Coir/glass hybrid fiber reinforced thermoset polymer composite laminates with room-temperature self-healing and shape memory functions

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

We propose the concept of hybrid coir/glass room-temperature self-healing and shape memory composite utilizing readily available natural fibers and room-temperature facile polymer matrix for sustainable and environmentally friendly manufacturing. Using this concept, we synthesized, tested, characterized, a shape memory polymer (SMP) hybrid composite with self-healing capabilities. The effect of the natural fibers, synthetic glass fibers and the room temperature self-healabble SMP is also investigated.

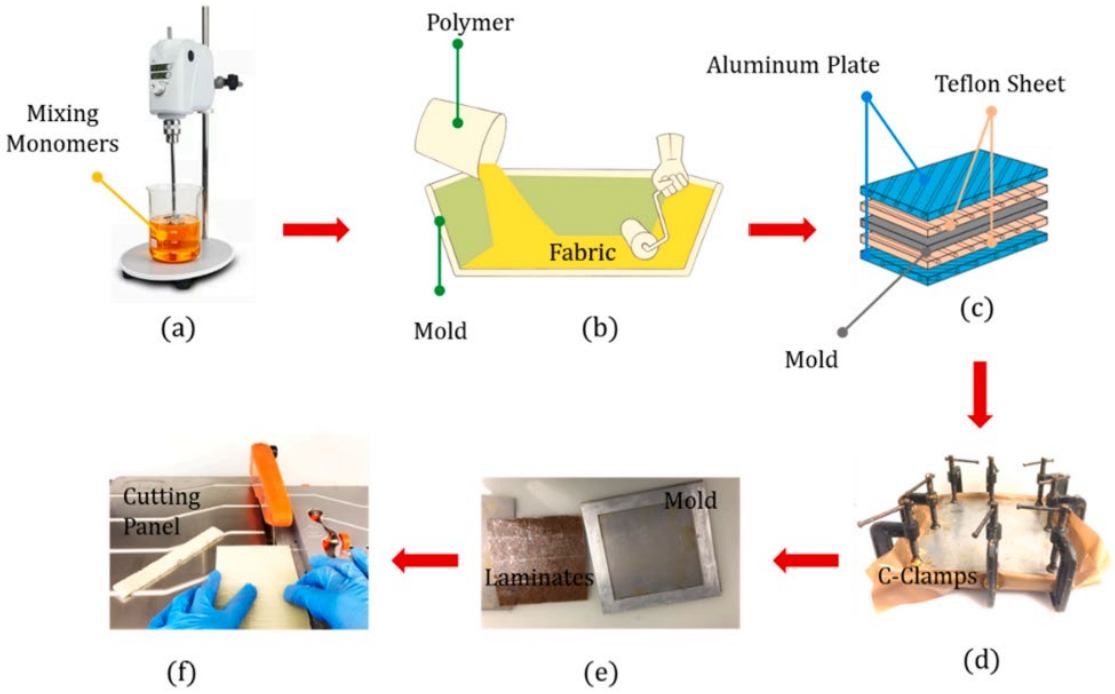
What is the impact? (1-2 simple sentences describing the benefits for science, industry, society, the economy, national security, *etc.*; suggested 50-word maximum)

This study employed cultivated natural coir fibers and synthetic glass fibers as reinforcement for a room temterature SMP matrix to achieve a lightweight and self-healable composite system. The laminated hybrid composite system showed similar mechanical properties compared with the samples with the synthetic glass fiber reinforcement even when a significant portion of coir fibers were used in the fabrication. Delamination and matrix cracks induced by low velocity impact inside the composite panels were repeatedly helaed at room-temperature due to the self-healing capability of the diglycidyl 1,2-cyclohexanedicarboxylate (DCN) and polyethylenimine (PEI) polymer matrix. The healing efficiency was up to 99% for the first healing cycle and 72% for the fourth healing cycle. This study opens new opportunities for manufacturing light weight structures which can have extended lifetimes for engineering applications and also meeting the sustainable manufacturing goals.

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.
Self-healing polymers are materials that have the ability to repair damage autonomously , mimicking the healing process found in living organisms. They can repair small cracks, delaminations, scratches and other types of damage without the need for external intervention. The hybrid coir/glass shape memory composite can be used in load bearing applications and also possess the tendency to mitigate damage by self-healing should the need arise.For example when used as loadcarrying member in a satellite or other space artefact it can restore the load carrying capacity to about 99% when damaged and repeat the process till the fourth time where it can still provide 72% of the load carrying capacity.

Dr. Li and his group have previously developed a novel room temperature-self healable shape memory polymer with outstanding shape memory properties and self-healing capabilities. Based on this novel SMP, LAMDA researchers, supported by NSF, fabricated a hybrid coir natural fiber-synthetic composite. Even with a significant proportion of natural coir fibers, the mechanical properties of the hybrid composites were close to those reinforced solely with glass fibers. Also the composite system could heal cracks and delamination damages due to the healing capability of the polymer matrix. This will help improve design and sustainable manufacturing of light weight structures for engineering applications.



Scheme (a) Mixing of monomers (b) lamination of fabrics (c) laminate sandwichched in the mold with aluminum plates covering (d) C-clamping to exert pressure on laminate, (e) demolding the sandwiched laminate after thermal curing, and (f) cuttingof panels into rectangular beams