

**Transportation Infrastructure Precast Innovation Center**

**(TRANS-IPIC)**

**University Transportation Center (UTC)**

*Desing, Manufacturing, and Characterization of Fiber Reinforced Shape Memory Polymer Rebars*

*[LS-23-RP-01]*

Quarterly Progress Report

For the performance period ending December 31, 2023

**Submitted by:**

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**Collaborators / Partners:**

None

**Submitted to:**

TRANS-IPIC UTC

University of Illinois Urbana-Champaign

Urbana, IL

**TRANS-IPIC Quarterly Progress Report:**

**Project Description:**

1. Research Plan - Statement of Problem

*The objective of this one-year project is to design, manufacture, and tension program fiber reinforced shape memory polymer (FRSMP) rebars and test their shape memory effect. A total of five tasks were proposed. Task 1. Selection of SMP matrix. Task 2. Selection of glass fibers. Task 3. Manufacturing of FRSMP rebars. Task 4. Programming of FRSMP rebars. Task 5. Recovery stress testing.*

1. Research Plan - Summary of Project Activities (Tasks)

*Task 1. Selection of SMP matrix. Selection of a thermoset shape memory polymer that has good shape memory effect and higher recovery stress is ongoing. Through a comprehensive literature survey, a very tough shape memory polymer (SMP), which is made of an epoxy resin diglycidyl ether of bisphenol A (DGEBA) cured by isophorone diamine (IPD), is selected as the candidate SMP matrix. A systematic study has been conducted previously in our lab on this SMP [1]. The reason that the PI selects this SMP is that several follow-up studies have been conducted in the PI’s lab and in other labs on this SMP network [2-5]. In the next step, we will add nanoparticles such as nanoclay to further enhance its recovery stress [6]. Because the subcontract has not been established at Louisiana State University (LSU), the PI was unable to hire the planned students and postdoc to work on the project. The PI expects that the subcontract will be established soon so that the nanoparticle reinforced SMP study can be conducted.*

**Project Progress:**

1. Progress for each research task

*Task 1 progress [50% completed]*

*Task 2 progress [0% completed]*

*Task 3 progress [0% completed]*

*Task 4 progress [0% completed]*

*Task 5 progress [0% completed]*

1. Percent of research project completed

*As mentioned above, because the subcontract has not been established at LSU, the PI was unable to hire the planned students and postdoc to work on the project. It is expected that the subcontract will be established soon so that the progress can be accelerated.*

1. Expected progress for next quarter

*Depending on when the subcontract will be established at LSU, the progress cannot be forecast at this moment.*

1. Educational outreach and workforce development

*Nothing to report.*

1. Technology Transfer

 *Nothing to report.*

**Research Contribution:**

1. Number of papers

*None.*

1. Number presentations (when, where)

*None.*

**References:**

1. J. Fan and G. Li. High Enthalpy Storage Thermoset Network with Giant Stress and Energy Output in Rubbery State. *Nature Communications*, 9: 642, (2018).
2. C. Yan and G. Li. A mechanism based four-chain constitutive model for enthalpy driven thermoset shape memory polymers with finite deformation. *Journal of Applied Mechanics-Transactions of ASME*, 87: 061007, (2020).
3. C. Wick, A. Peters, and G. Li. Quantifying the contributions of energy storage in a thermoset shape memory polymer with high stress recovery: a molecular dynamics study. *Polymer*, 213: 123319, (2021).
4. R. Mahmudzade, P. Nikaeen, W. Chirdon, A. Khattab, D. Depan. Photodegradation mechanisms and physico-chemical properties of EPON-IPD epoxy-based polymers. *Reactive and Functional Polymers*, 178: 105351, (2022).
5. T. Zaman, L.T. Mambiri, P. Nikaeen, J.A. Chauhan, D. Depan, A. Khattab, W.M. Chirdon. Artificial weathering and physico-chemical characterization of EPON-IPD thermosets with high enthalpy storage of shape memory. *Polymer Degradation and Stability*, 215: 110421, (2023).
6. G. Ji and G. Li. Effects of Nanoclay Morphology on the Mechanical, Thermal, and Fire-Retardant Properties of Vinyl Ester Based Nanocomposite. *Materials Science and Engineering A*, 498: 327-334, (2008).