CAAP Quarterly Report

Date of Report: *Mar. 31th, 2019*

Contract Number: *DTPH56-16-H-CAAP03*

Prepared for: *U.S. DOT Pipeline and Hazardous Materials Safety Administration*

Project Title: Development of New Multifunctional Composite Coatings for Preventing and Mitigating Internal Pipeline Corrosion

Prepared by: *North Dakota State University*

Contact Information: *Mr. Xingyu Wang, PhD student, Email: xingyu.wang@ndsu.edu, Phone: 701-231-7204; Miss. Mingli Li, PhD student, Email: mingli.li@ndsu.edu, Phone: 701-231-7204; Dr. Zhibin Lin, Email:zhibin.lin@ndsu.edu, Phone: 717-231-7204; Dr. Dante Battocchi, Email: Dante.Battocchi@ndsu.edu, Phone: 701-231-6219; Dr. Xiaoning Qi, Email: xiaoning.qi@ndsu.edu, Phone: 701-231-6464*

For quarterly period ending: *Mar. 31th, 2019*

Business and Activity Section

(a) Generated Commitments

Some purchase for nanoparticles

One conference full paper in ASCE Pipeline 2019 in July and another conference full paper in BEI-2019 in July were accepted.

(b) Status Update of Past Quarter Activities

The research activities in the 10th quarter continuing efforts by characterizing the nano-modified coatings and assess their long-term performance, as summarized below.

10.1 Objectives in the 10th Quarter

The modified epoxy resin has revealed a significant improvement in hydrophobicity.

To achieve the purpose of developing a multifunctional coating system, the study of the nano-modified epoxy has been conducted. A more comprehensive experimental study was proposed to evaluate the long-term performance in this report.

10.2 Experiment design

The plan of the experimental study was included:

i. Characterization of the nanofiller system and the results were used to support the beneficial properties of incorporating nanofillers into polymeric coating system.
ii. Long-term test to evaluate the sustainability of the developed multifunctional coatings.
iii. Flow instrument preparation, and the designed testing method will be applied in the future study.

10.3 Results

10.3.1 Characterization of nanofillers and nanocomposites

(a) X-ray powder diffraction (XRD)

The XRD results were conducted to demonstrate the degree exfoliation of various fillers. The interlayer spacing of the nanofillers could be calculated based on the diffraction peak angle and wavelength by utilizing Bragg's law Equation.

(b) Coupon tensile test

The analysis of tensile properties for the developed coatings was determined by the coupon tensile test, including the maximum tensile stress, strain at failure, and Young's modulus. The overall results indicated that the modification with nanoparticles could significantly improve their tensile properties.

(c) Corrosion barrier performance during salt fog test: EIS

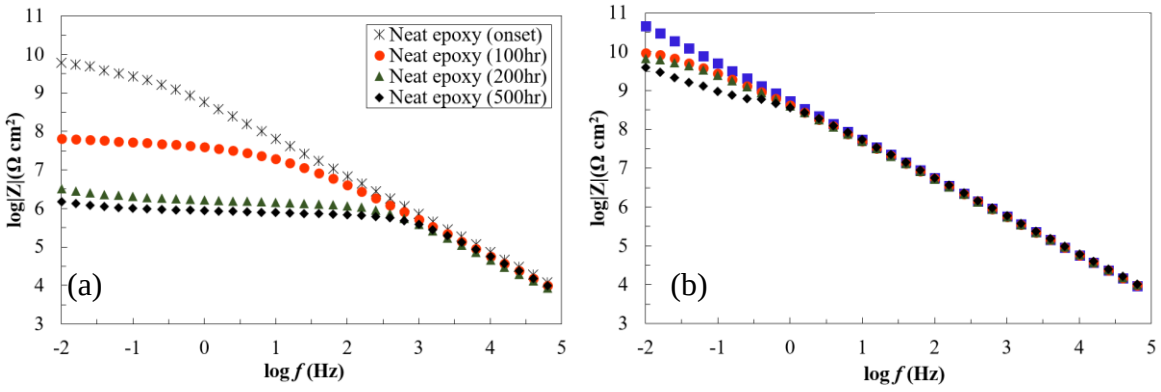

Figure 1 Bode curves of (a) the neat epoxy and (b) modifiled coating

The long-term performance of the coatings showed that the modified coatings (see Fig. 1b) have excellent barrier properties, as compared to the neat epoxy (see Fig. 1a). In the low-frequency region, the phase

angle of the neat epoxy group has dropped very closed to 0 degrees even after 100 hours. On the other hand, the value of phase angle in the low frequency maintained much higher in the new coatings.

(d) Adhesion during salt fog test: pull-off strength

From the previous study, it was worth to notice that the incorporation of nanofillers has decreased the adhesion strength of neat epoxy resin. However, no significant reduction in adhesive strength was observed in the new coatings.

On the purpose of studying the effect on hydrophobicity during the coating damage process, the contact angle for the coatings was measured at 0, 100, 200, and 500 hours as well.

10.4 Summary

- The results from tensile test revealed that the modified coatings could dramatically increase the strength, strain, and Young's modulus.
- The corrosion resistance, hydrophobicity, and adhesion tests were performed and their results have confirmed the improvement in the new coatings.

(e) Description of any Problems/Challenges

No problems are experienced during this report period

(f) Planned Activities for the Next Quarter

The planned activities for next quarter are listed below:

- The design and fabrication of instrument for the long-term test will be focused, so the performance of the developed coatings could be evaluated more comprehensively.