Natural Fiber Composites: Retting, Preform Manufacture & Molding

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This presentation does not contain any proprietary or confidential information.

Outline

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Purpose of the Program

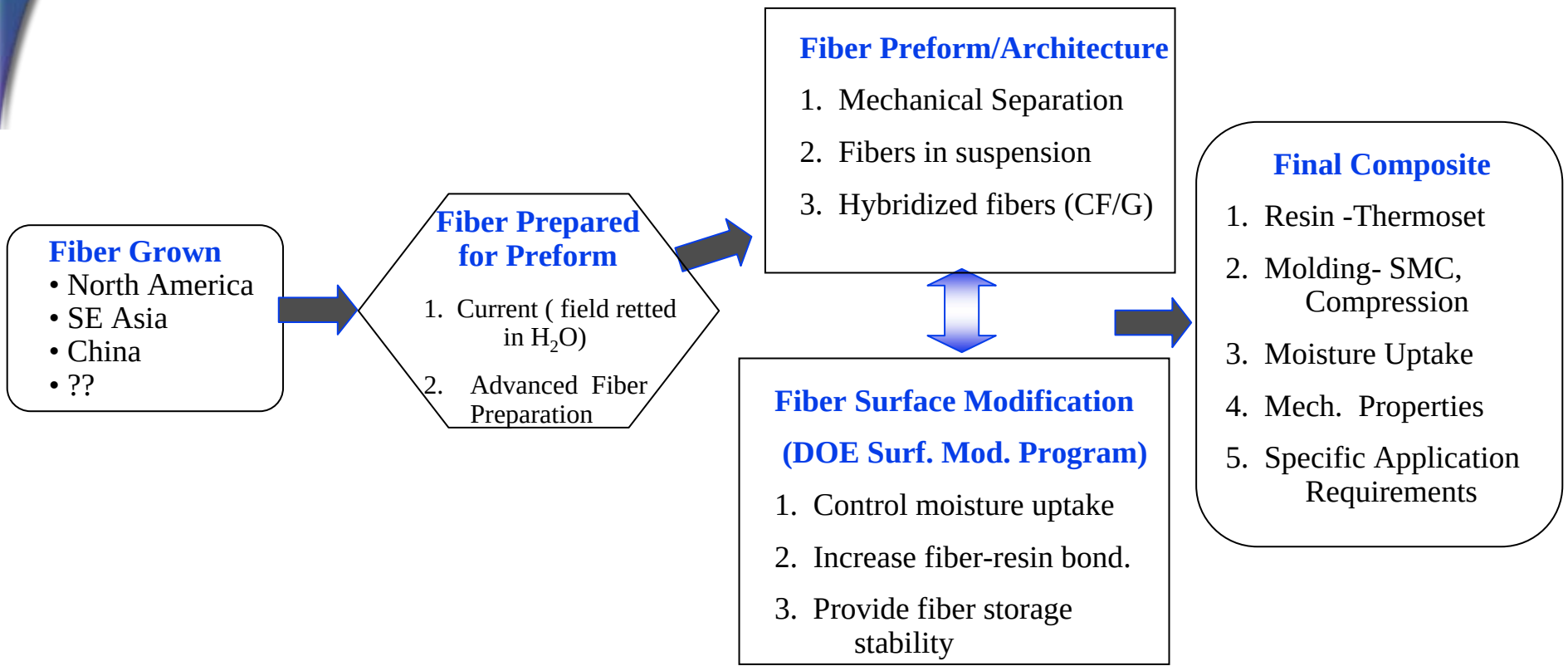
To accelerate the insertion of natural fiber composites into the auto sector, thus reducing US petroleum usage and increasing critical US bio-based manufacturing infrastructure.

1. Develop natural fiber preparation process and lab-scale apparatus.
   - Deliver a prototype apparatus applicable to kenaf, flax, hemp.
   - Focus on advanced methods of fiber preparation.
2. Design a scalable natural fiber preform manufacture process and produce a lab-scale prototype apparatus.
   - Capability to produce multi-fiber preforms.
   - Capable of integrating surface treatment technology.
3. With industry, develop natural fiber SMC materials.
   - Poly and vinyl ester (AOC).
   - Urethane (Reichhold).
   - Bio-based polyols including soy oil (Ashland).
4. Conduct composite characterization test plan.
   - Moisture Uptake.
   - Mechanical – Thermal Properties.

Barriers

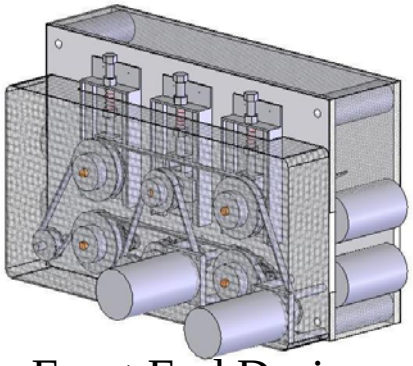
1. Develop an alternative mechanical-physical-chemical system to the 3-4 month field retting process.
   - How do we break the low-MW organics that anchor fibers within the plant?
   - What process technologies can be brought to bear on this problem?
   - What portion of the ~20% lignin in bast fibers should be removed? Can this be captured as a process fuel source?
2. Develop a *fluid-free* natural fiber preform manufacture process and apparatus.
   - Is it possible to produce a preform composite from dry fiber?
   - Is this process capable of hybridizing preforms for RTM and compression molding?
3. Develop natural fiber SMC thermoset composites in conjunction with industrial resin suppliers.
   - What scalable process can be developed that is amenable to natural fibers?
   - Is it possible to produce both ester and urethane SMC from such a process?
   - Are we capable of producing SMC materials based on bio-polyols?

Program Approach



Performance Measures/Technical Accomplishments/Progress/Results
(FY08 Milestones – 50% Complete)

1. Natural fiber preparation process.
   1. Lab scale process front end designed.
   2. Fiber decordication process explored and developed, lab-scale process unit drawings in process.
   3. Advanced fiber treatment processes being explored.
      - Super-critical fluid treatment.
      - Advanced extrusion methods.
      - Inert chemistry combined with steam-treatment methodology.
      - Short-pulse microwave exposure.
      - High-throughput sonic exposure.
   4. Fiber separation procedure identified; currently the scale and process details are being addressed.
      - Based on carding and cotton gin technology…



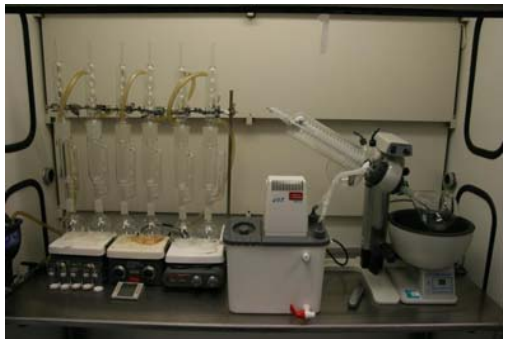
Front End Design

Decordicated Fiber – in Process

PNNL Fiber Separation

Technical Accomplishments /Progress/Results

2. Contracted 1 ton of kenaf – Kengro, Inc., Charleston MS.
   - Experiments currently underway with Kengro kenaf fiber.
   - Baseline fiber compared to fiber from SE Asia, Texas, and Canada.
3. Completed design and build of fiber analysis laboratory to analyze fiber structure.



4. Completed spectroscopic analysis of candidate fibers (XPS) and correlated these results with cellulose, hemi-cellulose, lignin, and LMW organic content.

Technology Transfer

1. Established relationships with AOC, Ashland, and Reichhold Chemical
   - In negotiation with AOC and Ashland to develop natural fiber SMC materials.
2. Established working relationship with Kengro, Inc., Charleston MS.
   - Intent is to develop value-added natural fiber market in North America
3. Established working relationship with USDA-WSU Prosser research facility to refine kenaf fibers.
4. Established working relationship with Tim-Tek Inc., Atlanta GA, for fiber processing.
   - Introduction to automotive industry of their forest products-based technology
5. Informal relationship with Material Innovation Technology.

Publications, Presentations, Patents

1. Review Presentation: ACC review meeting, Fall 2007.
2. Technical presentations
   - American Society for Composites technical meeting, Fall 2007.
   - SPE Automotive Composite Conference, Fall 2007.
3. Two process patents filed as of February, 2008.

Future Work – This Fiscal Year

1. Complete fiber preparation sample experiments.
   - Determine most effective method (s) to prepare fiber for surface treatment.
   - Quantify the fiber process to make final process decision.
2. Design and produce lab-scale unit to process fiber.
3. Conduct characterization study of processed fiber.
   - Currently we have requisitions for two summer hires to assist in this effort.

Future Work – Next Fiscal Year

1. Develop fiber preform process.
    1. Capable of integrating surface modification strategies/chemistries.
2. Design lab-scale preform manufacture apparatus.
    - Complete design review with ACC.
    - Produce unit and quantify performance metrics.
    - Complete prototype manufacture of natural fiber and hybrid units.
3. Begin natural fiber SMC development (3rd Quarter, year 2).
4. In parallel, begin composite mechanical, thermal, and environmental characterization.

Summary

1. Natural fiber composites show great promise in support of a bio-based manufacturing infrastructure within the United States
   - There is potential for significant petroleum displacement through fiber reinforcement and bio-polyol development.
2. PNNL efforts address critical needs in support of natural fiber composite development for transportation
   - Fiber preparation process including delivery time and cost
   - Preform development expanding fiber architectures
   - SMC development enabling rapid processing of natural fiber composites
3. The program is aggressive; PNNL continues to establish commercial relationships to rapidly insert developments into industry.