SERDP ♦ ESTCP SYMPOSIUM
2019 | Enhancing DoD's Mission Effectiveness
Washington, DC, December 3-5, 2019
Poster Number: 114

WP18-E1-1531
Pre-Demonstration Development of Controlled-Release Corrosion Inhibitors and Healing Agents as Alternatives to Hexavalent Chromium

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Introduction and Objectives

Transitioning to chromate-free coating systems for asset corrosion protection continues to be a significant challenge for the Department of Defense (DoD).

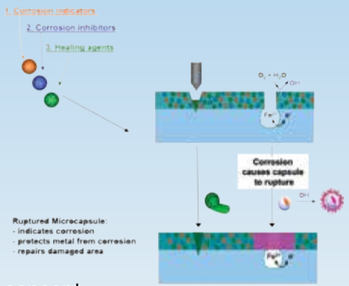
This Limited Scope Study was directed to achieve the following objectives:

(1) Scale-up of materials that can meet MIL-PRF-23377 (solvent-based primer).

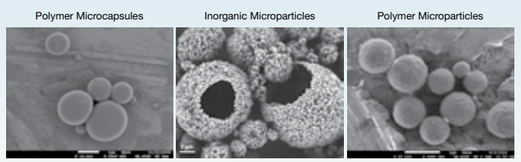
(2) Provide evidence of resistance to aircraft alkaline cleaners and de-icing fluids.

(3) Provide formulation for initial ecological and toxicity screening.

(4) Submit an interim report that will provide the basis for a future ESTCP demonstration effort.



Smart coating concept



Technical Approach

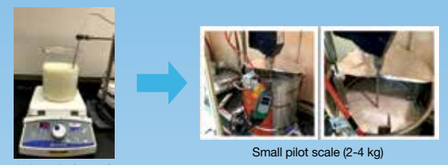
- Thorough assessment of the laboratory-scale process for two corrosion inhibitors to optimize: reaction conditions and duration; type and concentration of surfactant; duration and yield per batch.
- Evidence of resistance to alkaline cleaners and aircraft deicing fluids and compliance with MIL-PRF-23377 was gathered by replacing the inhibitor package, of an epoxy primer that meets the MIL-PRF-23377 requirements, with an encapsulated inhibitor and self-heling microcapsules. The properties of the primer formulation, that were expected to change, were tested to demonstrate that the primer still met the MIL-PRF-23377 requirements.
- Initial ecological and toxicity screening performed on formulation information.

Results

Summary of MIL-PRF-23377 compliance testing results

PRF-23377 requirement	Test	Coating Systems Test	Test Results 1	5	10	14
Physical properties – Paint before & after mixing	Fineness of grind	Primer Paint	N	N	Y	Y
	Accelerated storage stability	Primer Paint (10 only)	N/A	N/A	Y	N/A
	Viscosity	Primer Paint	N	N	Y	Y
	Pot life	Primer Paint	N	N	Y	Y
Physical properties - film	Surface appearance	Primer	Y	Y	Y	Y
	Drying time	Primer	N	N	Y	Y
	Adhesion	Primer: 1, 5 Primer and Topcoated: 10, 14	Y	Y	Y (primer) N (topcoated)	Y (primer) N (topcoated)
	Flexibility	Primer	Y	Y	Y	N
Resistance	Water	Primer: 1, 5 Primer and Topcoated: 10, 14	Y	Y	Y	Y
	Salt-spray corrosion	Primer: 1, 5 Primer and Topcoated: 10, 14	N	N	Y	Y
	Fil/form corrosion	Primer only: 1, 5 Topcoated: 10, 14	Y	Y	Y	Y
	Solvent (rare)	Primer	Y	Y	Y	Y
	Fluids: Lubricating oil hydraulic fluid	Primer	Y	Y	Y	Y
Working Properties	Mixing/dilution	Primer Paint	Y	Y	Y	Y
	Application	Primer Paint	Y	Y	Y	Y

Coating systems: 1 Polysulfide (fully inhibited); 5 polysulfide with 2.5 wt% self-healing microcapsules and 2.5 wt% 2-MBT micro particles; 10 Chrome-free primer (fully inhibited); 14 Chrome-free primer with 4.5 wt% self-healing microcapsules and 4.5 wt% 2-MBT microparticles.



Lab scale (grams)

Small pilot scale (2-4 kg)

Conclusions

- The encapsulation process for two corrosion inhibitors was scaled-up successfully to the target production of a small pilot scale (2.0-4.0 kg).
- Encapsulated corrosion inhibitor, 2-MBT, and self-healing microcapsules were incorporated into paint formulations.
- Paint formulation compatibilities of the chromate alternative materials were demonstrated using MIL-PRF-23377 testing as a guidance.
- Overall, the encapsulated inhibitors/healing agents showed excellent materials compatibility.
- Evaluation of primer formulations, that incorporated the encapsulated corrosion inhibitor, 2-MBT, and self-healing agents, provided evidence that the primer formulations met most of the MIL-PRF-23377 requirements. The only exception was the flexibility at high pigment loading. This result will be addressed with a further paint formulation effort.
- The epoxy primer formulations, with the chromate alternative materials, showed sufficient resistance to alkaline cleaners and aircraft deicing fluids.
- The epoxy primer formulations passed B117 when tested with chromate pretreatment, but failed when tested with PreKote non-chromate pretreatment. These test results will facilitate the formulation choice for the next epoxy primer optimization step before demonstration.
- The initial ecological and toxicity screening concluded that most of the proposed components are of low to moderate toxicity and are not a significant concern.
- A report was submitted to provide the basis for the follow-on ESTCP demonstration/ validation effort.

Project Team

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Acknowledgements

- Braxton B. Lewis and Robin A. Nissan, Strategic Environmental Research and Development Program (SERDP)

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SP-2019-10-3830-KSC