Development of New Protocols for Testing Pipeline Coating Performance

Canada's natural resources play an important role in the Canadian economy and a significant amount of our revenue is generated by exporting energy. Canada is the 5th largest natural gas producer in the world [1, 2] and it is predominantly produced from Western Canada. To serve the export markets in the northwest coast of B.C., new pipelines or expansion of existing pipelines are proposed in the B.C. areas [3]. These pipelines will encounter a variety of tough environments such as cold rough terrain (Figure 1), corrosive (Figure 2) and abrasive rocks in areas of the Rockies. To ensure safe reliable operation of pipeline in these areas, especially with the potential for interaction with acid generating rocks, it is crucial to select a fit-for-purpose pipe coating system. Shawcor Ltd., a Toronto-based company and global leader in pipeline coatings and related pipeline services, is interested in developing new cathodic disbondment test (CDT) methods to assess the performance of its external coating products in rocky and acid rock generating areas.

Figure 1. Pipeline construction – laying pipes in cold mountainous or rocky terrain.

Figure 2. Rocky areas with pyrite ores – acid rock drainage.

Supported by an NSERC Engage Grant, this research project was conducted by Dr. Min Xu in Professor Edouard Asselin's group in the Department of Materials Engineering. Using an overhead agitator to suspend sulphide minerals above the coating samples, UBC researchers have developed a way to incorporate both mechanical damage and acidification effects into the CDT. A schematic drawing of the experimental setup is presented in Figure 3. The new protocol developed offers the advantage of studying impact, abrasion, resistance to acids and cathodic disbondment simultaneously, which allows for accelerated testing of coating performance in rocky areas where acid may be generated.

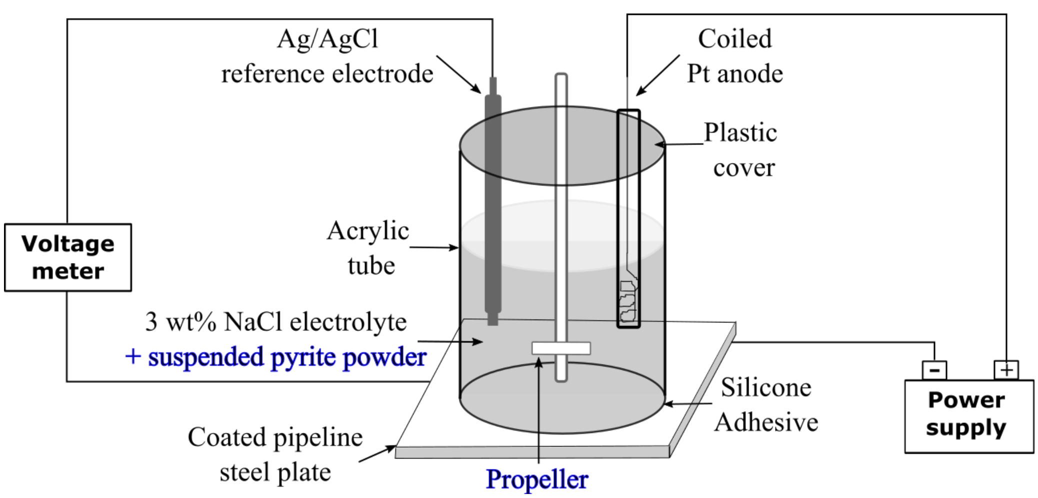

Figure 3. A schematic drawing of the modified CDT setup for attached cell method.

With this new protocol, the performance of two coating systems, i.e., a fusion bonded epoxy (FBE) and a high performance powder coating (HPPC) was examined and compared. A systematic study was performed to reveal the coating resistance to physical abrasion, water penetration and cathodic disbondment during a 28-day test. Figures 4 and 5 show the comparison of results obtained from the conventional CDT as per NACE TM0115-2015 and the modified CDT with the acidic electrolyte to simulate the burial environments in rocky areas with pyrite ores. In the case of FBE, the disbondment radius obtained from the acidic electrolyte (Figure 4b) was at least 2 folds larger than those obtained from the conventional CDT with 3% NaCl electrolyte (Figure 4a). In contrast, in the case of HPPC, no significant difference was observed between the conventional electrolyte and acidic electrolyte as shown in Figure 5. Under the same modified CDT conditions, HPPC exhibited smaller cathodic disbondment than FBE at both room temperature (RT) as shown in Figure 6 and at elevated temperature of 65 °C. These results indicated that HPPC is a more robust coating system under acidic environments, such as the areas with pyrites in the Rockies.

Electrochemical Impedance Spectroscopy was carried to assess the barrier properties (i.e., the ability of isolating the external environmental factors such as water, oxygen, and other corroding species from reaching the steel interface) of the two coatings exposed to acidic electrolyte at RT at different durations. As shown in Figure 7, HPPC exhibits higher coating impedance than that of FBE, and the decrease in coating impedance is more pronounced for FBE. These results again showed that HPPC is a more robust coating system than FBE.

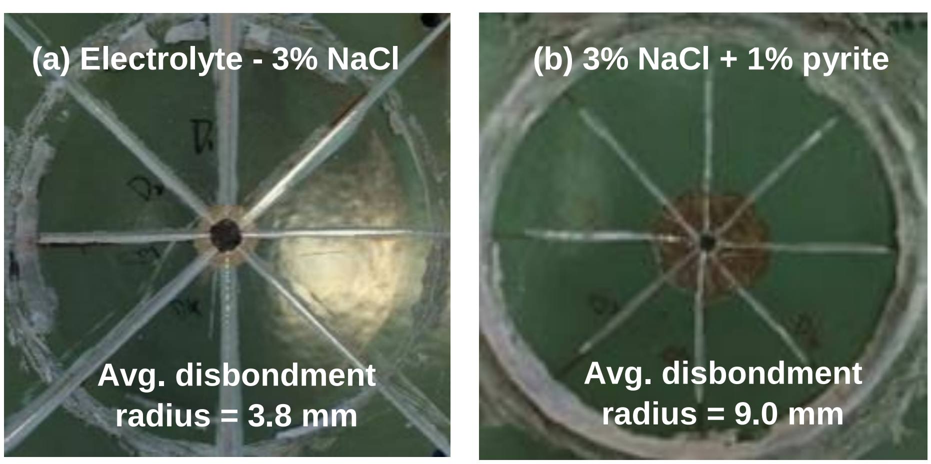

Figure 4. 28-day RT CDT results for FBE.
(a) Conventional electrolyte vs. (b) Acidic electrolyte

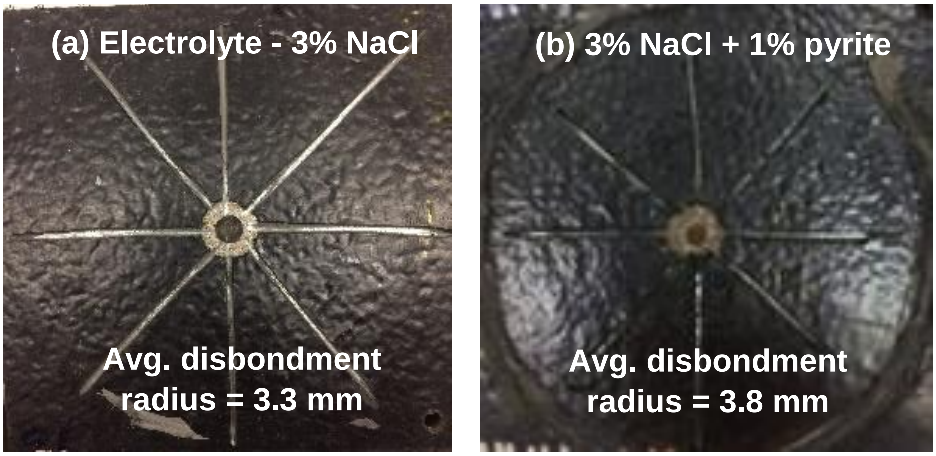

Figure 5. 28-day RT CDT results for HPPC
(a) Conventional electrolyte vs. (b) Acidic electrolyte.

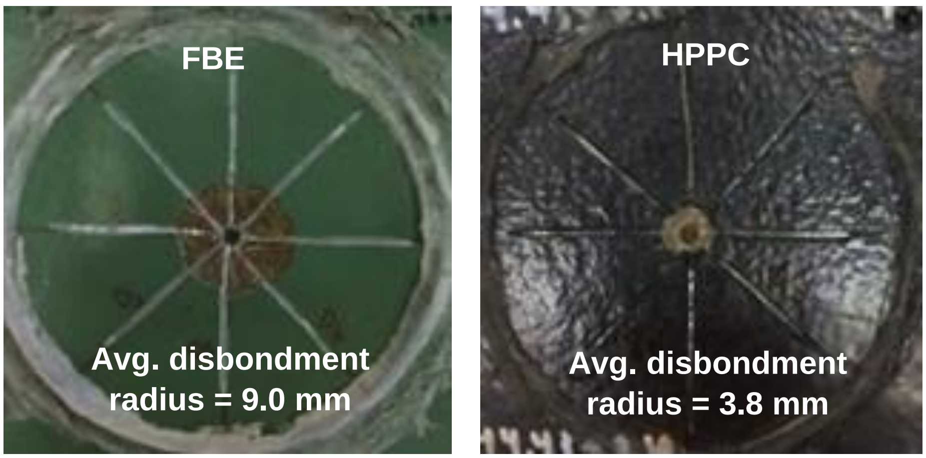

Figure 6. Comparison of 28-day RT modified CDT results for FBE and HPPC samples.
[Electrolyte: 3% NaCl + 1% pyrite powder; Overhead stirring speed: 1400 rpm]

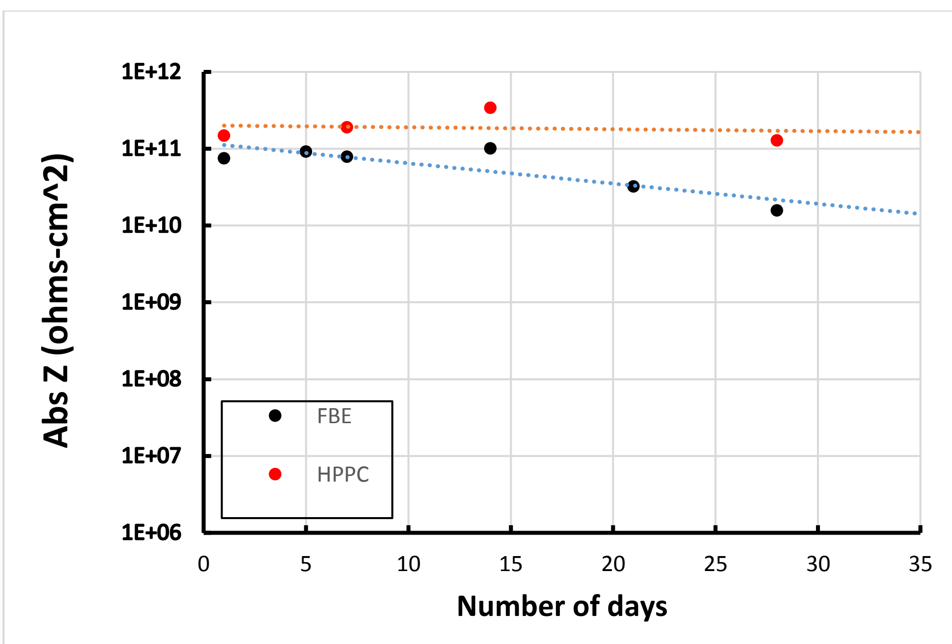

Figure 7. Comparison of the coating impedance at RT for FBE and HPPC samples (without a holiday).

This work has also facilitated the development of an NSERC Collaborative Research and Development (CRD) project, initiated in September 2017, which has the broader research scope of evaluating and improving the performance of field joint coatings as well as internal and external pipe coatings.

References:

[1] **Canadian Association of Petroleum Producers** – http://www.capp.ca/canadian-oil-and-natural-gas/natural-gas

[2] **Government of Canada, National Energy Board** – https://www.neb-one.gc.ca/nrg/sttstc/ntrlgs/index-eng.html

[3] **British Columbia Government, LNG in BC** – https://lnginbc.gov.bc.ca/pipelines/