Natural Fibers in Mycelium Reinforced Composites

Greg Holt, Ph.D.
Research Leader
Cotton Production and Processing Research Unit
Agricultural Research Service, U.S. Department of Agriculture
1604 E. FM 1294
Lubbock, TX 79403

There is a need for biodegradable alternatives to the inert plastics and expanded foams that are commonly used in both the manufacturing process and device componentry. Consequently, a significant amount of research is being conducted evaluating the use of natural fibers matrices for composites. A majority of natural fiber matrix studies involve the use of natural fibers or natural fiber blends with synthetic polymers. In 2010, Ecovative Design LLC in Green Island, New York initiated a Cooperative Research and Development Agreement with the USDA, Agricultural Research Service, Cotton Production and Processing Research Unit in Lubbock, Texas to enhance production and use of natural fiber composites using fungal mycelium as the binding polymer. The mycelium reinforced natural fibers, referred to as myceliated product, is currently marketed as an all-natural 100% biodegradable alternative to polystyrene packaging materials. To date, several studies have been completed evaluating the physico-mechanical properties of bio-composites samples manufactured with different fiber-fungal strain combinations and to analyze their appropriateness for uses ranging from acoustic absorbers to formed packaging material.

Results from one of the initial studies conducted by a graduate student, Alex Ziegler, was recently (April 27-29, 2015) presented at the 2nd International Conference on Natural Fibers in Sao Miguel, Azores, Portugal. For this study, physico-mechanical properties of composites produced from cotton and hemp natural fiber substrates were evaluated for surface hardness, specific gravity, water absorption, coefficient of linear thermal expansion (CLTE), and resistance to tension and compression. Since the type of natural fiber used, pack density of the agricultural substrate, duration allowed for mycelium growth, specific strain of the mycelia, the inoculation procedure, the surface binding material, and the ambient growth conditions are all parameters that impact the end product's material properties, the dataset was important in providing information in these critical areas. The Zeigler data helped revealed processes and practices where enhancements were needed in sample testing and manufacturing. Since the Ziegler study, improvements have been made in fiber processing and blending, fungal species selection, and production practices.

For those unfamiliar with the process, it involves using natural fibers that have been processed to a specific size range then sterilized to eliminate all biologicals that may exist. The sterilized fibers are then cooled and inoculated with a select fungal species. The inoculated fiber mix is used to fill a plastic mold (tool) in the desired shape of the final product. The tool is then sealed with a lid and placed in a shelving unit for 2 to 3 days until the mycelium covers the surface of the natural fibers. The part is then ejected from the tool and dried in an oven at 60 to 70C for 5 to 6 h. Once the parts exit the oven, the mycelium is dead and will not reanimate if it comes back in contact with moisture. There is another process where the inoculated natural fibers are placed in a container and dried at lower temperatures for less time to remove excess moisture. This secondary process produces a fungal-fiber matrix that is dormant that can be reanimated later with the addition of water. This secondary process is for shipping material to potential end-users for in-house fabrication of product.

Currently, research is underway to measure performance of myceliated acoustic absorbers for use in computers or automotive panels. Likewise, newer technologies in processing have resulted in the material being formed into densities similar to pressboard composites. New uses for the myceliated composites continue to expand as research continues.

Figure 1. The myceliated composite developed as a one-use-cushion for the deployment of tsunami buoys.

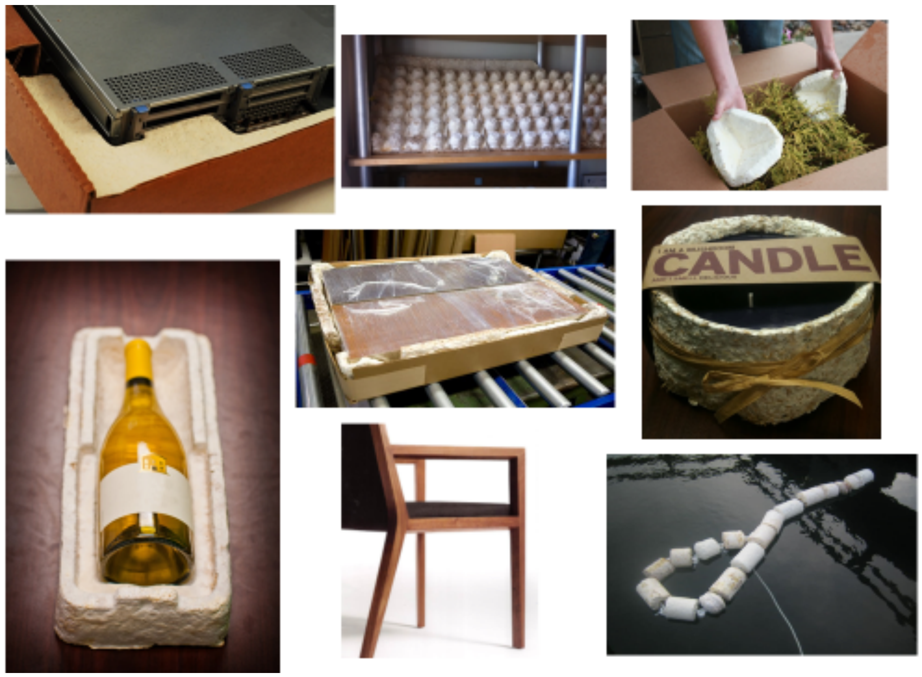

Figure 2. Various applications where the myceliated composite is currently being used or evaluated.