Preparation and Characterization of Green Composites using Poly(lactic acid) and Natural Fibers as Fillers

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Preparation

Apple

Lesquerella

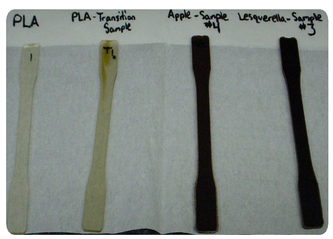
Agriculture waste material (fiber) is collected and ground to a fine particle (300 μm) and then dried. Proximate analysis indicates that each fiber is approx. 70% carbohydrate and 10% protein. Cuphea & Lesquerella are oil seed crops. Apple fiber is waste pulp from cider production. Milkweed is a persistent weed.

Cuphea

Milkweed

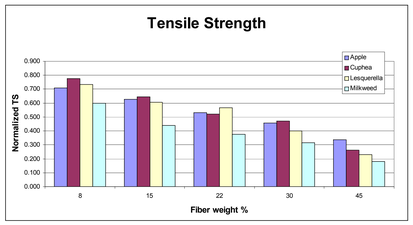
Poly(lactic acid), a biodegradable plastic made from renewable resources, is melted and then fiber is added. Extrusion adds thermal and mechanical energy to the system to produce a homogeneous PLA-Fiber composite.

The composite is injection molded into final form – tensile bars – for evaluation using the Instron. PLA composites are evaluated for tensile strength, modulus and elongation.

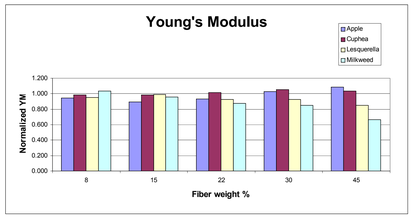


Characterization

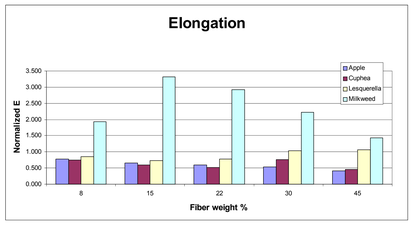
All data was normalized to a PLA control. The tensile, modulus and elongation of PLA is, by definition, equal to 1.0. The fiber content is 8%, 15%, 22%, 30% and 45%.



Tensile strength decreased with incorporation of fiber into PLA.



C & A exhibited increasing stiffness with more fiber. In contrast, the modulus of M & L decreased slightly.

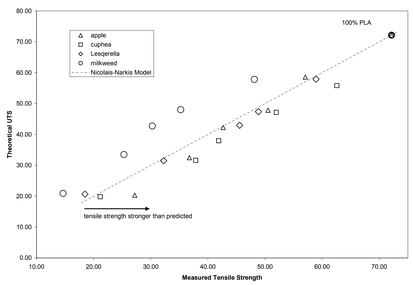


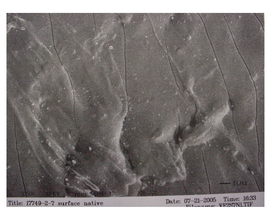
Unexpectedly, PLA-milkweed composites exhibited an elongation value 50% to 200% more than PLA by itself. All other fibers exhibited lower elongation as expected.

Nicolais-Narkis Model

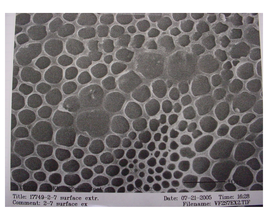
This model predicts ultimate tensile strength of composites as a function of filler content. The model represents no adhesion or interaction between filler and polymer matrix.

$$UTS = TS_{PLA}\,(1 - 1.21(V_f^{0.66}))$$





Scanning electron microscope images of PLA surface (left) and an extracted surface (right) showing the fiber distribution in the PLA matrix. Fiber weight percent is 45%.



Conclusions

- All composite samples had a final moisture content of less than 1%
- All PLA-fiber composites except milkweed exhibited stronger tensile strength than predicted by the model especially at higher levels of fiber content.
- PLA-milkweed composites show unusual elongation accompanied by stress-cracking or whitening.

Future Work

- 21-day TME
- Moisture absorption
- Biodegradability Studies
- Effect of repeated wet/dry cycles on PLA-fiber composites (rain)