CAAP Quarterly Report

July 6, 2023

Project Name: Selection and Development of Safer Polymer and Composite Pipeline Liners through Microstructural and Macroscopic Study of Materials and Designs

Contract Number: 693JK32250001CAAP

Prime University: Brown University

Prepared By: Ryan Poling-Skutvik, Edith Mathiowitz, and Vikas Srivastava

Ryan Poling-Skutvik, Ph.D.
Email: ryanps@uri.edu
Phone: 401-874-2627

Edith Mathiowitz, Ph.D.
Email: Edith_Mathiowitz@brown.edu
Phone: 401-863-1358

Vikas Srivastava, Ph.D.
Email: vikas_srivastava@brown.edu
Phone: 401-863-2863

Reporting Period: April 01, 2023 – June 27, 2023 (Q1)

Project Activities for Reporting Period:

This is the first quarter where the research project was kicked off and initiated. The work focused on conducting literature reviews. A literature review of polymer aging, polymer chemistries and developing a procedure to age the liner polymers was initiated. The literature review has also been conducted on studying damage models and theory for liner-like materials. A preliminary literature review of polymers commonly used in liners with a focus on DSC, XRD and polarized light experimental characterization methods was conducted.

Currently, early experimentation research has been initiated and is ongoing, which includes 2D-XRD of polyvinyl chloride and polyethylene samples after being subjected to high temperatures over different time periods. Commercially available PVC and PE pipes were purchased, and DSC experiments and analysis of material samples from these pipes have been initiated. These studies are conducted as a source of preliminary observations of morphological changes before exposure to aging conditions. At URI, coordination work for the installation of compressed natural gas at different realistic compositions for this project has begun. This gas will be used to fill pressure vessels in which to age the polymer liners. The appropriate three-point bending geometries to conduct the described micromechanical measurements have been investigated. In addition to the partial help from the current students, all three faculty have successfully recruited one new Ph.D.

graduate student to start working on this project starting in August. The students are new Ph.D. and will start their first year in the fall. These students have relevant experience and will be further learning and conducting polymer microscopic and macroscopic characterization experimental and damage theory and modeling research.

Project Financial Activities Incurred during the Reporting Period:

Polymer samples were purchased for preliminary tests. Purchase orders on preliminary polymeric samples relevant for natural gas deliveries and pressure vessels for aging behavior have been initiated. Graduate support and fractional PI summer salaries were used.

Project Activities with Cost Share Partners:

Partial support for Co-PI salary and partial support for graduate students was provided as per the cost share agreement. A three-point bend test fixture was procured using one of Brown's internal funding mechanisms (this is an additional leverage beyond the cost share) that could be used for future experimentation in this project.

Project Activities with External Partners:

As part of the literature review process, Co-PI Poling-Skutvik traveled to the ACS Colloids and Surface Science Symposium held at North Carolina State University from June 4-7 where he attended talks and participated in discussions on polymer phase behavior, composite properties, and polymer rheology. The PIs also had an online meeting to discuss the pipeline liner needs and research ideas with key representatives from Plastics Pipe Institute, Flex Steel Pipe and Dow Chemicals.

Potential Project Risks:

One of the primary risks and challenges facing aging and micromechanical tests is the long sample preparation times. This risk is being mitigated by active communication and planning amongst all PIs to determine the quantity and size of materials that will be subjected to the aging process. This process will then be conducted by Co-PI Poling-Skutvik to provide uniform samples for characterizations by co-PIs Poling-Skutvik, Mathiowitz, and Srivastava. The polymers have complex and varying microstructures. The research findings for liner polymer materials will be new, and there could be a risk of unanticipated new findings. This risk will be managed by adjusting the research methods as new data comes.

Future Project Work:

In the next quarter, we aim to acquire the gas compositions for installation within the laboratory at URI. The pressure vessels and ovens will also be installed in the next several months at the URI facility to begin sample aging. The recruited graduate students will begin work on this research project within a few months. The dog-bone samples for micromechanical analysis will be prepared using a hydraulic press, aging the polymers within the pressure vessels, and conducting three-point bending dynamical mechanical analysis. The development of a theoretical framework to develop damage models for liner polymers will start.

Presently, commercially available pipes were purchased, and thermal analysis, as well as X-ray diffraction, was conducted prior to starting the accelerated aging experiments. In the coming quarter, the aging temperature will be determined by two parameters, the glass transition and the melting point of the different polymers used in the pipes. Aging tests will be initiated and the aging will be done between the glass transition and at least 10 degrees below the melting point. Some aging in certain polymers may occur at lower temperatures as well, and to understand this, aging studies for such polymers will be done at temperatures below the glass transition.

Potential Impacts to Pipeline Safety:

The fundamental understanding of liner materials' response, materials database, and material and design guidelines obtained through this collaborative research and the successful outcome of this research will help increase liner materials and design combinations for safer pipelines.