Native Michigan Grasses as New, Renewable, Biofiber Reinforcements For Soy-protein based Bio-composites

Project number: GR02-066
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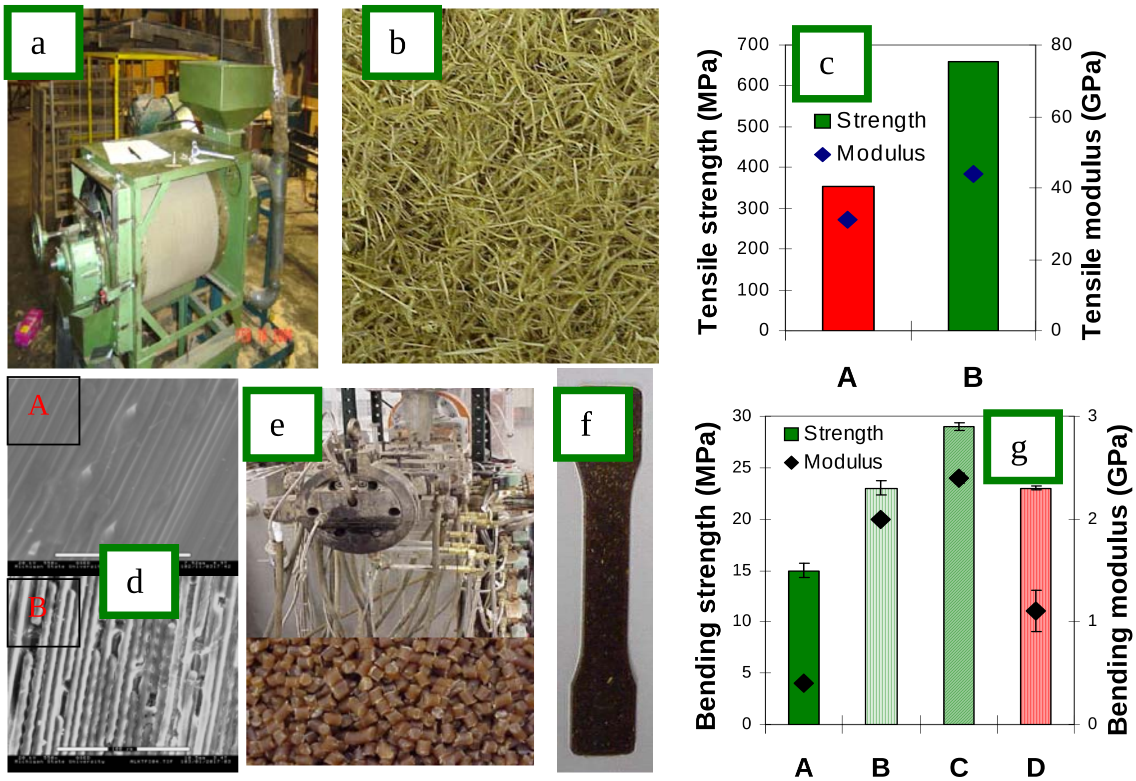

Figure 1: *Pictorial representation of project accomplishments. (a) Industrial scale equipment to chop Michigan grasses (b) Michigan grass after alkali treatment and ready for bio-composite fabrication, (c) Tensile properties of raw (A) and alkali treated grass fiber (B), (d) Morphology of raw (A) and alkali treated grass fiber (B), (e) Twin screw extruder used for compounding and soy pellets, (f) Injection molded grass/soy biocomposites (g) Flexural properties of bio-composites (A, bioplastic, B, Raw fiber composites, C, alkali treated fiber composites) vs. LDPE/grass composites(D)*

Project Justification

The main challenge is to investigate the processing and properties of biobased composite materials made from Michigan grasses and soybean-flour. The bio-composites developed under this project can find value-added applications in the automotive parts and furniture industries. Additionally, the economic feasibility of utilizing native grasses is being studied. Native grasses can grow in areas that are underutilized for agriculture, and can provide financial benefits to Michigan farmers as a new material for industrial applications.

Objectives

- ➢ Investigate the strength, morphology and thermal behavior of native grasses.
- ➢ Develop a low cost treatment process for native grasses to make them reactive.
- ➢ Formulate soy-flour based bio-plastics via reactive extrusion to produce grass-soy plastic injection moldable compositions for testing and characterization.
- ➢ Optimize the processing to produce sustainable bio-composites having physico-mechanical properties suitable for structural applications.
- ➢ Conduct an economic feasibility and impact study of Michigan grass.

Results and Accomplishments

Results obtained through this research have documented the performance and economic potential of soy plastic and native Michigan grass for industrial applications utilizing the approach developed in this project.

Technological: Accomplishments are summarized graphically in **Figures 1:a to 1:g**. A simple alkali treatment altered the morphological structure and improved the mechanical and thermal properties of native grasses. Soy protein plastic modified with a compatibilizer of glycidyl methacrylate grafted polyester amide was prepared by using reactive extrusion which improved the mechanical properties of soy plastic. With optimized processing conditions, soy plastic was produced that has high tensile elongation. Composite mechanical properties including tensile, flexural and impact strength improved more than 30% over that of grass reinforced LDPE composites. These results support the conclusion that native grass/soy biocomposites are ready for industrial applications.

Economic aspects: Besides technological accomplishments, we have investigated the economic aspects of these biobased materials. In the United States alone over 12 million cars and light trucks were produced in 2002 (Ref; Plunkett Research, 2003). Domestically produced native grass crops offer the potential to supply a large portion of the total future demand for the natural fiber reinforcements market in the United States. At current domestic automotive production levels, if 40 lbs per vehicle was supplied by domestically produced native grass crops, at an average yield of 5 tons/acre, and if a usable fiber recovery rate of 40% were achieved, approximately 120,000 acres of warm season grass crops would be required to meet anticipated demands. This acreage would generate over $60 million in new economic returns to agricultural producers. The value of biocomposites from this production based on 90 cents/pound of compounded material using 30 percent fiber reinforcement would be almost $1.44 billion. Utilization of native Michigan grass and soy flour in biocomposites has the potential to generate substantial economic benefits to Michigan and US farmers.

<u>Presentations/Publications/Patent</u>

1. Liu, W., Mohanty, A. K., Misra, M., Askeland P. Drzal, L. T., "*Effects of alkali treatment on the structure, morphology and thermal properties of native grass fibers as reinforcements for polymer matrix composites*", **Journal of Materials Science**, 2004, 39(3), 1051

2. Liu, W., Mohanty, A. K., Misra, M., Drzal, L. T., "*Injection Molded Green Composites From Native Grass and Soy Based Bioplastic*", **18th Annual technical conference American society for composites**, Oct. 19-22, 2003 Gainesville, FL, CD ROM #Paper 189,

3. Liu, W., Mohanty, A. K., Misra, M., Drzal, L. T., "*Thermal and mechanical properties of functional monomer modified soy protein plastic by reactive extrusion technology*", **SPE ANTEC 2004, Chicago, Conference proceedings**, CD ROM Paper ID# 1298, Composites – 39.

4. Liu, W., Mohanty, A. K., Misra, M., Drzal, L. T. 2004, "*Fabrication and properties of green composites from soy based plastic and natural fiber*", **Polymer Processing Society Annual**

Meeting and 20th Anniversary, June 20 - 24, 2004, Akron, Ohio. Full paper published in the PPS-20 Conference proceedings, CD ROM Paper #: 135.

5. Liu, W., Mohanty, A. K., Misra, M., Drzal, L. T., "*Green composites from soy based thermoplastic and grass fiber*", **59th ACS Midland Section Fall Scientific Meeting**, Green Chemistry, October 17, 2003, Midland, MI.

6. Liu, W., Mohanty, A. K., Misra, M., Drzal, "*Effects of Alkali treatment on structure, morphology and thermal properties of grass fiber*", **4th international plant biomechanics conference**, July 20-25, 2003, East Lansing, MI

7. Mohanty, A. K., Liu, W., Drzal, L. T., Misra, M., Tummala, P., "*Value-added nonfood applications of soybean protein through design and engineering of green plastics and their biocomposites: The hope and reality for US agriculture*", Division of Cellulose and Renewable Materials, **228th ACS National Meeting, Philadelphia**, PA, August 22-26, 2004.

8. Mohanty, A. K., Liu, W., Tummala, P., Drzal, L. T., Misra, M., Narayan, R., "*Soy protein based plastics, blends and composites*", **CRC Book Chapter**, (in press, 2004).

9. Drzal, L. T., Mohanty, A. K., Liu, W., Misra M., "*Cellulosic Biomass based Biocomposites and methods of making those*", **US Provisional Patent applied (08/27/04)**.

Impacts

The results of this research project indicates that using bicomposites made from soy based bioplastic and grass fiber have the potential to produce substantial economic benefits to farmers by creating a new generation of industrial products of significant commercial value. This research shows that optimized processing and surface treatment fiber reinforced soy-based biocomposites have better performance, compared with grass reinforced LDPE composites. Biocomposites from grass and soy plastic can be used as medical packaging materials, building materials and in automotive applications such as internal panels, door and floor panels, seat backs, and other component parts. Ford has targeted biocomposites for interior automotive use at 50% fiber content for 90,000 vehicle units. This would require 3.6 million pounds of compounded materials at a value of approximately $3.6 million. Overall sales forecasts for biobased composite materials are projected to generate over $28 million in revenue by 2014 on one Ford vehicle program produced at one plant. The future of native Michigan grass as a non-food agricultural product is very promising.

Summary Statement

This project identified and evaluated native Michigan grasses as biofiber reinforcements for renewable resource based biocomposites made with soy flour based bioplastics. The results of this project can create a new value-added product for both Michigan-based grass fiber/grass seeds as well as an additional use for soybean flour.

Funding Partnership

Project GREEEN was requested to provide $112,857 over 2 yrs. The actual award was $40,000/2 yrs with the remaining funds of $72,857 being supplied as matching funds through the Composite Materials and Processing Research Excellence Fund.

Discussions are underway with several Michigan based companies to develop and transition this technology to the commercial sector. These companies include MBI International (Mark Stowers); Smith, Adams & Associates, LLC (Tom Smith and Bob Adams); Eurotech Design, Inc. an automotive design and Engineering company; Ken Berg and Gary Barg, Tool North, Traverse City, Michigan; Fred Sorensen, ACRA Plastics, Traverse City, Michigan; Fred

Homann, Max Manufacturing Albion, MI., FORD MOTOR COMPANY have shown their interests in our biocomposite research funded by PROJECT GREEEN for future funding and collaboration. We are planning to apply to NSF this year under the ERC program (funding at a range of ~ $40 Million for 10 years in the area of *green/biobased materials*) in which Michigan grass based biocomposites will play an integral part of the program and funding request.