Center for Bioplastics and Biocomposites

INDUSTRY ADVISORY BOARD PROPOSAL TOPICS

Proposal applications due Monday, September 14, 2015

Listed below are proposals topics from the CB² Industry Advisory Board. Proposal applications should address one or more of the topics. For more information on application guidelines or how to submit an application, visit www.cb2.iastate.edu/call-for-proposals.html.

Determine optimal coupler type and percentage to improve the adhesion of the natural fiber to polymer matrix. This experiment should include a variety of natural fibers such as sisal, wood fiber, flax, ground rice hulls and other commercially available fibers. The proposed experiment would compare no coupler vs. a variety of coupling agents at varying percentages.

Determine the optimal type and percentage of UV stabilizer to prevent polymer and fiber degradation. This experiment should include a variety of different types of natural fibers. Current industry standard for UV performance is SAE J 2527 (2500 Kj/ M2) and SAE J 2412 (1250 Kj/M2). This experiment would compare controls vs. exposed materials for both color and physical property change.

Determine the optimal amount and type of heat stabilizer to prevent polymer and fiber degradation when exposed to continual heat. For this experiment a variety of natural fibers and heat stabilizers should be used. Typical industry standard is 1000 hours of continual exposure at 150 degrees C. The compound must retain 80% of its original physical properties.

At this time I would be interested in seeing additional work with the bioadhesive project (poly-glycerol acrylate). Perhaps some additional characterization and applications development.

Chitin is a polysaccharide biomaterial found in the exoskeletons of crustaceans and insects. It is pliable while retaining strength, as well as resistant to environmental conditions. Furthermore, chemical modifications can be done to synthesize composite materials. The strength, pliability, and potential for chemical modification make chitin a compound of interest for development as a coating material for packaging applications. This would require chemical modification which could be accomplished *via* the free hydroxyl group on chitin monomers (N-acetylglucosamine). If the chitin polymer could be made soluble in organic solvents, potential exists for it to be applied as a coating to grant increased resistance to environmental conditions and improved structural strength for packaging materials.

Biopolymers w/ Nutrients vs. Granular Fertilizer

– Compare growth between the two
– Root Growth and Plant Height
– Compare Fruits
– Quantity and Size
– Compare Costs

Purpose: To evaluate if there are advantages to one method of feeding plants over another.

Biopolymers w/ Nutrients in Plant Results

– Grow more plants with the stated technology
– Find out where the advantages are within what plant family
– Track Growth
– Roots
– Size of plant
– Volume and quantity of fruit/vegetable

Purpose: To evaluate where or if there are advantages when used with different plants

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Direct Feeding w/ Biopolymers vs. Granular Fertilizer and Water Runoff

– Track the amount of nutrients that feed the plant compared to running off away from plant
– Compare soil samples nearby or water ways nearby to show potential runoffs

Purpose: To evaluate if one method of adding nutrients to plants is more environmentally safe to the surrounding soils and waterways. Clean water is definitely a future topic for generations to come.

An investigation into the use of "conventional" catalysts instead of enzyme systems to facilitate the conversion of cellulosic biomass to platform chemicals e.g. Lactic acid, 3-HPA etc.

Anything that deals with welding will be of interest.

Development of biobased polypropylene. Much research has been performed on biobased routes to produce polyethylene (PE) and polyethylene terephthalate (PET), both of which are being commercially produced. Far less research has been done on biobased polypropylene (PP) despite it being the second highest volume polymer globally behind PE. Over 16 billion lbs were produced in North America alone in 2014, representing 18% of total thermoplastic resin production according to the American Chemistry Council[1]. PP is used in a wide range of applications, varying from rigid packaging such as yogurt tubs and drink cups, to flexible films used for labels and breathable films, to durable applications such as automotive parts. Development of a biobased PP would have a tremendous impact on the sustainability of the plastics industry.

[1] American Chemistry Council. "U.S. Resin Production & Sales 2014 vs. 2013." March 2015.

Use of corn or soy as an alternative raw material for biobased polyethylene. Polyethylene (PE) is the most prevalent resin worldwide. A biobased ethylene monomer could be used in the production of high density polyethylene (HDPE), low density polyethylene (LDPE), and linear low density polyethylene (LLDPE). Total PE production in the North America alone was over 38 billion lbs in 2014, representing over 40% of total thermoplastic resin production according to the American Chemistry Council[1]. Although routes to produce biobased polyethylene have already been developed, the primary route is based on sugar cane, which does not grow in the majority of the US. A route based on corn or soy would be much more beneficial to the US.

[1] American Chemistry Council. "U.S. Resin Production & Sales 2014 vs. 2013." March 2015.

Nanocellulose

We are interested in the evaluation of nanocellulose fillers in multiple polymer systems such as structural adhesives and aerogel materials. Such a program would include blending of nanocellulose particles into standard structural adhesives with a goal if understanding the fundamental advantages and disadvantages of this filler material. Many variables of this type of project could be studied including factors (processing, surface treatment) that effect compatibility and performance of nanocellulose in thermoset materials such as epoxies.

Lignin

We remain interested in the valorization of lignin as a raw material for use either as a filler or a precursor to resins. Our interests are broadly related to composites and films, so the overall concepts of this type of project are to understand how modified lignin can be used as an effective (performance and cost) additive into these polymer systems. One possible starting point could be the use of lignin as a additive in epoxy structural adhesives. If a modified lignin can be prepared that works effectively as a low cost toughener, filler, or co-resin, this would be of value in the composite area.

Safer Plastics Additives – Work to design and produce low hazard additives for use with bioplastics. The Center for Bioplastics and Biocomposites could integrate green chemistry design for safer alternatives by functional class. Three research areas of particular interest include: 1) alternatives to phthalates in inks and dyes for textiles, 2) safer flame retardants and biopolymers for electronics housings; or 3) alternatives to isocyanate (MDI and TDI in particular) used as an intermediate in the synthesis of polyurethane.

Everyday Products from Renewable Feedstocks – Research the use of canola, a renewable feedstock, to produce a suite of bioplastics products that are currently derived from petroleum. Canola production is a logical choice for biochemical production in the Pacific Northwest for several reasons. It grows well in most agricultural areas of the region and serves as a good rotational crop for the predominant cash crops of wheat, potatoes, and corn. Canola has high oil content, approximately 40%, compared to about 30% for yellow mustard and 20% for soybeans, a crop which is not well suited for production in most of Washington State.

LEGO Sustainable Materials Project – CB^2 could work with LEGO and other partners in creating sustainable plastics to replace ABS. LEGO is searching for biobased materials that meet quality, durability and safety needs. LEGO has signed a partnership with the World Wildlife Fund to assess the overall sustainability and environmental impact of biobased materials. CB^2 could be an effective technical solutions partner with LEGO and WWF.

Cellulose Nanofibrils Reinforced Polymer Composites

Cellulose nanofibrils (CNFs) have received significant attention during the last decade not only because of their inherent renewability and sustainability in addition to their abundance but also because of their unsurpassed quintessential physical and chemical properties. CNFs have been showing much greater potential to enhance mechanical and physical properties of polymer composites. Ford Motor Company is looking for high modulus materials that are relatively cost effective/require a minimal amount of filler to achieve the necessary stiffness for body interior and exterior applications. We would like to replace talc fillers and glass fibers filled polymer composites (PP and TPO) materials with less than 5-6% cellulose nanomaterials.

Ford currently uses soy-based PUF in seat cushions and seat backs in all vehicles produced in North America. The technology has successfully migrated to other automotive applications, and now efforts are underway to increase the content of soy-based polyol in the foam formulations. One potential method of doing so involves reinforcing the foam with nano materials. Not only can improvements in mechanical properties be achieved, but also thermal properties and renewable content are strengthen and increased. PUF reinforced with TiO2, nanoclay, graphene, carbon nanofibers, and pristine and organically-modified layered silicates have been investigated and shown to provide a significant enhancement of thermal and mechanical properties. However, to date, little work has been done on developing flexible PUF reinforced with CNFs. A better understanding is also needed on effects of the CNFs dispersion on flexible PUF process and structure/property relationships.

Biopolyamides are among the most promising families of plastics based on fully or partially derived renewable sources. Because of these evident advantages and their biobased performance which feature all the performance criteria important to high quality car components, technological developments and commercial applications of biobased polyamides within the automotive sector have shown enormous growth. To produce fully sustainable nanocomposites, which are the next generation of materials for the future, both the polymer matrix and the reinforcements have to be derived from renewable resources. We believe that development of practical and high performance (improved mechanical and thermal properties) biobased polyamide micro and nanocellulose composites could offer solutions for sustainable automotive applications.

The United States has set the pace for nanotechnology innovation world-wide with the National Nanotechnology Initiative (NNI), launched in 2001 with eight agencies and a budget of $494 million. The NNI today consists of 16 individual and cooperative nanotechnology-related activities among 25 Federal agencies with a range of 17 research and regulatory roles and a proposed budget of $1.7 billion in 2014. It is clear that nanotechnology research in forest products such as characterization of CNF, predictive modeling of CNF, surface modification of CNF, and sensor development using CNF will be a major focus area for years to come, and the funding opportunities for research in the area should continue to grow. The research proposed here will build on strengths of Ford in the area of sustainable nanocomposites research utilizing bioresins and will help leverage research in cellulose nanotechnology being conducted in association with Ford Policy on Sustainable Bioproducts.

Self-healing Composites

Damage is generally an inevitable phenomenon for automotive industry and much time and labor works have been spent on such issues. For future prospect, the vehicle that can repair itself might be possible with the development of self-healing materials. Self-healing is a smart and promising way to make materials more reliable and longer lasting. Micro-based method can repair the internal cracks or delaminations through the healing agent for internal damage. Shape-memory polymer based structures can be induced to the original shape through heat or stimulus for external deformation (once occurred). For each self-healing chemistry, four aspects are important: (1) which matrix materials have been self-healed, (2) if there is a catalyst required, (3) what kind of damage has been repaired and (4) what is the reported efficiency of each system.

The 2015 U.S. Tech Choice Study found that the top five vehicle technologies consumers prefer are 1) blind-spot detection and prevention systems, 2) night vision, 3) enhanced collision mitigation systems, 4) rearview camera and monitors and 5) self-healing paint (did not ask self-healing materials in general). Research into the self-healing of functional properties (electrical, electromagnetic, electromechanical, magnetic and thermal conductive) is still in its early stage development. However, as the demand for functional polymer composites is increasing, it is expected that the focus of researchers will broaden to the development of materials that are capable of healing both structural and functional properties in the upcoming years. Although not easy, the conceptual idea of most self-healing systems could and should, in our opinion, be taken to an upscalable application in close collaboration with universities.

Development of Hybrid Composites for Automotive Applications Based on Lignocellulosic Filers and Carbon/Glass Fibers

The use of renewable materials, e.g. lignocellulosic fillers is of great interest to the automotive industry. However, the mechanical properties of compounds exclusively filled with lignocellulosic fillers do not fulfill the requirements for many automotive applications. Hybrid compounds filled with lignocellulosic fillers in combination with carbon/glass fibers can fulfill the demands required for many injection molded automotive applications. The combination of glass/carbon fibers with lignocellulosic fillers will enhance the mechanical and physical properties while concurrently maintaining environmental benefits and weight reduction. The aim is to develop a simple and cost effective approach for the development of light-weight, super-tough and stiff hybrid material for automotive applications.
