USDA/NIFA Program: ***Biobased Products and Bioenergy Production Research***

TITLE: Morphology Based Modeling of Micro-Mechanics and Failure Mechanism in Bio-Materials with Polymer Matrices

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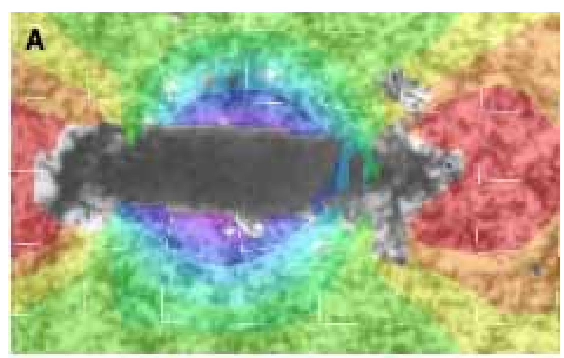
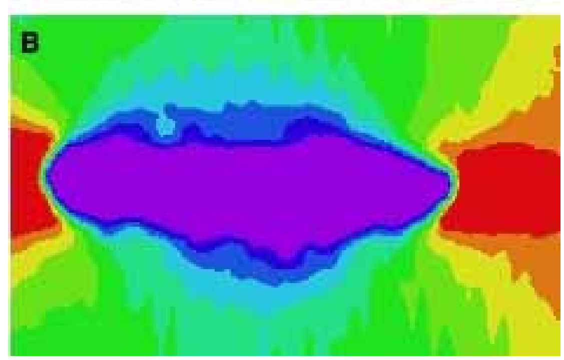
NON-TECHNICAL SUMMARY: The use of composite materials made from natural fibers and/or a bio-based matrices holds the promise of providing renewable and sustainable green materials that can replace composites made from high-energy-cost synthetic fibers and petroleum-based matrices. The development of natural composites, however, has been hampered by inadequate composites science needed to characterize the unique ways natural fibers reinforce matrix materials. To solve this problem, this project is developing a new approach to composite science based on coupling advanced imaging experiments with morphology-based numerical modeling. The results of this project will aid the development of improved biobased composites with sufficient properties to replace current synthetic products.

The research is focusing on the way wood particles interact with plastic matrices. The first experiments were to make a series of "model" composites comprised of a single wood particle in a plastic matrix. These composites were then mechanically loaded within a microscopic and optical methods (called digital image correlation) were used to measure the surface deformations and the full strain distribution around the particle. Figure A shows contours of measured strain in the *x* direction. The method was not able to evaluate strains within the particle (the gray object in the middle), but it was able to fully determine the matrix strains. To interpret these results, we have input the shape of the particle (from the optical images) into a computer model based on the material point method (MPM). Figure B shows MPM results for prediction of strains based on an initial guess for *in situ* particle and matrix properties. By comparing such numerically predicted surface strains to the experimental results and matching them using inverse problem methods, we will determine wood particle properties inside the composite and study the interface between the wood-particles and the binding plastic material. These initial results agree fairly well, but we can detect differences near the particle ends that are likely caused by the interface or the interactions between the particle and the matrix. These fine details are now under study.

This project's direct coupling of experiments and modeling is a paradigm shift in the analysis of the deformation and failure mechanisms in composites. Besides bio-based composites, it will have applications in many other areas of science for complex materials.





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