Alabama Innovation and Mentoring of Entrepreneurs

Innovation and Entrepreneurship at Work

2007 Annual Report

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# Table of Contents

I. Director’s Executive Summary ................................................................. 4
II. AIME Administration .............................................................................. 7
III. AIME Prospectus: Increasing Alabama Competitiveness ....................... 8
IV. AIME Facilities ..................................................................................... 12
V. Student Awards and Recognition .......................................................... 13
VI. Project Summaries ................................................................................ 14
   A. Development of Controlled Release of Flavorants and Sugars for Application into the Functional Foods Industry .......................................................... 15
   B. Hydrophilic/hydrophobic block copolymers for enhanced adhesion between cellulose/polypropylene blends ................................................................. 20
   C. Effects of Aprotic Regeneration Solvents on Enzymatic Hydrolysis of Ionic Liquid Reconstituted Cellulose ........................................................................ 22
   D. Film Extrusion ....................................................................................... 24
   E. Alabama Launchpad ............................................................................. 26
VII. Student Triage Team Invention Disclosure Summaries ....................... 27
VIII. Meetings, Presentations, Proposals and Publications ......................... 28
1. Director’s Executive Summary

AIME Vision: The vision of AIME is to enhance the culture of high technology research and development at The University of Alabama by innovation, mentoring and entrepreneurship.

AIME Mission: The mission of AIME is to identify and facilitate value added innovation and foster entrepreneurship leading to commercialization of intellectual property.

The University of Alabama stands on the threshold of a new era in its service as the Flagship University of the State of Alabama. As global competitiveness becomes a dominant theme for the 21st century, the University is transforming itself into an engine for high technology economic development and a source for the workforce of tomorrow. A key component in this transformation is the Alabama Innovation and Mentoring of Entrepreneur (AIME) Center. As demonstrated by its vision and mission, AIME is dedicated to bringing about local, regional, national and global competitiveness by providing an integrated and synergistic program to add commercial value to the knowledge and intellectual property created by faculty and students through innovation, mentoring and entrepreneurship. To achieve this vision and mission, AIME developed a Prospectus to serve as a working plan to realize its full potential. The Prospectus is enclosed as part of this annual report and comments are invited.

AIME has continued to enjoy considerable success during the past year. In particular, we are providing highlights and accomplishments for several strategic focus areas, as defined below.

1. UNDERGRADUATE STUDENT TRAINING IN ENTREPRENEURSHIP AND INNOVATION

- Nineteen undergraduate students participated with AIME under the AIME Triage Model. This model of entrepreneurship and innovation allows students to work in the area of technology development and enhancement. The goal of the triage teams were to present to the Patent Council a business plan and a patent assessment that would give them the necessary information to warrant the University’s investment in the legal fees for the issuance of a new patent. Students participate in such activities as marketing analysis, development of preliminary business models, interviewing inventors, assisting inventors in preparing intellectual property disclosures, and performing prior art patent searches.

- As part of the training of entrepreneurs, AIME clustered students into five business model teams and submitted business plans based on UA IP to the Alabama Launchpad competition. Each team had their plans reviewed by mentors from the business school prior to submission, plus received feedback from reviewers. The resultant plans are available for potential business teams to start a high technology company.

2. GRADUATE STUDENT TRAINING IN ENTREPRENEURSHIP

- Eight graduate students from the AIME research teams have taken the lead in the formation
of business plans to assist incubating companies to attract venture capitalist funding. This opportunity offers these students the potential for employment as business and technical officers in UA based start-up companies.

3. FORMATION AND IMPLEMENTATION OF STRATEGIC PARTNERSHIPS WITH INDUSTRY

- **Development and Implementation of a Technical Resource Information Exchange.** AIME developed and implemented a technical resource information exchange service to allow industry, governmental agencies and the university to work together on special projects designed to enhance the introduction of industry products into the local community.

- **Economic Growth and Development.** It is a goal of AIME to contribute to the economic growth and development of the City of Tuscaloosa, Tuscaloosa County and the State of Alabama. AIME works with these governmental agencies to foster relationships and grow companies both small and large by providing technical and business information. AIME has also provided service this year to the Chamber of Commerce, Southern Alliance for the Utilization of Biomass Resources (SAUBR), Tuscaloosa County Industrial Development Authority, Alabama Forestry Association, Alabama Cooperative Extension Systems, the BlackBelt Cooperative, Hager Oil and Alabama Biodiesel in Moundville, Al.

- **BASF Contract to Fund Research to Enhance Ionic Liquid Technology.** BASF agreed to continue funding of the Centre of Green Manufacturing within AIME for another year at $185,000. This research is being carried out by two undergraduate students, three graduate students, and three post doctoral students. Hosting several meetings with BASF to review this work has given the University and its students a chance to share and receive industrial feedback on the business models. It has also allowed students and staff to work closely with BASF for potential career growth.

- **AIME Business Model/Plan Development.** AIME has developed several business models/plans based on the University’s Intellectual Property using technologies in which our partners are interested in licensing. The partner targeted in 2007 was BASF. AIME is sharing these plans with other potential clients who have also expressed interest in use of this technology for start-up companies. These other potential clients show a willingness to work with UA partners.

- **Southern Company Contract for Combustion of Bio-fuels** AIME worked closely with the Southern Company and Dr Ajay Agrawal for the combustion of bio-based fuels for $80,00 for one year. This research was based on earlier work done at AIME. AIME workers developed the matrix and blending of fuels used by Agrawal’s laboratory for the combustion analysis. This work will assist the Southern Company in the chose of alternative fuels.
4. STRATEGIC PARTNERING WITH THE STATE OF ALABAMA ECONOMIC DEVELOPMENT PARTNERSHIP OF ALABAMA (EDPA) AND OTHER ALABAMA UNIVERSITIES IN THE DEVELOPMENT AND IMPLEMENTATION OF A STATE-WIDE BUSINESS PLAN COMETITION.

- The University of Alabama has united with five other state universities and the Birmingham-based Economic Development Partnership of Alabama (EDPA) to develop the Alabama Launchpad Business Plan Competition. This four-phase business plan competition is unique in that it is the first of its kind to involve multiple universities.

- Personnel from AIME were instrumental in the formation of this competition and have served on the Board of Directors and various working groups that included the design of the Launchpad web site.

5. RECRUITMENT OF VENTURE CAPITALISTS TO VISIT AND MEET WITH UA OFFICIALS AND FACULTY INVENTORS

- Venture Capitalists from Randar Corporation (Tuscaloosa), Greer Capital (Birmingham) and Third Trimester (Tuscaloosa) met with UA faculty interested in incubating in BTI. Several presentations were made both at AIME and in Birmingham to these Venture Capitalists. AIME is actively involved in assisting our companies within the incubator to attract funds from the above firms.

6. VALUE ADDED PRODUCT ENHANCEMENT OF UA INTELLECTUAL PROPERTY

- One page summaries of several IP offerings are provided in this annual report of the research projects AIME has undertaken to enhance the value of UA IP. The one page summaries are shown, but the full publication has a brief description of the inventors’ biographical information. These one page overviews are used for both internal and external marketing contacts at the inventor’s presentation and technical meetings.

The above six initiatives have been developed by AIME and the Office of Research over the past three years.

Following the Prospectus, we provide in this report an introduction to AIME administration, technical summaries from ongoing AIME innovation projects, and disclosures from several entrepreneurial teams.

AIME personnel are proud of our accomplishments from the past year and look forward to serving The University of Alabama in the future.
II. AIME Administration

Daniel T. Daly
Director

Rachel M. Frazier
Research Scientist

Scott K. Spear
Research Scientist

Whitney M. Swatloski
Innovation Coordinator

Renae D. Sullivan
Administrative Specialist

Students

Graduate Research Assistants
- Austin Cone
- Whitney Hough-Trotman
- Brett Price

Graduate Student Assistants
- Chris Cater
- Grant Gibson
- Brack Hudson
- Michael Alff
- Gerald Franks

Undergraduate Students
- Julia Bevill
- Anna Grace Bishop
- Natasha DeJesus
- David Holt
- Britney King
- Thomas Langham
- Heather Layton
- Garth Legvold
- Bethany Lindsrom
- Samantha Mrozynski
- Ryan Nelms
- Laura Ogren
- Rebecca Paxton
- Kristin Rogers
- Jolee Seaborn
- Tara Shinholtet
- Ryan Thomas
- Rachel Thorne
- Savannah Watts

<table>
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III. AIME Prospectus: Increasing Alabama Competitiveness
Daniel T. Daly and Keith McDowell

Creating a thriving environment at The University of Alabama that will foster the growth of intellectual property while meeting the changing needs of our state and nation in the area of economic development is an important task for the 21st century. The University of Alabama through its AIME Center is striving to reconfigure itself to meet the challenge posed by the 2006 American Competitiveness Initiative (ACI) of President George W. Bush. This new initiative has focused the attention of the nation on the issue of global competitiveness. ACI follows on the heels of many reports in Washington including “Rising Above the Gathering Storm” by the National Academies and the book “The World is Flat” by Thomas Friedman. The gist of this new approach to competitiveness is a strong coupling of university research through innovation and the commercialization of intellectual property as well as increasing the pipeline of American students in science, technology, engineering and math (STEM) for the workforce. This new approach compliments the Governor of Alabama’s delegation, of which UA is a member, which went to Israel in 2005 and China in 2006 for the purpose of creating economic growth in Alabama through increased trade.

A key component of this new approach to competitiveness is the emerging role of entrepreneurship as the key driving force for growth and global competitiveness through the formation of wealth. In a summative sense the sequence of the words research, innovation, commercialization, STEM workforce and entrepreneurship capture the essential ingredients of the ACI concept.

Universities have traditionally played major roles in research and the development of the STEM workforce, but lesser and even non-existent roles in innovation (defined as adding commercial value to generated knowledge), commercialization and entrepreneurship. Recently (2006), Carl Schramm’s article “The Broken M.B.A.” published in The Chronicle of Higher Education discussed the changes needed in business education and the requirement for an entrepreneurial education in the modern world. Universities have begun to pay attention to innovation and commercialization as a result of the changing dynamics in the late twentieth century through the formation of offices of technology transfer and more recently with business incubators and research parks. While such changes are essential in universities, they tend to confront the ACI concept in a rather piece-meal manner instead of an integrated approach. At The University of Alabama, we believe in an integrated approach that plays to our vision of a student-centered research university as well as a vision of enhancing the life of Alabama residents which is at the core of our mission.

THE CHANGING ROLE OF AIME

To realize the goal of an integrated approach to American competitiveness, The University of Alabama has formed an Office of Research (OR) headed by the Vice President for Research. Within OR, both the Office of Technology Transfer and the Bama Technology Incubator were formed in 2004 and 2005 to handle parts
of the ACI equation. The missing components of innovation and entrepreneurship were delegated to a revitalized Alabama Institute for Manufacturing Excellence (AIME).

The initial plan for AIME was to serve as an experiment to learn how best to implement innovation and entrepreneurship. As a result of this experiment and our increasing understanding of the needs of the ACI concept in universities as well as our desire to play strongly to the vision and mission of UA, the Office of Research is proposing a new and more expansive role for AIME. To fit this role, we propose changing the name to the Alabama Innovation, Mentoring and Entrepreneur Center, thereby preserving our acronym while capturing the new role. A number of factors locally, nationally and globally lead OR to propose a change. These factors are:

- Shift from state supported to state assisted for university budgets drives the need for new funding streams.
- Bayh-Dole Act and other government polices require universities to commercialize IP.
- Corporations and industry will continue to invest less in early stage development due to market pressures to show a profit, forcing universities to engage in developmental or innovative research.
- Industry is not likely to license IP that is not developed to a commercial stage leaving universities with untapped IP.
- Venture capital rarely invests in startup companies for the purpose of bringing IP to a commercial stage making it hard for universities to spin off IP into startup companies. Biotechnology and IT are often exceptions to this rule.
- Universities need to become competent in building a compelling case for corporations to invest in our inventions (license game) and/or encourage entrepreneurs to invest their efforts in our inventions (startup company game).
- Innovation, the act of adding value to new knowledge or intellectual property, presumably for commercial purposes, requires a sustainable innovation ecosystem.
- The innovation ecosystem in a university requires people (faculty, staff and students) who already are part of the infrastructure as well as physical infrastructure.
- The mission of universities is to educate and train students in all facets of the competitiveness agenda in an integrated manner. Through our Entrepreneurship training, CEOs and CTOs will emerge to be integrated into these locally established start-up companies.

Universities traditionally are the principal generators of new knowledge and early stage IP. A conclusion to be drawn from the above facts is that they need to fill the innovation gap and position themselves higher on the commercial value chain by forming innovation research centers and engaging in R&D to add commercial value to IP. Such innovation centers should be in addition to an office of technology transfer and a business incubator and form part of an integrated system known as the innovation ecosystem. However, to carry out the broader vision of The University of Alabama as a student-centered research university, it is important that students and their education be an integral part of the innovation ecosystem.
How can we accomplish these multi-faceted goals at UA?

NEW AIME

The proposal of OR is that we reconstitute AIME and significantly enhance what is already being done, but emphasize and develop an innovation ecosystem driven by the involvement of both undergraduate and graduate students. Our plan is modeled on the thinking behind the “moot corp” program at The University of Texas at Austin, but takes a rather different form (see: http://www.mootcorp.org/). The plan also involves a modification of the strategy behind DARPA.

The “moot corp” program at UT involves running a business competition for funding new startup ventures. At UA we want to start with intellectual property that has been disclosed to UA, build an entrepreneurial team composed of faculty and students around a given IP, develop an innovation and marketing plan for the IP, compete the IP before a moot “venture capital (VC)” board composed of students and faculty, and send the winning IP into the innovation center labs (or other university labs as appropriate) for research development as well as legal, marketing and business development. We will then utilize the DARPA concept. This concept is one where a person or team gathers around a specific new concept and seed funds universities and others as part of a broad team to bring the concept to fruition for eventual military use. In AIME we will form similar teams to carry out research to add value to UA IP chosen by the moot VC process. Each team will also conduct the legal, marketing, and business analysis. The teams will be comprised of faculty, students and staff at AIME. The ultimate goal of these teams is to add value to the IP and to commercialize it through licensing.

Student involvement in AIME will be driven eventually through a new multi-disciplinary and multi-college entrepreneurial curriculum and program to be developed at UA. Major players will be the College of Commerce and Business Administration, the College of Engineering, and the College of Arts and Sciences. Student participation in AIME will include, but is not limited to, marketing research prior to investment in IP development (independent work or classroom projects), mock investment decision games on AIME investment in IP development (moot corp game), part-time research staff member, and marketing and sales of IP to the business and venture capital communities. The overall goal is to train UA students on how to start his/her own company or become a participant in these companies.

Students will learn how to protect intellectual property, form business models and recruit funding. They will be exposed to the companies in BTI and could provide an entrepreneurial team for a given company. We will have venture fellows brought into the university to help the incubating companies in BTI obtain funding. Students will work with these fellows. As part of their training, they will participate in writing SBIR/ STTR grants and assist the incubated companies in presenting business models/plans to venture capital and angel investors. Students will also be asked to participate in the moot corp exercise used by AIME to choose projects and to join entrepreneurial teams associated with the projects. There is an expectation that the students could join BTI companies since startups are always in search of business
executives or form new startups from AIME developed IP.

Some of the outcomes expected from the new AIME are:

- Generate resource/income from IP for UA through commercialization of IP.
- Provide experiential learning for students through entrepreneurial activities (marketing studies, moot corp, etc.) and research laboratory experience.
- Enhance UA research image.
- Foster local economic development (particularly if AIME creates, as opposed to incubates, startup companies).
- Develop Alabama-centric entrepreneurs.
- Attract industrial sponsored research and partnerships.
- Attract quality faculty because of existence of AIME.

ACHIEVING A CULTURE OF HIGH TECHNOLOGY ENTREPRENEURSHIP AT UA

To achieve these outcomes, UA will adopt for AIME an overall strategy of initially investing in AIME in order to assist it in its new mission and then in future years using some of the resulting increased royalty stream to grow the enterprise. Initially, we will invest limited resources and efforts targeted at the development work necessary to take our early stage IP with the highest probability of success to commercialization by adding value. As we become more successful at this, then we can take on larger funding and higher risk areas. We define value added as having IP developed to the point that there is a promise of commercialization in 2-3 years. This could include a market research document and business model/plan document for the specific IP. The vision of AIME will be “a culture of high technology entrepreneurship at UA.” The mission will be “to identify and facilitate value added innovation and foster entrepreneurship leading to commercialization of intellectual property.”

THE FUTURE

The University of Alabama through a revitalized AIME is poised to make significant advances in the commercialization of university IP and the startup of new high technology companies in Tuscaloosa and the State of Alabama. The plan presented herein is a roadmap to guide UA in the start of this new venture. The future begins now.
IV. AIME Facilities

The AIME building houses an Administrative Conference Room, Assembly Hall, Planning Room and Executive Meeting Room which are overseen and maintained by the AIME staff. These rooms, along with the Lobby and Administrative Kitchen are available to hold events and classes through an online reservation process that is accessible through the AIME website.

AIME implemented an online survey process in the year 2007 that is sent to the individuals that reserve and utilize the AIME rooms. The goal is to receive feedback that can be utilized to identify areas needing improvement and the areas that individuals are highly satisfied with. These results are reviewed and action plans are put into place to make improvements. A total of forty-eight surveys were sent out in the first three quarters of 2007 with 10 being completed and returned providing a 20.8% response rate.

The answers provided on the returned surveys provided the following information.

1. The areas having high level of satisfaction were:
   a) The ease of utilizing the online room reservation request.
   b) The clarity of the guidelines for the use of the facilities.
   c) Response time of the AIME staff to your email or voicemail.
   d) Professionalism and helpfulness of the AIME staff.
   e) Cleanliness of the facilities.

2. The areas needing improvement were:
   a) The room is too cold.
   b) Locating and the clarity of the media equipment instruction booklet in the Executive Meeting Room.
   c) Condition of furniture and equipment in the conference room.
   d) Not given access to the building for a weekend class.
   e) The metal stairs with the grooves are not conducive to women’s footwear.

Based upon this feedback the following action items have been identified and completed:
   a) Media equipment instruction booklets were placed in areas of easy access.
   b) Revised the front desk duties so that they include the proactive issuing of keys for weekend reservations.
   c) Omitted unnecessary information on AIME facilities guidelines.
   d) Routinely check the temperature in the rooms and reset the thermostats if needed.
   e) Purchased and replaced the computers in the rooms.

A trial period of utilizing hardcopy surveys in place of the online survey is being implemented in 2008 to see if this method will increase the response rate.
V. Student Awards & Recognition

An awards and recognition ceremony was held in AIME to honor the hard work and dedication of our students. AIME was honored by the presence of distinguished guests Dr. Judy Bonner, UA Provost; the Honorable Vanessa Leonard, UA Board of Trustees; and Dr. Marianne Woods, former UA Associate Vice President for Research.

<table>
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<tr>
<th>Student Awards and Recognition, Fall 2006 - Spring 2007</th>
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<td><strong>Outstanding Contributor</strong></td>
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<tr>
<td><strong>Alabama Launchpad Semifinalist</strong></td>
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<tr>
<td><strong>Elevator Pitch Participants</strong></td>
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<tr>
<td><strong>Research Poster Event Participants</strong></td>
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<tr>
<td><strong>Front Desk Distinguished Service Awards</strong></td>
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VI. Project Summaries

The projects developed by AIME are focused on adding valuation to UA Intellectual Property. Thus, each project has an associated supporting business plan and is positioned to present a licensing opportunity or to be the basis for a start-up company. The partnership developed with BASF has dictated much of the initial development work carried out within AIME. This is a direct result of the licensing deal in which BASF licensed five of The University of Alabama’s ionic liquid processing of cellulose technologies. These business opportunities were then presented to BASF for feedback, and potential commercialization. With feedback in hand, and a licensing agreement in place, AIME is advancing these technologies to launch start-up companies. In the following pages, we provide technical summaries of these projects.
A. Development of Controlled Release of Flavorants and Sugars for Application into the Functional Foods Industry

Objective
The average diet in the U.S. is composed of 90% processed foods and 10% whole foods. Processed foods, most of which contain large amounts of simple sugars and carbohydrates, result in large fluctuations in blood glucose levels. Processed foods also tend to offer very little nutritional value in terms of vitamins, antioxidants, and minerals; there is growing concern in the U.S. about the harmful effects of these foods. Food manufacturers are under constant pressure to innovate in order to keep up with consumer interests and demands. Not only do consumers want convenient foodstuffs with a long shelf-life, but they are also seeking more sophisticated foods, often with exotic or ethnic flavors. Consumers are also demanding foods that contain natural and organic ingredients, foods that can assist in weight control, and foods that can benefit their health in other ways. These market trends are impacting all levels of the food market including the additives sector, with the manufacturing sector passing on some of the responsibility to satisfy these demands to their suppliers. As a result, certain sectors of the additives market are seeing growth in natural products, such as cellulose, at the expense of synthetics. There is increasing demand for fat replacements and sweeteners in the weight control market and explosive demand for functional food ingredients in the nutraceuticals market. A functional cellulose additive will allow the slow release of sugar and flavor agents, maintaining healthy blood glucose levels while extending flavor release. This will help control the fluctuation in blood glucose levels that often results in unhealthy eating habits and future medical complications.

Figure 1: Blood Glucose Level Comparison (normal vs. controlled release)
The nutraceuticals market is growing rapidly as public awareness of functional foods advances, and as the abundance and quality of nutraceutical products increases. The primary driver behind the nutraceutical market growth is the recent cooperation of nutritional and medical sciences. In the past, the U.S. medical field did not place emphasis on the ability of food products or ingredients to therapeutically affect human health. Now, however, the medical community is studying the effects of phytonutrients, antioxidants, flavanoids, probiotics, anthocyanins, and many other potential therapeutic food compounds. The market for nutraceuticals was valued at $23.5 billion in 2006, up $6.3 billion since 2001. With 25% of sales, infant nutrition is the dominant category in the nutraceuticals market. Nutritional drinks for both weight loss and weight gain make up 10% of the market. Energy and performance bars are 6.3% of the market and comprise the fastest growing product category in the nutraceutical market.

The major goal of this project is to create an edible cellulose vehicle which can encapsulate a diverse range of nutritional and nutraceutical compounds including flavor agents, sugars, and vitamins. The objective of this project is the encapsulation and controlled release of several model compounds and the demonstration that a consistent level of nutritional compounds can be delivered for an extended period of time.

**Approach.**
The ability to design micro-scale cellulose beads for controlled delivery of nutritional and nutraceutical compounds is dependent upon the successful completion of the following specific milestones:

i. The conjugation of active model compounds to polymer linkers
ii. The encapsulation of polymer-bound model compounds in cellulose matrices
iii. The formation of cellulose micro-particles of consistent size and form
iv. The characterization of release profiles and byproducts as a result of hydrolysis

**Development of molecular scaffolds providing time-dependent release of active ingredient.** The first step in the process involves the functionalization of the polymer building block to attach the active ingredient to the cellulose bead. Commercially available polyetheramines are functionalized through reactions with both glycidol and ethylene oxide resulting in the formation of hydroxyl groups replacing the amine groups. The nucleophilic hydroxyl groups on the linker react with the electrophilic active ingredient to form an acetal bond, in the case of flavorants. An alternative pathway involves the oxidation of the hydroxyl groups to aldehydes, which then form acetals with sugars. The molecular scaffold (functionalized polymer plus active ingredient) is incorporated into the cellulose beads during bead formation. The beads are formed by dissolution and regeneration of cellulose in ionic liquids. The solution is stirred to create shear stress, which leads to bead formation. The objective is to make cellulose beads with different concentrations of imbedded versus surface-bound active ingredients. This approach will take advantage of the projected 3D conformation of different polyetheramines in the ionic liquid, which will be used to control both the release rate and the dosage of released active ingredient. The result will be a nutritional device that slowly releases sugars and flavorants.
Synthesis of Molecular Scaffolding. The two critical links in the molecular scaffold are the polyetheramine-linkage and the active ingredient bond (acetal). Since the active ingredient release rate depends on hydrolysis of the acetals, the overall objective is to optimize the yield of acetal formation. The polyetheramine will be reacted with glycidol to form the functionalized polymer. The hydroxyl functionality will be used as the starting material for the acetal formation, as shown below in 1A and 1B.

When attaching flavorants, it is necessary to catalyze the reaction with the functionalized polymer. The current catalyst of choice is vanadyl triflate, which has been shown to effectively form acetals between diol substrates and aldehydes with greater than 90% yields (12). When attaching sugars, the hydroxyl groups will be oxidized to aldehydes using pyridinium chlorochromate, which is effective in converting alcohols to aldehydes with yields greater than 90% (13). Sugars will be attached to the aldehydes using the same technique used with the flavorants.

Bead Formation and Encapsulation. Cellulose beads will be formed using a proprietary method that involves dissolving cellulose in an ionic liquid, creating shear stress to form cellulose spheres, and thorough
rinsing to remove residual ionic liquid. Encapsulation of the polymer and active ingredient involves adding the product into the ionic liquid/cellulose solution at the start of the above process. The size and size distribution of the beads will be optimized, and the impact of size on external to internal acetal formation will be determined. Size and size distribution will be controlled by stirring speed, which manipulates the shear stress in solution.

Conformation Analysis and Optimization of Release Mechanism. The release mechanism of the active ingredient is based on the hydrolysis rate of the acetal bond in the molecular scaffold. When subjected to a slightly acidic environment, the acetal bonds break, cleaving the active ingredient and releasing it into solution. The hydrolysis solution will closely mimic that of stomach acid (pH 2-4). The hydrolysis rate will be determined for the various combinations of polyetheramines and active ingredients. This will be done by logging the absorption over a period of time with a UV/Vis spectrophotometer. The active ingredients absorb at specific wavelengths, and the concentration profile will be determined by comparing the accumulated absorption with a calibration curve. The correlation between bead size and external/ internal acetals will be analyzed through a systematic investigation of the hydrolysis rate.

Results
Jeffamine D2000 (Huntsman Corp) was reacted with glycidol in a three-neck round bottom flask for four hours under vigorous stirring in 50 mL of tetrahydrofuran (THF). The THF was evaporated and the product analyzed by FTIR and NMR spectroscopy. The IR spectrum shows OH stretching, indicative of the formation of hydroxyl groups. The functionalized polymer was then reacted with benzaldehyde dimethyl acetal and analyzed by IR and NMR spectroscopy. The IR spectrum shows the presence of an aromatic ring and the reduction of the OH stretch. The NMR data shows a shift corresponding to an acetal and aromatic ring. Cellulose was dissolved into an ionic liquid and the product was added to the solution. Beads were formed by adding the solution to polypropylene glycol stirred at 850 rpm. The beads were then filtered from solution and washed with copious amounts of water. An optical micrograph of the beads is shown in Fig. 1. The presence of bands in the ethylene oxide region of IR spectra showed the product (polymer and benzaldehyde dimethyl acetal) was encapsulated into cellulose beads. The rinse water was tested for residual product and a reduced amount was found by both spectrophotometry and IR. Further investigation was necessary to verify that the product can be encapsulated into the beads and that slow release of the active ingredient can be achieved.
Beads were also made by the above method with Jeffamine T5000 in place of D2000. The beads were stored in deionized water and the solution was scanned using a Perkin Elmer UV/Vis spectrophotometer from 500 to 200 nm to obtain an initial measurement for the hydrolysis investigation. A small peak at 250 nm indicated the hydrolysis of a very small amount of active ingredient in DI water. Dilute acid (pH ~2) was added to hydrolyze the acetals. To monitor the hydrolysis, UV/Vis measurements of the solution were taken over 44 hrs. The active ingredient was released between one and 24 hours and remained constant afterward. The resulting data are shown in Figure 1. These results indicate that slow-release ingredients can be achieved via cellulose bead encapsulation of an appropriate molecular scaffold. Future work involves developing the process to extend to a wider variety of active ingredients.
B. Hydrophilic/hydrophobic block copolymers for enhanced adhesion between cellulose/polypropylene blends

Objective
The markets for thermoplastics resins are over $30 Billion per year. There currently is a growing need for the introduction of bio-based polymers into these markets. However, combinations of cellulose and polypropylene are normally difficult because the former is a hydrophilic polymer and the latter is a hydrophobic polymer.

By preparing a block copolymer containing both hydrophobic and hydrophilic regions, AMAPPA (amine maleic anhydride polypropylene adduct), to be used as a coupling agent we have prepared cellulose/AMAPPA/polypropylene laminates. We report here the strength properties of composites prepared from AMAPPA/cellulose blends at 1, 5, 10, 15, 20, 25, 35, and 50 % AMAPPA by weight of cellulose and the resulting adhesion of these blends laminated to polypropylene sheets.

Approach
In this work we demonstrate the potential for use of a hydrophilic/hydrophobic block copolymer from samples provided by Huntsman Specialty Chemical Co. prepared by reaction of a polyetheramine (PEA) and maleic anhydride polypropylene (MAPP) as coupling agents for microcrystalline cellulose (MCC)/polypropylene (PP) composites.

Results
Films with varying amounts of the polypropylene polymer AMAPPA, amine maleic anhydride polypropylene adduct, ranging from 1-50%, were made. The films contain 1%, 5%, 10%, 15%, 20%, 25%, 35%, and 50% AMAPPA to cellulose. The more AMAPPA in the film, the more opaque and the more plastic-like it became.

As shown below, increasing the amount of AMAPPA in the cellulose membranes increased the films opacity and wrinkling. Higher concentrations of AMAPPA resulted in more ‘plastic-like’ membranes, making drying difficult and causing the wrinkles.
The membranes were tested before lamination with PP, and compared to the plain cellulose. In general, failure strength and modulus decreases, but failure strain increases due to AMAPPA incorporation in cellulose (see Table 1).

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<th>% AMAPPA in MCC film</th>
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<th>Ultimate stress, su (MPa)</th>
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<td>3.55</td>
<td>9.16</td>
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The ability of the AMAPPA-cellulose membrane blends to bond to either polypropylene or cellulose films was investigated. Adhesion of the AMAPPA-MCC composites was only observed to occur to PP at 35 % & 50 % AMAPPA on cellulose.

<table>
<thead>
<tr>
<th>% AMAPPA in MCC film</th>
<th>Bonding to PP film</th>
<th>Bonding to MCC film</th>
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<td>50</td>
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* (+) Bonding observed; (-) Bonding not observed
Objective
In the U.S. renewable energy market about $2.5 Billion was sent on research and development by corporation and $1.5 Billion by the government in 2006.
The call for cellulosic ethanol, a non-food source is mounting. The ability to produce ethanol from cellulose is being actively investigated by AIME researchers.
Enzymatic hydrolysis of cellulose by cellulase proves to be time consuming and incomplete. For this project, the hydrolysis kinetics and degree of hydrolysis of varied types of regenerated celluloses using cellulase were explored. By conversion of the crystalline regions that exist within cellulose molecules to wholly amorphous cellulose, one can observe significant increases in the amount of cellulose hydrolysis by cellulose enzymes. In order to further enhance this effect, AIME researchers studied the ionic liquid dissolution of microcrystalline cellulose followed by reconstitution of the cellulose in aprotic (nonpolar) solvents such as acetone and diethyl ether.

Approach
Preparation of Calibration Curve
A calibration curve was prepared by using a glucose solution at different concentrations and measuring the absorbance at 635 nm using a Spectronic 21D UV-Vis spectrophotometer. Five working standard tubes were prepared at 5, 10, 15, 20, and 25 mg/dL glucose. In six test tubes, 0.1 mL of water and 0.1 mL of the five concentrations of glucose standards were added, then 5 mL of o-Toluidine reagent was added to each test tube. The samples were heated in a boiling water bath for exactly 10 min, then set in a cooling bath for approximately 3 minutes. The glucose solution and o-Toluidine reagent react in heat to form a blue-green colored complex that can be quantified by measuring absorbance at 635 nm.

Preparation and Reaction of Cellulose Samples
Microcrystalline cellulose was dissolved in ionic liquids (1-butyl-3-methylimidazolium chloride) followed by reconstitution in three types of solvents in an attempt to interrupt the rigid structure of cellulose so that enzymatic hydrolysis can be more successful. Water, acetone, and diethyl ether were used as antisolvents for precipitating cellulose from the ionic liquid.

Enzymatic Hydrolysis of Cellulose Samples
Enzymatic hydrolysis of regenerated and untreated samples of cellulose was carried out at 50° C in a reciprocating shaker incubator of 150 rpm. A 3 mL solution of pH 4.8, 0.05 M citrate buffer and the enzyme Trichoderma reesei cellulase was added to each 50 mg sample of cellulose. 10 milligrams of enzyme was used per sample of cellulose. The enzyme reaction was monitored by periodically withdrawing 0.1 mL samples from each of the vials and measuring the release of soluble reducing sugars using the o-Toluidine reagent. Each sample was treated as the glucose standards were treated for the calibration curve described above.
Results
In the graph below there is a significant increase of reducing sugars in the regenerated samples. In the acetone and diethyl ether treated samples, almost 100% of the cellulose was reduced to soluble glucose. The water treated sample had a slightly better result than the untreated microcrystalline cellulose.
D. Film Extrusion

Objective
To support our efforts to penetrate the thermoplastic market with a bio-based polymer. AIME needed to improve the quality and the reproduceability of films produced for studies. AIME researchers designed and developed a laboratory film extrusion system for film regeneration. This was necessary in order to reproduce the same regeneration process every time. A schematic is provided below.

This included a die for ionic liquid-cellulose melts to form a thickness of 100 microns and a width of 2 inches. The melt then submerges into a tub of water and goes through a series of six spools, driven by a chain, with a motor mounted on the back. The bath should remove the Ionic Liquid from the cellulose and leave a film. Film extruder in operation is shown at right.

Results
Below are the powder XRD spectra for three cellulose film samples: a commercially prepared cellophane film; a cellulose film prepared using our extruder; and a cellulose film prepared by casting on glass plate. For the first two film samples, the first peak occurs at 12.5° and second peak at 25.6°; For the cast film there is only broad peak around 20°.

One readily observes from the graph below the completely amorphous nature of the cellulose film prepared by dissolving in emimCl and casting on a glass plate. Another easily observable feature of the graph below
is how well our extruded cellulose film compares to highly ordered commercially available cellophane (195 LST).

A comparison study of cellulose films prepared by casting and by extruding was conducted with respect to orientation to a pair of polarized filters at 90 degrees to each other. Cellulose molecules are optically active which simply means they can rotate polarized light. When all the cellulose molecules within a cellulose film are oriented in the same direction the cellulose film can behave like a polarizing filter. By sliding the cellulose film between the two polarized filters, one can readily observe the effect processing has on orientation of the cellulose molecules in the film.

In the figure below, the dark is with the sample aligned with the bottom or the top polarizer (0 or 90 degrees). One polarizing filter below and one polarizing filter above the sample (strictly speaking, the bottom one is called the polarizer and top the analyzer). The brightest position for the sample is at 45 degrees to the polarizer and analyzer, and when the cellulose sample is highly oriented the polarized light will be rotated enough to pass through the ‘analyzer’ filter. This is good evidence that we have high orientation of cellulose molecules in our extruded films.
E.  Alabama Launchpad

The University of Alabama has united with five other state universities and the Birmingham-based Economic Development Partnership of Alabama (EDPA) to develop the Alabama Launchpad Business Plan Competition. This four-phase business plan competition is unique in that it is the first of its kind to involve multiple universities.

Competing teams are comprised of university students, faculty, staff researchers, alumni of no more than five years, and former university faculty of no more than three years. Winning competitors receive up to $100,000 in cash prizes as well as in-kind services.

“This is an exciting business-university alliance that will help entrepreneurs at these institutions get their companies and ideas off the ground,” says Alabama Launchpad Director Glenn Kinstler. “There is so much ground-breaking research being conducted at all of the participating institutions. Getting these ideas into the marketplace will undoubtedly strengthen the state’s economy. Other communities like Boston, Silicon Valley and Raleigh, N.C. have done this successfully for years.” Kinstler graduated from The University of Alabama College of Communication and Information Sciences in 1995 with a Bachelor’s degree in Public Relations.

Dr. Daniel T. Daly, Chairman of the Alabama Launchpad Board of Directors stated that “the level of interest in entrepreneurial endeavors at The University of Alabama is extremely high. I am confident that our faculty, staff and students will participate in this state-wide business plan competition.”

Results:  Forty-one teams total registered to participate in Alabama Launchpad. Twelve of those teams are from The University of Alabama. Alabama Launchpad’s inaugural competition included only seven teams from UA. Of those seven, four teams are from AIME. Eleven of the twelve teams advanced to the semifinals, including all four of the AIME teams.

The four AIME team business plans will be made available to any start-up company that wishes to explore these opportunities. Working closely with the Office for Technology Transfer, we will encourage the use of these plans for high technology start-up companies.

Other participating universities include: Alabama A&M University, Alabama State University, Auburn University, The University of Alabama at Birmingham and The University of Alabama in Huntsville.
VII. Student Triage Team Invention Disclosure Summaries

In 2007, AIME received 37 invention disclosures through the Office of Technology Transfer and our student triage teams have successfully completed and presented business models for 34 of these disclosures. The required formats of the business models are a PowerPoint presentation, a patent and prior art search spreadsheet, and a one page summary. There were 22 of the 34 completed business models that were utilized by the inventors in their presentations to the IP Committee. The other 12 business models either provided findings that showed that the invention was not patentable or that it may need further research or refinement.
VIII. Meetings, Presentations, Proposals and Publications

Much of the efforts listed below are a result of AIME continued support of the Southern Alliance for the Utilization of Biomass Resources (SAUBR):

SAUBR continues to provide valuable information to its members in Government, Academia, Industry, and private land-owners in the form of e-letter updates.

Within the State of Alabama:

1) Recommended potential members to serve on Gov. Riley’s and Commissioner Sparks Alternative Energy Committee.

2) Assist Clarence Mann of ADECA with disseminating information and federal solicitations to SAUBR members.

Presentations:


Meetings Attended:


2) Energy Knowledge Seminar, Hager Oil, October 17, 2007, Jasper, AL.

Publications


Chem. 2007, Accepted.


Proposals (Funded/Pending/Declined):


2) DOE EPSCoR proposal, “Engineered Lightweight Multiscale Materials & Structures for Energy Efficient Transportation,” w/ Prof. Anwar Haque & Prof. Robin Rogers at UA, and in cooperation with UAB, AU, and TU; UA Budget - $435,000, Declined.

3) USDA Pre-proposal, “Processing MSW Cellulose for Placement in Petrochemical and Energy Markets,” w/ Prof. Robin Rogers, Robin Curtis & Dr. Karen Boykin; $550,000, Declined.

4) USDA Pre-proposal, “Exploiting Ionic Liquids: Separating Cellulose, Hemicellulose, and Lignin,” w/ Prof. Robin Rogers, Prof. Joe Ng (UAH) and Radiance Technology - Pending


Collaborative/Exploratory Meetings:

1) Westervelt Co. - Moundville, AL
2) Billy Watson – CEM Machine, Inc.
3) Billy Symon - Rock-Tenn Corp. - Demopolis, AL
4) Bob Smith & Scott Smith - Precision-Husky Chipper – Leeds, AL
5) Peter Brandsma - Hager Oil – Jasper, AL
6) Raymond Bean & Beryl Nichols (American Forestry Association)
7) Alabama Biodiesel – Moundville, AL
8) Jim Kimble - ConocoPhillips
9) Prof. Roy Broughton – Auburn University
10) Jess Hornsby
11) Prof. Ken Marsh
12) Nippon Chemicals
13) Gene Quick
14) Aaron Hammon & Mika Harvey