Hybrid hemp/glass fiber reinforced high-temperature shape memory photopolymer with mechanical and flame retardant analysis

S. Mahmud, J. Konlan, J. Deicaza and G, Li, Louisiana State University

Award Title:	RII Track -1: Louisiana Materials Design Alliance (LAMDA)
NSF Award Number:	NSF OIA-1946231
Principal Investigator:	Michael Khonsari
Lead Institution Name:	Louisiana State University
Award Start Date:	August 1, 2020
Award End Date:	June 30, 2025
Highlight Submission Date:	February 28, 2024

What is the outcome or accomplishment? (1-2 short sentences describing it and why it is transformative; 50-word maximum suggested)*

LAMDA developed the concept of hybrid hemp/glass fiber reinforced high-temperature shape memory composite utilizing readily available natural fibers and flame retardant polymer matrix for sustainable and environmentally friendly manufacturing. Using this concept, we synthesized, tested, characterized, a shape memory polymer (SMP) hybrid composite. The effect of the natural fibers and flame retardant photocurable SMP is also studied.

What is the impact? (1-2 simple sentences describing the benefits for science, industry, society, the economy, national security, *etc.*; suggested 50-word maximum)

This study utilized cultivated natural fibers and synthetic glass fibers as reinforcement for a flame retardant SMP matrix to achieve a lightweight composite. The synthesis used in this study is economical and environmentally friendly because it uses UV irradiance under 35% intensity (232 nm, ~45 mW/cm^2) in just 40 s at room temperature. The hybrid composite exhibited good shape memory properties, with atleast 52% shape fixity, 71% shape recovery and 24 MPa recovery stress. The findings of this study present exciting prospects for utilizing low-strength and flammable natural fibers in multifunctional load-bearing composites that possess both flame retardancy and shape memory properties.

What explanation/background does the lay reader need to understand the significance of this outcome? (1-2 paragraphs that might include, for example, more on who, when, where; NSF's role; support from multiple directorates/offices; what makes this accomplishment unique; additional intellectual merits; or broader impacts such as education, outreach, or infrastructure improvement that are integral to this outcome; suggested 150-word maximum)

Shape memory polymers (SMPs) are a type of polymer that can be stimulated using heat, light, electric current, or other similar forms of energy, to release stored energy in doing work by changing their shape. They are broadly used in different industries, including space exploration, aerospace applications, automobile, naval and many more. The hybrid hemp/glass shape

memory composite can be used in load-bearing applicationsand environments with harsh temperature environments due to their characteristic flame retardancy characteristics.
For example, when used as load-carrying member in satellite for space application, it can be programmed to store mechanical energy and released it later in space when needed to do work by shapeshifting from one form to another. Also in case of fire accident, the composite can help quench the fire from growing and as a result protect the electronic components of the satellite.

Dr. Li and his group have previously developed a novel flame retardant high temperature SMP with excellent shape memory properties and flame retardancy. Based on this novel SMP, LAMDA researchers, supported by NSF, fabricated a hybrid natural fiber-synthetic composite. Even with a significant proportion of natural hemp fibers (hRFP), the mechanical properties of the hybrid composites were close to those reinforced solely with glass fibers (G). This will facilitate design and sustainable manufacturing of light weight structures for engineering applications.

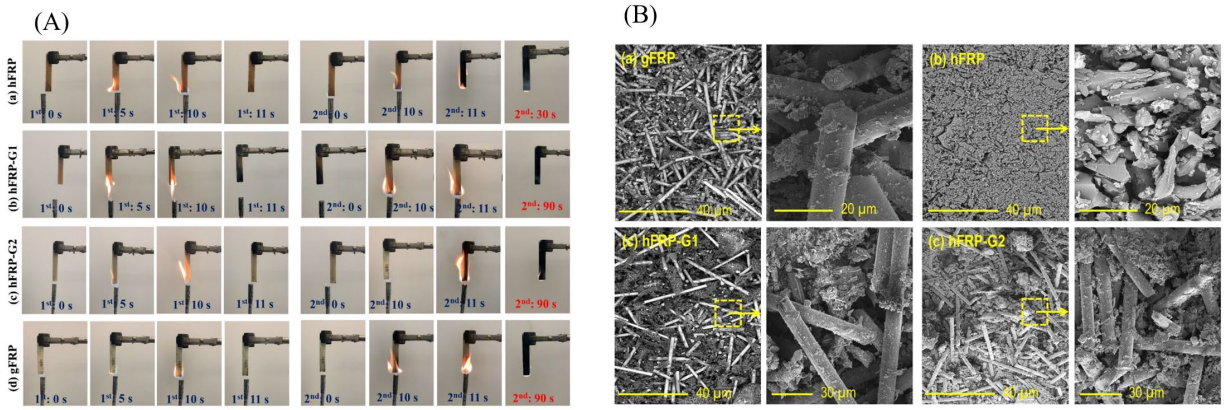

Fig. (A) Vertical ignition test of (a) hFRP, (b) hfrp-G1, (c) hFRP-G2, and (d) gFRP, where G1, G2 symbolise 1 and 2 layers of synthetic glass fibers used in the hypbid
(B) SEM images of char redues of (a) Gfrp, (b) hFRP, (c) hFRP-G1, and (c) hFRP-G2 laminate composites