Georgia Tech Institute of Paper Science and Technology NEWS
May 2013

IPST Executive Conference Focuses on Industry Transformation for Future Success

Thirty-four students exhibited at the 2013 Executive Conference Poster Session.

Transformation strategies will be required for the forest bioproducts industry to thrive 20 years from now, according to the outcome of an annual Executive Conference of the Institute of Paper Science and Technology at Georgia Tech (IPST) in April. The industry will be facing an emerging global middle class, a burgeoning population and higher demand for critical resources, based on futurists' forecasts.

Norman Marsolan

"IPST research is playing several roles in looking toward the future," said Norman Marsolan, Director of IPST at Georgia Tech. "We are focused on improving the pulp and paper processes for the existing industry, while searching for innovative new products that will meet consumer demands in the future."

Ron Brown

Dr. Ron Brown, president of the Agenda 2020 Technology Alliance, presented a series of predictions based on his recent study of existing industry forecasts, commissioned by IPST. While global demand for traditional paper products could increase 1.5 percent a year over the next 40 years, the industry may see a global pulp shortage by 2020, and wood removals by 2050 may occur at three times the current rate. The forecasts call for mills to become host platforms for new bioproducts, and they will be pressured to show significant reductions in emissions, waste, and use of energy and water.

"Today's technologies are not sufficient," Brown said. "Sustainable manufacturing will require new technologies." There was significant support among the 25 participating organizations for research that advances the manufacturing capabilities of today's pulp and paper companies.

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Executive Conference

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Sten Nilsson, CEO of Forest Sector Insights, Sweden, said," Only systematic change will keep pace in the rapidly changing world. The U.S. is not alone –the entire Northern hemisphere is in the same situation." He cited a 15 percent net loss of U.S. capacity for paper and paperboard since 2000. Projected increases in pulp production will serve a U.S. export market, which will have to grow.

Sten Nilsson

G.P. "Bud" Peterson

"Through IPST, your industry has access to the full range of our research and expertise," Georgia Tech President G.P. "Bud" Peterson told the conference participants. "More importantly, our experts across Georgia Tech have a portal into the industry with expertise on cellulose and its practically unlimited potential. Bring us your problems – we have lots of answers."

"We also want to continue to listen to you, the experts in the field, as we move forward with new innovations and solutions for the industry," Peterson said. "As a world-class educational and research institution, we can offer even more to progressive companies like yours, companies willing to look 20 years into the future to evaluate the implications, opportunities, and challenges that most certainly will be different from those we face today."

IPST is a leading forest bioproducts research organization that engages 50 students a year in forest bioproducts research. IPST research today involves the pulp and paper industry and future developments in sustainable energy (biofuels), sustainable chemicals, advanced packaging, pharmaceuticals, electronics, advanced materials and others. The Institute, dedicated to supporting the pulp and paper and related industries, has produced more than 1,500 graduates with advanced degrees since 1929. For more information, go to www.ipst.gatech.edu.

To see PDF versions of the Conference presentations:
http://www.ipst.gatech.edu/exec_conf/2013/presentations.html.

Dr. Stephen Cross, Executive Vice President for Research, Georgia Tech

Gen. Ron Johnson, Managing Director, Tennenbaum Institute at Georgia Tech

Dr. Arthur Ragauskas, Chemistry and Biochemistry at Georgia Tech

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Dr. Paul Baker, Associate Director,
Center for 21st Century Universities

Ken Matthews,
AkzoNobel Chemicals

Dr. Sujit Banerjee,
Chemical and Biomolecular Engineering

Dr. Beril Toktay,
Professor of Operations
Management,
Scheller College of Business

Don McConnell,
Executive Director
of Industry Strategy and
Commercialization

Chris Leuttgen, Kimberly-Clark

Jennifer Jarratt, Principal,
Leading Futurists LLC

Ray Heuchling, Heuchling Group

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Executive Conference Dinner at the Historic Academy of Medicine

Dr. Tim Lieuwen,
Executive Director,
Strategic Energy Institute

Ron Brown, Agenda 2020; Gregg Reed, Imerys;
Kim Nelson, American Process

Harshad Pande, Domtar Paper, with student Hongzhi Wang

Student Poster Presenters

Rededication Celebrates IPST Traditions and Future Outlook at Georgia Tech

A look into future challenges and opportunities for the forest bioproducts industry sprang from a glance back in time at the 20th anniversary rededication ceremony for the Paper Tricentennial Building at Georgia Tech last week. Guest speakers addressed the challenge of building on the legacy of the Institute of Paper Science and Technology (IPST) to prepare for the future.

Pete Correll

Pete Correll, former chairman and CEO of Georgia-Pacific and former chairman of the IPST board of trustees, said, "This is where ideas have blossomed into technologies, which have blossomed into alternatives, into viable concepts. May you continue to be that place where things happen."

Carl Landegger

Carl Landegger, a member of the International Paper Hall of Fame and a former chairman of the IPST board of trustees, who led Parsons & Whittemore and Black Clawson, addressed the future of the forest bioproducts industry by saying, "We'll solve the problem by making new products."

Jim Ferris

Alumni, former IPST executives such as past president Jim Ferris, and Georgia Tech officials rounded out the guest speaker list. They addressed the history of IPST and its move to Atlanta from Appleton, Wis., in 1989, the long legacy of the Institute of Paper Chemistry (IPC) since its founding in 1929, and its contributions to industry success. IPC became the Institute of Paper Science and Technology upon its move to Atlanta.

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Rededication

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Georgia Tech executive vice president-research Steve Cross commented that IPST is emblematic of Tech's tri-fold strategy of Research, Partnership, and Impact, a model he hopes to propagate across the campus.

Steve Cross

Norman Marsolan

"We are a product of 84 years of heritage, focused today on the forest bioproducts potential in the future," said IPST director Norman Marsolan. "We have produced more than 1,500 graduates with advanced degrees, many of whom are leaders for pulp and paper and related companies today. Our research programs at IPST are providing a path for the enhancement of pulp and paper production, while setting a course for entirely new products that will meet the demands of future markets."

The rededication featured contrasting presentations by the old and the new. George L. Clarke,(MS'37, PhD'39), the oldest living alumnus, addressed the group by recorded message, describing his recruitment to the Institute in 1935 and his impression when he arrived. "They got together the most fantastic group of people I have ever heard of."

Kim Nelson

American Process Inc. vice president Kim Nelson (MS'04, PhD '07), provided a recent perspective on the IPST program, noting that the Institute is "at the entrepreneurial forefront of the forest bioproducts industry." Georgia Tech School of Chemical and Biomolecular Engineering chair Ron Rousseau, who twice served as interim IPST director, noted the collegiality and leadership of the Institute over the years.

Ron Rousseau

The five-story Paper Tricentennial Building was constructed and equipped at a cost of $68 million in 1993, complete with 64 laboratories and 68 fume hoods. It also is the home of the Robert C. Williams Museum of Papermaking. The building was jointly funded by the State of Georgia and private industry. IPST currently engages 50 graduate students a year.

IPST research today involves the pulp and paper industry and future developments in sustainable energy (biofuels), sustainable chemicals, advanced packaging, pharmaceuticals, electronics, advanced materials and others.

Rededication Dinner

ARAUCO Joins IPST as Corporate Member

Latin American forestry company ARAUCO Investigaciones Forestales Bioforest S.A. is a new corporate member of the Institute of Paper Science and Technology (IPST). Celulosa Arauco y Constitución S.A. (ARAUCO) is one of the major forest products companies in Latin America, with 2011 sales exceeding US$4.3 billion. The company employs more than 35,000 through its industrial operations in Chile, Argentina and Brazil, in addition to its network of sales offices around the world.

"We welcome ARAUCO and look forward to a productive relationship," said IPST director Norman Marsolan. "They add another dimension to our international roster of high-profile forest bioproducts companies."

ARAUCO operates in five business segments:
Forestry: ARAUCO's forest land is distributed throughout Chile, Argentina, Brazil and Uruguay with 2.5 million acres of forest plantations, 963,700 acres of native forest and 484,300 acres assigned for other purposes.
Woodpulp: The company produces 3.2 million tons per year of bleached and unbleached market Kraft pulp.
Timber: A total of 2.8 million cubic meters a year are produced in Chile and Argentina.
Panels: 3.2 million cubic meters a year are produced in Chile, Argentina, Brazil, USA and Canada.
Bioenergy: In Chile, ARAUCO provides electric energy for its industrial operations through its cogeneration power plants, which sell to Chile's energy grid. ARAUCO also has two cogeneration power plants in Argentina that supply electric and thermal energy to its production facilities in Piray and Esperanza.

ARAUCO owns 963,700 acres in Chile for preservation, research and conservation purposes. The company conducts conservation, preservation and research in more than 407,700 acres of native forest in Chile, Argentina and Brazil. In Chile, there are 155,600 acres classified as High Value Conservation Areas, rich in biodiversity and social and cultural attributes.

ARAUCO has been contributing to education for 28 years. It manages three schools: Colegio Constitución, Colegio Cholguán and Colegio Arauco. Through Arauco Educational Foundation, established in 1989, the company contributes to the improvement of municipal education. The Foundation has benefited 557 schools, 4,700 teachers and more than 85,000 students.

Trees Used to Create Recyclable, Efficient Solar Cell


Bernard Kippelen

Georgia Institute of Technology and Purdue University researchers have developed efficient solar cells using natural substrates derived from plants such as trees. Just as importantly, by fabricating them on cellulose nanocrystal (CNC) substrates, the solar cells can be quickly recycled in water at the end of their lifecycle. The technology is published in the journal Scientific Reports, the latest open-access journal from the Nature Publishing Group. Georgia Tech College of Engineering Professor Bernard Kippelen led the study and says his team's project opens the door for a truly recyclable, sustainable and renewable solar cell technology.

The researchers report that the organic solar cells reach a power conversion efficiency of 2.7 percent, an unprecedented figure for cells on substrates derived from renewable raw materials. The CNC substrates on which the solar cells are fabricated are optically transparent, enabling light to pass through them before being absorbed by a very thin layer of an organic semiconductor. During the recycling process, the solar cells are simply immersed in water at room temperature. Within minutes, the CNC substrate dissolves and the solar cell can be separated easily into its major components.

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Solar Cell

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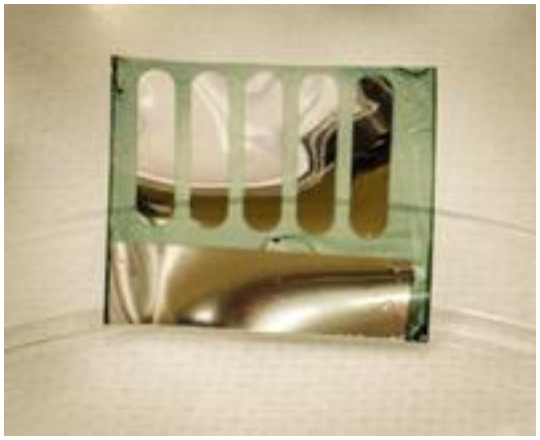

Solar cell made from trees

Photograph of a solar cell fabricated at Georgia Tech on nanocellulose substrates derived from trees. Photo courtesy of Canek Fuentes-Hernandez

"The development and performance of organic substrates in solar technology continues to improve, providing engineers with a good indication of future applications," said Kippelen, who is also the director of Georgia Tech's Center for Organic Photonics and Electronics (COPE). "But organic solar cells must be recyclable. Otherwise we are simply solving one problem – less dependence on fossil fuels – while creating another – a technology that produces energy from renewable sources but is not disposable at the end of its lifecycle." To date, organic solar cells have been typically fabricated on glass or plastic. Neither is easily recyclable, and petroleum-based substrates are not very eco-friendly. For instance, if cells fabricated on glass were to break during manufacturing or installation, the useless materials would be difficult to dispose of. Paper substrates are better for the environment, but have shown limited performance because of high surface roughness or porosity. However, cellulose nanomaterials made from wood are green, renewable and sustainable. The substrates have a low surface roughness of only about two nanometers.

"Our next steps will be to work toward improving the power conversion efficiency over 10 percent, levels similar to solar cells fabricated on glass or petroleum-based substrates," said Kippelen. The group plans to achieve this by optimizing the optical properties of the solar cell's electrode.

Purdue School of Materials Engineering associate professor Jeffrey Youngblood collaborated with Kippelen on the research. A provisional patent on the technology has been filed with the U.S. Patent Office.

There is another positive impact of using natural products to create cellulose nanomaterials. The nation's forest product industry projects that tens of millions of tons of them could be produced once large-scale production begins, potentially in the next five years.

The research is the latest project by COPE, which studies the use and development of printed electronics. Last year the center created the first completely plastic solar cell.

This research was funded in part through the Center for Interface Science: Solar Electric Materials, an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences under Award Number DE-SC0001084 (Y.Z., J.S., C.F., A.D.), by the Air Force Office of Scientific Research (Grant No. FA9550-09-1-0418) (J. H.), by the Office of Naval Research (Grant No. N00014-04-1-0313) (T.K., B.K.), and the U.S. Department of Agriculture –Forest Service (Grant No. 12-JV-11111122-098). Funding for CNC substrate processing was provided by USDA-Forest Service (Grant No. 11-JV-11111129-118) (R.J.M., J.P.Y., J.L.). The authors thank Rick Reiner and Alan Rudie from the U.S. Forest Service- Forest Products Laboratory (FPL) for providing CNC materials.

"Breaking New Ground" at Papermaking Museum

The Robert C. Williams Papermaking Museum at Georgia Tech has opened Breaking New Ground, a retrospective look at the Institute of Paper Science and Technology (IPST) over 84 years. Beginning with the early days in Appleton, the exhibit provides an account of the history of the organization and highlights some of the numerous research successes. The exhibit is an engaging narrative that helps to put faces onto an organization that has had a significant impact on the dynamic pulp and paper industry since 1929.

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Museum

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In addition to housing renowned expert Dard Hunter's papermaking collection, the Museum is the repository for the photos, artifacts, and journals of the Institute. These records provided the basis for Breaking New Ground, and presented a rich history of the development of the Institute. A large timeline, represented as the growth rings of a tree, adorns one gallery wall. Visitors will discover some of the people who made the Institute such an important place, and learn about research projects such as tree genetics.

IPST comprises numerous forest bioproducts research areas, and a few are highlighted within the exhibit. Developing forestry practices, including tree cloning, begin the research side of the exhibit. The processes of mechanical and chemical pulping are explained, and the recovery of chemicals, gasification, and corrosion are illustrated. The exhibit delves into paperboard container research and testing and how IPST developed a non-destructive way to test finished paper.

Exhibit visitors also will be able to get a glimpse into the future of IPST and the industry. The conclusion of Breaking New Ground explores the current scientific direction in which the Institute is headed. This emphasizes that the Institute is looking to the future and beginning to answer questions that are being conceived only now. The founding faculty would be proud to see the long-standing impact their students and research have had.

Museum Director Teri Williams worked closely with Kathy Dixson of Avient Museum Services to develop the content of Breaking New Ground. They approached the exhibit from multiple perspectives: from the people and events that made up the Institute to the scientific issues that students and faculty tackled to improve the pulp and paper industry. To help explain the intricacies of the scientific research areas, former IPST faculty member Dr. Gary Baum provided valuable content to explain high-level concepts, simplified for easy understanding.

Breaking New Ground will be open through the summer. The Robert C. Williams Papermaking Museum is open from Monday through Friday from 9-5. Admission is free, donations are accepted. The Museum is at 500 10th Street NW, Atlanta, GA 30332.

Qining Sun Studies Poplar as Energy Crop and Source of Cellulose Nanowhiskers for Novel Film

Poplar lignocellulosics bioconversion to fermentable sugars and their utilization for novel biocomposites development is the subject of extensive research being done by Qining Sun, Institute of Paper Science and Technology Fellow and graduate student in Paper Science and Engineering, School of Chemistry and Biochemistry, at Georgia Tech. One segment of Qining's research received the Institute of Paper Chemistry Foundation's $10,000 award for innovative research in forest bioproducts this year, as part of the 2013 Georgia Tech Research and Innovation Conference.

His presentation was entitled, "Comparison of Changes in Cellulose Ultrastructure during Different Pretreatments of Poplar." His advisor is Professor Art Ragauskas, Chemistry and Biochemistry.

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Qining Sun

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Qining Sun

Qining explains that from lignocellulosic biomass, cellulose and hemicellulose are amenable to produce ethanol and other alcohols by their enzymatic hydrolysis to hexose and pentose, followed by fermentation. Due to the complex nature of biomass, pretreatment is used to break down the lignin structure and disrupt the cellulose crystalline structure, whereby enzymes can access and hydrolyze the cellulose and hemicellulose.

He is involved in three studies, the first of which aims to establish the effect several leading pretreatment technologies have on cellulose crystallinity, crystalline allomorph distribution, and ultimately cellulose ultrastructure in poplar, a prospective energy crop, as it relates to changes in enzymatic hydrolysis. Hot-water, organo-solvent, lime, lime-oxidant, dilute acid and dilute acid-oxidant pretreatments are compared in terms of changes in cellulose ultrastructure as well as carbohydrate/ lignin distribution, cellulose degree of polymerization (DP) and cellulose crystallinity.

His second study aims to investigate the lignin effect and redistribution on cellulose ultrastructure during dilute acid pretreatment, to better understand the complex mechanisms occurring during lignocellulosic deconstruction. Enzymatic sugar release assays, 13C cross polarization and magic angle spinning (CP/MAS) nuclear magnetic resonance (NMR), gel permeation chromatography (GPC), X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR) and high performance anion exchange chromatography with pulsed amperometric detection (HPAEC-PAD) for sugar analysis were applied to investigate how cellulose crystallinity, crystalline allomorph relative proportion and fibril dimensions, along with other signatures of degradation, respond during pretreatment as a function of lignin content.

Qining's third study is to isolate poplar cellulose crystalline parts as cellulose nanowhiskers to prepare novel biodegradable films with hemicellulose and crosslinker. Poplar cellulose nanowhiskers have been isolated and measured by Atomic Force Microscopy (AFM) in nano-scale: around 4.5 nm in width and 675 nm in length, which make film that has fascinating properties, such as transparency, high modulus, high strength and minimal thermal expansion, for potential packaging and information-transfer medium utilization.

An active member and officer of the TAPPI Student Chapter at Georgia Tech, Qining earned his chemical engineering Bachelor's degree and Master's in Engineering Wood Science and Technology in China prior to enrolling at Georgia Tech for his PhD. He expects to complete his doctoral work in December 2014.

Tyrone Wells Studies Potential of Lignin as Carbon Fiber Precursor

Can carbon fibers produced from lignin provide a cost-effective alternative to today's costly carbon fiber production? Tyrone Wells, a Georgia Tech PhD candidate directed by Professor Art Ragauskas, will be spending a year in Sweden through the Gunnar Nicholson Fellowship Program to further study this very possibility of more optimal carbon fiber derivatization from forest bioproducts.

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Tyrone Wells

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Carbon fibers are composed of aligned crystal atoms of carbon and are virtually five-fold stronger than steel, with only 20% to 30% of the weight consequence. Carbon fibers also possess a tensile strength greater than titanium, a thermal expansion lower than today's most commonly used alloys, and can even be spun into strands thinner than a human hair or molded into rigid shapes suitable for next-generation spacecraft.

Tyrone Wells

Tyrone sees lignin-derived carbon fibers as a material with the potential to easily revolutionize the future of civil, energy and automotive engineering.

"Carbon fiber also might be used in the future as a replacement for steel in the manufacture of cars, reducing weight significantly without sacrificing strength," Tyrone explained. "Fuel efficiencies could be realized even without changes to standard engines or electric and hybrid engines in use today."

His vision is that while the mass production of carbon fibers for many consumer applications is too costly today, alternative methods that can generate carbon fibers from highly abundant precursors, such as lignin, may result in a more cost-effective production strategy in the future.

Currently, 98% of Kraft lignin is burned as low-value fuel in pulp mill recovery boilers. Issues that may arise at recovery boiler-limited mills have further stimulated the incentive to repurpose the biopolymer for higher utility functions. Kraft lignin, therefore, has developed substantial interest as a potential carbon fiber precursor.

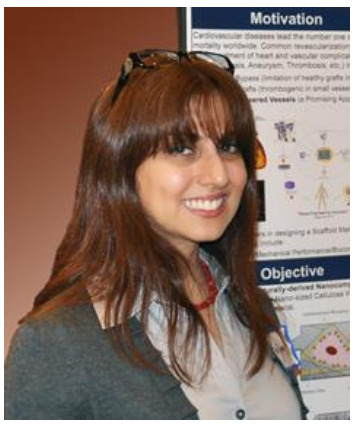
"Research has made it clear that the mechanical properties of the resulting carbon fiber derivatives are related to the quality and chemical nature of the isolated Kraft lignin, which has spurred investigations toward economical upgrading processes of this biopolymer," Tyrone said.

His interest in carbon fiber production will continue with his fellowship at Chalmers University of Technology in Gothenburg, Sweden, to work with Professor Hans Thielander beginning late in the spring of 2013. His challenge will be to investigate novel means of optimizing Kraft lignin for carbon fiber production.

Tyrone has been doing research at the Institute of Paper Science and Technology (IPST) since 2010, initially working with bacteria that digest lignocellulosic biomass in order to produce higher utility biofuels. Using novel pre-treatment methods, he has seen dramatic results in Kraft lignin upgrading processes towards carbon fiber development, which led him to file a provisional patent last year.

Parisa Pooyan Receives National Science Foundation Fellowship Award

Parisa Pooyan, Paper Science and Engineering graduate student, Mechanical Engineering, has received a National Science Foundation Fellowship Award for the Summer Institute on Nanomechanics, Nanomaterials and Micro/Nanomanufacturing, at Northwestern University, Evanston, Ill.



Parisa Pooyan

She also has been published in the *Polymer* journal for her work: Pooyan P., Kim I.T., Jacob K.I., Tannenbaum R., Garmestani H., [2013], "Design of a Cellulose-based Nanocomposite as a Potential Polymeric Scaffold for Tissue Engineering", *Polymer*, Volume 54(8), 2105-2114, DOI:10.1016/j.polymer.2013.01.030. Her advisors are Cyrus Aidun and Hamid Garmestani.

Former High School Intern at IPST Receives President's Award

George Fei

George Fei, a Georgia high school student who was hired by IPST last summer in Dr. Yulin Deng's group, has received a President's Award based on his high academic achievement and test scores, and has been invited to the White House by President Barack Obama. George will spend two days in the White House and will have dinner with Obama this summer. He is one of two students from Georgia to receive this award. His research work at IPST is part of the academic achievement that helped him earn this recognition.

Alumni Welcome to Keep in Touch

All alumni of the Institute of Paper Chemistry, Institute of Paper Science and Technology and Georgia Tech's Paper Science and Engineering program are invited to become members of the Paper Heritage Alumni Foundation. The alumni foundation's purpose is to serve alumni by engaging former students in active and effective partnerships with the IPST community and the industry. Governed by alumni, for alumni, the Foundation promotes mutually beneficial interaction between alumni and the current student body and offers the opportunity to build Institute friendships that will last a lifetime.

For further information, go to www.ipst.gatech.edu/alumni, or email steve.forsyth@ipst.gatech.edu.

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