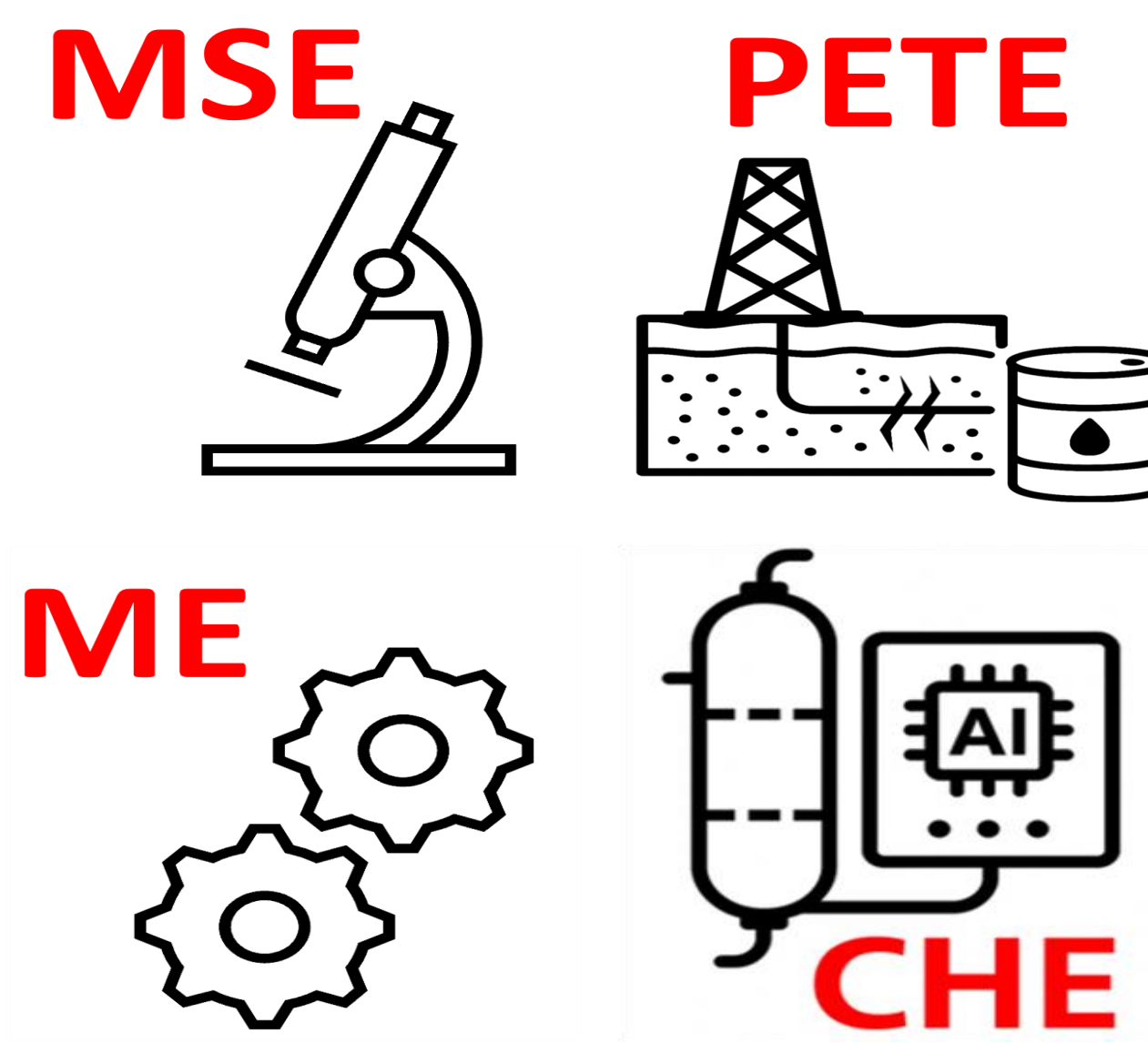


Self-Healing Protective Coatings for Corrosion Mitigation in Oil and Gas Production Systems

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Introduction

- Corrosion costs industry \$2.5 trillion/year; oil and gas pipelines and flanges are among the most affected assets
- Conventional epoxy coatings fail upon mechanical damage, requiring costly manual inspection and recoating
- Proposed solution: linseed oil + silica powder self-healing additive in Hempadur Mastic 45881 epoxy on Mitwalli Steel flanges
- Design target: corrosion rate ≤ 0.10 mm/y | Multidisciplinary team: CHE, ME, PETE, MSE

Prototype Design

- Substrate: Mitwalli Steel flanges (carbon steel) sandblasted to Sa 2.5; baseline coat: Hempadur Mastic 45881 epoxy
- Self-healing additive: linseed oil (healing agent) + silica powder / diatomaceous earth (carrier) blended into topcoat
- 6-coupon matrix: 3 baseline vs. 3 self-healing coupons, each scribed with controlled damage before immersion
- Healing mechanism: upon damage, linseed oil migrates to the scribe, oxidatively polymerizes, and autonomously seals the defect

Testing & Validation

- Immersion in 3.5 wt% NaCl solution simulating oilfield produced-water corrosive service conditions
- EIS quantifies coating barrier resistance over time; Tafel polarization extracts i_{x_0} °C to determine corrosion rate (mm/y)
- Healing efficiency: corrosion rate reduction ratio between healed and unhealed damaged coupons
- Self-healing coupons achieved corrosion rate below 0.10 mm/y, confirming autonomous protective healing

Conclusion

- Linseed oil / silica powder self-healing system met the ≤ 0.10 mm/y design target; confirmed via EIS and Tafel data
- Self-healing coupons showed significantly superior barrier performance vs. damaged baseline after scribing
- Autonomous healing reduces maintenance intervention and lifecycle cost; compatible with existing epoxy application workflows
- Future work: optimize linseed oil loading, test under H₂S/CO₂ sour service, and validate at full flange scale

Constraints	Specifications
Total prototype budget $\leq 5,000$ SAR (materials, test coupon)	Pull-off adhesion ≥ 10 MPa (ASTM D4541)
VOC content of coating ≤ 250 g/L; comply with local/REACH	Neutral salt spray (ASTM B117) ≥ 48 h
Healing chemistry must exclude restricted/banned substances	Usable pot life ≥ 30 minutes at 25 °C
Standard test coupon size 100 x 150 x 3 mm	Pressure < 5 bar
Total dry-film thickness (DFT) ≤ 200 μ m	Flow rate < 2 L/min
Surface preparation limited to Sa 2½ (SSPC-SP10)	Healing efficiency $\geq 90\%$ recovery of tensile strength
	Corrosion rate ≤ 0.10 mm/y in 3.5 wt% NaCl

