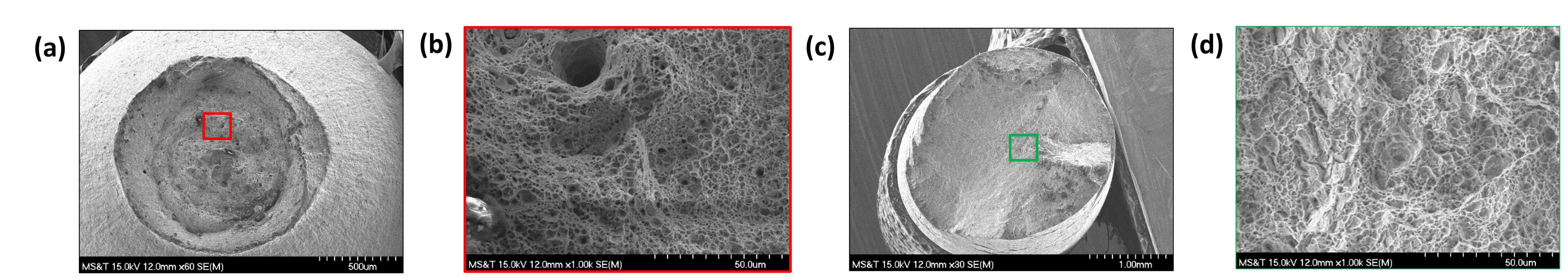

Figure 7. Surface fracture morphology of enamel coated X65 steel tested (a and b) in the air and (c and d) at CP -1200 mV after the slow strain rate tests.

Acknowledgments

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Public Project Page: https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=631