SSC Project Recommendation for FY 2016

Advanced Damage Responsive Coatings for Corrosion Protection of Ship Structures

1.0 OBJECTIVE.

1.1 The objective of this project is to develop novel damage responsive anti-corrosive coatings based on conducting polymers for ship structures such as hulls and ballast tanks with improved corrosion protectiveness and minimum maintenance requirements.

2.0 BACKGROUND.

2.1 Corrosion and corrosion-related issues are considered to be the most important factors leading to the structural degradation and even failures of ships, due to the highly aggressive environments the ships are exposed to (which consist of seawater with high salt content, high humidity, wet and dry cycles, UV light etc.). Anti-corrosive coatings have been commonly applied on metallic ship structures such as hulls and ballast tanks to provide corrosion protection and extend their service lives. Polymer coatings such as epoxy based paints are the most widely used and have shown excellent corrosion protective properties. However, despite the fact that regular maintenance and inspection operations have been conducted for corrosion control and monitoring of various ship structures, severe corrosion of hulls was found recently on two Canadian Navy ships - HMCS Iroquois and Preserver and has led to their early decommissioning [refs 8.1, 8.2]. This indicates that corrosion protection of ship structures remains a big challenge for the safety operation of navy ships to achieve their designed service lives. New generation of protective coatings that can self-diagnose and respond to damage and changes in the external environment is demanded.

2.2 Shortly after the discovery of inherently conducting polymers, DeBerry et al. demonstrated that such materials could anodically protect stainless steel in sulfuric acid by maintaining its potential in the passive region [ref 8.3]. Over the years, many conductive polymers have been developed and used for the fabrication of corrosion protective coatings [refs 8.4, 8.5]. Recent researches [refs 8.6, 8.7] have exhibited very promising results of conducting polymers such as polyaniline with better corrosion resistance than conventional polymer coatings for structural materials in marine environments. The corrosion protection was attributed to the increase in the resistance of the polarized conducting polymer film, and the corrosion inhibiting anion released by the conducting polymer while it becomes polarized through galvanic coupling to the base metal substrate at defects in the coating. The presence of releasable dopants in the conducting polymers makes them excellent candidates for damage-responsive coatings for the enhanced corrosion protection of ship structures with extended maintenance cycle and service life.

3.0 REQUIREMENTS.

3.1 Scope.

3.1.1 The Contractor shall identify appropriate conducting polymer materials that have the best corrosion protection performances and are cost effective and nonhazardous.

3.1.2 The Contractor shall conduct an assessment of protectiveness of the conducting polymer coatings versus the conventional epoxy polymer coating against corrosion in marine environments.

3.1.3 The Contractor shall characterize the material properties and corrosion protection mechanisms of the conducting polymer coatings, generating data and knowledge that can used for the optimization of coating application and corrosion monitoring operations for the ship structures with such coatings.

3.2 Tasks.

3.2.1 The Contractor shall conduct a literature review of previous researches and patents on conducting polymers for corrosion protection, and select the most promising candidate materials.

3.2.2 The Contractor shall conduct laboratory experiments to fabricate conducting polymer coatings on ship structure metals.

3.2.3 The Contractor shall conduct laboratory experiments assess the corrosion performances of metal samples with the selected conductive polymer coatings versus those with the conventional epoxy coating, using accelerated corrosion testing methods that best mimic the service environments of ship structures.

3.2.4 The Contractor shall investigate the corrosion mechanisms of the metal samples with conducting polymer coatings utilizing advanced materials characterization and surface analysis techniques such as laser profilometer, SEM/EDS, TEM and FIB.

3.2.5 The Contractor shall analyze all experimental data and prepare reports to Ship Structure Committee.

3.3 Project Timeline.

Task	Task	Q1	Q2	Q3	Q4
3.2.1	Literature review and identify appropriate conducting polymer materials				
3.2.2	Laboratory experiments of fabricate polymer coatings on metal samples				
3.2.3	Laboratory accelerated corrosion testing of coated metals				
3.2.4	Materials characterization and surface analysis of corrosion samples and investigation of corrosion mechanisms				
3.2.5	Assess outcomes and write final report				

4.0 GOVERNMENT FURNISHED INFORMATION.

4.1 Standards for the Preparation and Publication of SSC Technical Reports.

5.0 DELIVERY REQUIREMENTS. (Identify the deliverables of the project).

5.1 The Contractor shall provide quarterly progress reports to the Project Technical Committee, the Ship Structure Committee Executive Director, and the Contract Specialist.

5.2 The Contractor shall provide a final report detailing literature review results, experimental procedures and data, analysis results, and mechanism discussions.

5.3 The Contractor shall provide a print ready master final report and an electronic copy, including the above deliverables, formatted as per the SSC Report Style Manual as posted on the website http://www.shipstructure.org.

6.0 PERIOD OF PERFORMANCE.

6.1 Project Initiation Date: date of award.

6.2 Project Completion Date: *12* months from the date of award.

7.0 GOVERNMENT ESTIMATE. These contractor direct costs are based on previous project participation expenses.

7.1 Project Duration: *12* months.

7.2 Total Estimate: $ 95,000.

7.3 The Independent Government Cost Estimate is attached as enclosure ($ 95,000).

8.0 REFERENCES.

8.1 D. DeBerry, J. Electrochem. Soc. 132, (1985)1022 .
8.2 M.I. Khan, A.U. Chaudhry, S. hashim, M.K. Zahoor, M.Z. Iqbal, Chem. Eng. Res. Bull. 14, 73 (2010) 73.
8.3 T. Ohtsuka, International Journal of Corrosion (2012) 7.
8.4 G.M. Spinks, A.J. Dominis, G.G. Wallace, D.E. Tallman, J. Solid State Electrochemistry 6 (2002) 85.
8.5 P. Sambyal, G. Ruhi, R. Dhawan, S.K. Dhawan, Surface & Coatings Technology (2015) in press.

NOTE:

- Please do not submit any proprietary information in this outline. This will be posted on the SSC Website regardless if the project is selected to be funded.