Evaluation of the bond between Natural Fibers and Resins formulated from Natural oils

Hristina Milojevic '15
Professor Ronald B. Bucinell, Ph.D., P.E.

Introduction and Background

One of the largest global issues is pollution. Pollution is formulated from a variety of sources, and currently, researchers are diligently working across disciplines and master forms, to detect methods for preserving a healthy living environment. Material scientists have taken a particularly interesting route, changing the face of composites – famous high strength, low-weight materials with an abundance of applications – for their sustainable alternative: green composites. Their development is rapid, and their demand growing, as carbon-fiber composites circulate back no further than the waste accumulation landsfills, posing a hazard of slow-paced degradation. The importance of technological sustainability has only become prevalent within the last century, as scientists and engineers arrived at means of rapid development of increasingly disruptive products, making their usable life span significantly shorter. The favorably physical characteristics of composites allow them to be applied in a variety of devices, ranging from wind power to aircraft industry.

In the broad context, composites are defined as materials made up of two or more constituents characterized by distinctly different physical and chemical properties. Lawrence T. Hrusal may have described the nature of composites best, acknowledging the presence of fiber as “superior constituent” used for reinforcement, and matrix as the “medium” that transmits the reinforcement power of fiber throughout the composite. [1] It is an aspiration of this project to begin to investigate ways of fabricating 100% green composites, such that would offer complete decomposition upon disposal. These natural composites could be applied in devices that do not prioritize precise extreme properties of composites, and could easily maintain their performance under slightly different conditions. As such, the project relies on Single Fiber Fragmentation Test (SFFT) as an experimental procedure commonly applied to traditional composites, as well as both natural fibers and natural resins for green specimen fabrication in controlled lab conditions. The primary goal is investigation of bonding between the natural constituents, as bonding quantifiers commonly differ even for SFFT performed on traditional composites in identical lab conditions. Hence, the dual task, although still in developmental stages, will involve both assessment and optimization of bonding process between natural fiber and resin within each green composite sample.

Materials

Natural fibers biomid, flax and jute were selected from theory as favorable for use in composite applications, and were obtained in their fabric state, consisting of intertwined yarn. The thinnest individual fiber in use was biomid. Biomid is visualized in Figure 1, in its yarn state, appearing white and glossy, with a smooth fabric surface. Individual biomid fibers are geometrically held together by multiple yarn intersection within the fabric. This allows each yarn to preserve straight, unmodified state of individual biomid fiber, making biomid characterization appear most reliable out of the three fibers.

Another fiber under consideration was flax. Flax exhibits softness, lightness, and fragility upon touch. Much like biomid, flax is also delivered in the form of a yarn network, yet each yarn is additionally twisted for added fabric strength and durability. A yarn of flax is easily untwined, partially due to its high ductility, although once untwined the separated fibers quickly proceed to curl back with a tendency to return to their previous state. Fiber of flax appears comparable in size to the biomid fibers.

Final fiber considered was jute. Jute fibers came originally in intertwined yarns which were then, much like those of flax twisted and crossed to ensure fabric durability. Jute had particularly strong yarn connections across the fabric, while as a fiber, it was brittle, coarse, thick, and dry, with many smaller stems springing out along each single fiber, making specific extraction rather difficult and requiring of an added “peel-off” step to remove unwanted stems. Furthermore, jute yarn provides a strong curl-back force during the fiber extraction.

Testing Technique

Preliminary experimental methods involved four critical steps: sophisticated mold design and composite fabrication, followed by microscopy characterization of composite samples, and finally maximum stress findings from tensile test data. As the project continued to evolve over the course of its duration, several challenges emerged, dynamically changing the timeline of the project. The final experimental procedure changed steel mold design and obtained a chemical-resistant silicone casting compound that will in the next stages of the project be used to cure a medium-hard mold. Furthermore, the project evolved into a study of individual fibers rather than composite specimens, due to delays in resin supply and tensile stage set-up. Hence, single fiber paper-reinforced samples were fabricated for tensile testing, as well as characterized under a microscope, measuring their diameter and obtaining a picture of each individual fiber. Furthermore, the tensile stage endured a calibration procedure, upon which the individual fiber specimens were tested to obtain their critical load using NYESTInstruments software.

Results and Accomplishments

Upon a close characterization and testing of select biomid and flax fibers, adequate analysis was completed showcasing relationships between load and stress results for different fibers.

Conclusion and Recommendations

The main requirement of the project indicates that upon completion, project would have optimized the bond between natural fibers and resins, which is currently difficult to quantify and difficult to define based on available data. The main conclusion of the project proposes that studying and optimizing green composites is a lengthy and thorough process, which requires extensive effort, time dedication, and precise experimental work. The timeline of troubleshooting and repairing various issues can impose undesirable stalls on the project, and should be taken into account in the future. The recommendation for the continuation of this project involves fabrication of silicone molds, as well as fabrication of individual natural composite specimens for SFFT testing.

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References

[1] ©2009 Veeco Instruments
[1] Some Critical Issues for Inje

Figure 1: Specimen fabrication process, illustrated from Middle to Top

Figure 2: Stress-strain curve for (left) biomid and (right) flax

Figure 3: Tensile test versus position of fiber failure for (left) biomid and (right) flax

Table 1: Composites that are analyzed in Figure 11, obtained by using biomid and flax fiber.