A 20-Year Outlook for the Forest Bioproducts Industry: Implications, Challenges, Opportunities

2013 Executive Conference

The Institute of Paper Science and Technology
Georgia Institute of Technology

April 18-19, 2013
Georgia Tech Hotel and Conference Center
Atlanta, Georgia

www.ipst.gatech.edu/meeting/2013
IPST-GT ANTITRUST STATEMENT

INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY

Antitrust Notice Guidelines for Meetings

As required by law as well as IPST-GT Bylaws, Appendix II, neither Georgia Tech’s Institute of Paper Science and Technology nor any committee or activity of IPST-GT shall be used for or include discussions for the purpose of bringing about or attempting to bring about any understanding or agreement, written or oral, formal or informal, expressed or implied, among competitors with regard to prices, terms or conditions of sale, distribution, volume of production, or allocation of territories, customers, or suppliers.

No IPST-GT activity shall involve exchange or collection and dissemination among competitors of any information regarding prices, pricing methods, costs of production, sales, marketing, or distribution.

Neither IPST-GT nor any committee thereof shall make any effort to bring about the standardization of any product for the purpose of or with the effect of preventing the manufacture or sale of any product not conforming to a specified standard. IPST-GT does not become involved in or establish any product standards and is precluded from endorsing any product or process.

The above described discussions and/or actions are expressly prohibited and shall not be permitted.

Rev. 2/2011

www.ipst.gatech.edu/meeting/2013
A 20-Year Outlook for the Forest Bioproducts Industry: Implications, Challenges, Opportunities

2013 Executive Conference

The Institute of Paper Science and Technology
Georgia Institute of Technology

April 18-19, 2013
Georgia Tech Hotel and Conference Center
Atlanta, Georgia
TABLE OF CONTENTS

IPST - Georgia Tech Antitrust Statement .................................................................................. i
Table of Contents .................................................................................................................. 3
About IPST ............................................................................................................................. 4
IPST Member Companies ....................................................................................................... 5
Welcome .................................................................................................................................. 7
Speaker Biographies ............................................................................................................... 9
Student Poster Session ......................................................................................................... 21
Student Poster Abstracts ....................................................................................................... 23
IPST Faculty, Staff, and Students .......................................................................................... 37
  IPST Academic and Research Faculty ................................................................................. 39
  IPST Support Staff ............................................................................................................... 42
  Paper Science and Engineering Students ........................................................................... 43
IPST Testing Services .......................................................................................................... 59
Membership Options ............................................................................................................ 67
To Make a Donation .............................................................................................................. 67
About IPST

The Institute for Paper Science and Technology (IPST) is an industrial research and development center focused on providing solutions to strategic, economic, and technical challenges facing forest bioproducts and paper industries.

Vision

To be the premier research institute for the cost-competitive transformation of forest biomaterials into value-added products, including traditional and new forest products, renewable energy, chemicals, advanced materials and pharmaceuticals.

Mission

Provide members solutions to their strategic, economic, and technical challenges by building a research collaborative that enables access to world-class research personnel at IPST, across Georgia Tech, and globally.

Strategic Thrusts

Operational Excellence
Biorefining
New Forest Biomaterials
Business and Policy
Education
IPST Member Companies 2013

ARAUCO

Kimberly-Clark

ASHLAND

MEADWESTVACO

Domtar

NewPage

eka

Rayonier

General Mills

Renmatix

IMERYS

sappi

INTERNATIONAL PAPER

UPM

Kemira

Weyerhaeuser
Welcome to the 2013 Executive Conference

A 20-Year Outlook for the Forest Bioproducts Industry: Implications, Challenges, Opportunities

April 18, 2013

Dear Friends,

It is my pleasure to welcome you to our 2013 Executive Conference, “A 20-Year Outlook for the Forest Bioproducts Industry: Implications, Challenges, Opportunities.”

The conference will explore potential implications of factors such as natural resource availability, world population, economic transformation, and environmental constraints for our industry’s success in 2035. The discussion will be based on professional presentations, discussion and findings from our own workshop in February, attended by more than 25 industry representatives as well as faculty and outside experts. We will discuss some specific project opportunities and the research breakthroughs that can help the industry prepare for a challenging future. Key faculty experts and students in advanced stages of their graduate research will deliver presentations on these topics. You will also have the opportunity to visit with the many Paper Science and Engineering graduate students displaying their IPST endowment-sponsored research at the reception and poster session—a great time to meet these future industry leaders and their work.

As you may know, we are celebrating the 20th anniversary of the IPST Paper Tricentennial Building this year. The Robert C. Williams Papermaking Museum has been renovated, and we are featuring a new retrospective exhibit about the contributions of IPST research to the industry and to its future directions. The Museum is a popular destination for students, teachers, and members of the general public, and we invite you to visit our latest exhibits.

I am delighted to have you with us as we explore this year’s critical topics, and I look forward to hearing your thoughts.

Norman F. Marsolan
Director
SPEAKER BIOGRAPHIES
Speaker Biographies

**Paul M. A. Baker**  
404-385-3366  
paul.baker@gatech.edu

Dr. Paul M. A. Baker is the Associate Director of the Center for 21st Century Universities and former Director of Research at the Center for Advanced Communications Policy (CACP) at the Georgia Institute of Technology. He formerly served as the Project Director of Policy Initiatives for the Rehabilitation Engineering Research Center (RERC) on Workplace Accommodations. Baker holds a courtesy appointment in the School of Public Policy and is on the faculty of the Institute for People and Technology and the GVU Center at Georgia Tech. He is also an Adjunct Professor with the Centre for Disability Law & Policy at the National University of Ireland, Galway. Additionally, he serves on the editorial boards of a number of journals. Baker's research involves communication and social media policy, educational technology, institutional change, online communities, e-accessibility, and disability policy.

**Sujit Banerjee**  
404-894-9709  
sujit.banerjee@ipst.gatech.edu

Dr. Sujit Banerjee is a Professor of Chemical and Biomolecular Engineering at Georgia Tech. His research interests are in the areas of environmental engineering and in the development and application of industrial polymers. A major objective is the commercialization of laboratory findings. A present focus is on the conversion of cellulosic materials to glucose for ethanol production using polymers to enhance the enzymatic step. The fundamental aspect of the work involves study of the interaction between enzyme and polymer using atomic force microscopy among other means. Pilot scale runs are also made for commercial evaluation.

The behavior of industrial polymers such as cationic polyacrylamides used for sludge dewatering, mineral flotation, fiber flocculation, and other applications are modified using cyclodextrin-related additives. Several of these modifiers are now in commercial use. Laboratory experiments are done with high speed photography and particle size and charge measurements. Full-scale measurements are also made in the field and real-time data collected and analyzed.

Dr. Banerjee is also involved in pulp and paper research, particularly in paper recycling and in the development of new pulping catalysts.
Ron Brown
202-463-2742
ron_brown@agenda2020.org

Dr. Ron Brown is President and Executive Director of the Agenda 2020 Technology Alliance, which identifies technology needs of the forest products industry and facilitates collaborative R&D programs to address those needs.

Mr. Brown has more than 30 years of experience in technical management in the paper industry. He held leadership positions in research, engineering, and manufacturing with MeadWestvaco Corporation. He has served as a member of the TAPPI Board of Directors and as President of the Miami University Paper Science and Engineering Foundation. He earned a B.S. from North Carolina State University and M.S. and Ph.D. from the Institute of Paper Chemistry, which is now IPST at Georgia Tech. Currently he is serving on the Secretary of Agriculture’s USDA Forestry Research Advisory Council.

Since joining Agenda 2020 in 2008, Mr. Brown has worked with companies, government agencies, and research institutions to advance the development of new technologies for the forest products industry. He led the preparation of the 2010 Forest Products Industry Technology Roadmap.

Stephen E. Cross
404 894 8885
cross@gatech.edu

In addition to serving as Georgia Tech’s Executive Vice President for Research, Dr. Stephen E. Cross is a professor in the H. Milton Stewart School of Industrial and Systems Engineering and an adjunct professor in the College of Computing and the Ernest J. Scheller College of Business. He served as a Vice President and Director of the Georgia Tech Research Institute from 2003 to 2010. Previously, Cross was at Carnegie Mellon University as a research faculty member in computer science and Director and CEO of the Software Engineering Institute. Earlier, he was a program manager at the Defense Advanced Research Projects Agency and a faculty member at the Air Force Institute of Technology. A retired military officer, he received the Air Force Research Award in 1986 and the Federal 100 Award in 1992.

Cross is a member of the Defense Science Board. A past member of the Air Force Scientific Advisory Board, he has supported studies by the National Research Council, testified to Congress, and served as a consultant to government and industry. He has published widely on artificial intelligence, software engineering, and technology transition. Cross is a fellow of the Institute of Electrical and Electronic Engineers (IEEE) and a former editor-in-chief of IEEE Intelligent Systems. He is currently an associate editor of the online Journal of Information, Knowledge, and Systems Management. He received his BSEE from the University of Cincinnati, his MSEE from the Air Force Institute of Technology, and his PhD from the University of Illinois at Urbana-Champaign.
Dr. Soumen Ghosh is a professor of Operations Management in the Scheller College of Business at Georgia Tech. He also served as the Director of the Center for Quality and Change Leadership for eight years. He received his PhD in Business Administration with specialization in Operations Management and MS in Industrial & Systems Engineering from The Ohio State University. He holds a BS in Mechanical Engineering from Birla Institute of Technology (India).

His research and teaching interests are in the areas of global operations strategy, supply chain strategy, operations strategy, product development and supply chain interface, quality management, and manufacturing planning and control. Professor Ghosh worked as a production engineer with Tata Industries, and has provided consulting and training services to several organizations on quality, operations, and supply chain improvement. He has also served on the Board of Examiners of the Georgia Oglethorpe Quality Award.

Professor Ghosh is a member of the Decision Sciences Institute (having served as Vice President for two separate terms), the Institute for Operations Research and Management Sciences, and the Production and Operations Management Society. He is a former Associate Editor for Decision Sciences and the Journal of Operations Management, and also serves/served on the Editorial Review Boards of Production and Operations Management, IEEE Transactions on Engineering Management, and the Quality Management Journal.

Jennifer Jarratt
202-270-0903
jjarratt@leadingfuturists.biz

Jennifer Jarratt, Principal at Leading Futurists, LLC, has been working since 1984 on wide-ranging futures activities. She is a recognized leading thinker and author among futurists on human resources and social/demographic change.

Ms. Jarratt consults with organizations and groups on key factors shaping their future. She leads seminars and courses on thinking like a futurist, scenario building, and practical tools for working with the future. Some recent keynote speeches by Jennifer include a presentation at the Smithsonian Museums for the New Millennium international symposium and at the First Annual Texas Coastal Issues Conference.

Ms. Jarratt is past board chair and a founding member of the Association of Professional Futurists. She was a public representative on the board of the International Association for Financial Planning, now the Financial Planning Association, from 1996-1999. She was an adjunct faculty member of the University of Maryland-University College program in distance learning, and was a visiting instructor in Studies of the Future, University of Houston-Clear Lake, 1990-91. In her earlier career as a journalist in the U.S. and Britain, Ms. Jarratt shared in a Pulitzer Prize.

Ronald L. Johnson
404-894-2331
ron.johnson@gatech.edu

Ronald L. Johnson is a Professor of the Practice in Industry and Systems Engineering (ISyE) and the Managing Director of the Tennenbaum Institute (TI) at Georgia Tech. As a Professor of the Practice in ISyE, Johnson uses his substantial experience and extensive background to assist the School in identifying teaching and research opportunities that support the public interest and societal needs. He teaches courses, advises students, and works with faculty on projects and research.

In Johnson's role as Tennenbaum Institute Managing Director and member of Georgia Tech's Institute for People and Technology (IPaT) leadership team, he provides overall administrative oversight for TI. He also engages and expands relationships with industry and government partners to provide knowledge and skills for enterprise transformation, engages in research and economic development, and coordinates with other Georgia Tech Interdisciplinary Research Institutes and their staff. TI, the first multi-disciplinary center of its kind, uniting academic, government and corporate experts to create industry-shaping business models to deal with real, large-scale enterprise transformation, is an integral part of IPaT.

Johnson received his bachelor's degree from the United States Military Academy at West Point, and his master's in operations research from ISyE in 1985. Johnson served as the National Basketball Association's (NBA) first Senior Vice President of Referee Operations from July 2008 until July 2012. In this role, he was responsible for all aspects of the NBA's officiating program. Prior to his work with the NBA, Johnson had an illustrious 32-year career in the U.S. Army, where he held the title of deputy commanding general and deputy chief of engineers, the second highest-ranking senior engineer staff officer for the U.S. Army Corps of Engineers (USACE).

Johnson serves on the Executive Advisory Council of Mission: Readiness, the National Workforce Solutions Advisory Board, and is a Trustee on the Georgia Tech Foundation. He is a past member of the Georgia Tech President's Advisory Board. Johnson serves on the Board of Directors of Leave No Veteran Behind and is an Advisor to the Rushman-Micah Foundation, both 501 (c)(3) nonprofits.
Dr. Satish Kumar, Professor of Materials Science and Engineering at Georgia Tech, received his Ph.D. degree in 1979 from the Indian Institute of Technology, New Delhi, India in the area of Polymer and Fiber Science. He obtained his post-doctoral experience in the Polymer Science and Engineering department at the University of Massachusetts (1979-82). For the year 1982-83, he was a visiting scientist at the Atomic Energy Commission of France, C. E. N. G., Grenoble, France. During 1984-89 he was associated with the Polymer Branch, Air Force Materials Laboratory, Wright Patterson Air Force Base, Dayton, Ohio on contract through Universal Energy Systems and the University of Dayton Research Institute. He joined the faculty of the School of Polymer, Textile and Fiber Engineering at Georgia Tech in 1989.

Dr. Kumar’s research is in the areas of high performance materials, bio materials, energy storage, nano materials, functional electronics, optical materials, as well as fibers and composites. Polymer/carbon nano tube composite as well as polymeric nano composites with other nano materials are areas of special emphasis as are polymer crystallization in the presence of carbon nanotubes, carbon nanotube based carbon fibers, electro-chemical supercapacitors, bio-medical applications of polymers, fibers, nano fibers, and nano composites and nano composites with thermal and electrical conductivity.

Dr. Tim Lieuwen, executive director of the Strategic Energy Institute and Professor of Aerospace Engineering at Georgia Tech, is active in both instruction and research programs. His interests lie in the areas of acoustics, fluid mechanics, combustion, and signal processing. He is responsible for teaching several courses in the areas of fluid mechanics, aeroacoustics and combustion.

His research activities involve both theoretical and experimental work in combustion, flame-acoustic wave interactions, combustion noise, and development of ultrasonic diagnostic techniques. Combustion and acoustics focused research in the fields of energy and the environment include: combustion of alternative and coal-derived fuels; dynamical combustion phenomena including flashback, blowoff, and combustion instabilities; and acoustics in inhomogenous media and thermoacoustics.

Dr. Lieuwen received his B.S. in Engineering from Calvin College, and his M.S. and Ph.D. from Georgia Institute of Technology.
John B. Mahaffie
202-271-0444
jbmahaffie@leadingfuturists.biz

John Mahaffie, Principal at Leading Futurists, LLC, has been a speaker and consultant on the future since 1987. He has authored over 3 dozen futures studies for corporations, government agencies, and nonprofit groups. He is an author and speaker on the future of science and technology, the environment, transportation and infrastructure, health and medicine, work and worklife, telecommunications, and other futures topics.

He gives courses and workshops on futures topics and techniques for corporations, government agencies, and trade and professional associations. Mr. Mahaffie’s recent projects have included workshops on scenario development, studies on telecommunications, and research and presentations on the future of libraries.

He co-authored 2025: Scenarios of U.S. and Global Society Reshaped by Science and Technology (Oakhill, 1997) with Joe Coates and Andy Hines. Other books include From Scan to Plan: Integrating Trends into the Strategy Making Process (ASAE 2003), Future Work (Jossey Bass, 1990), Managing Your Future as an Association (ASAE, 1994), and The Future of the Apartment Industry (NMHC, 1995). He is a co-founder and past Board Chair of the Association of Professional Futurists.

Norman Marsolan
404 894 2802
norman.marsolan@ipst.gatech.edu

Dr. Norman Marsolan is Director of the Institute of Paper Science and Technology (IPST) and Professor of Chemical and Biomolecular Engineering at Georgia Tech. As director, Dr. Marsolan is responsible for engaging the research capacity of Georgia Tech in the service of IPST member companies and the industry. After twenty years of service, Dr. Marsolan retired from International Paper Company in 2008, where he last served as director of research & development. He held assignments as mill manager and as director of technology manufacturing solutions responsible for the worldwide support of pulp and paper manufacturing. Dr. Marsolan is the immediate past chair of the Technical Association of the Pulp and Paper Industry (TAPPI). He is an affiliate member of the forest products industry’s Agenda 2020 Technology Alliance and a TAPPI Fellow.
Kenneth Matthews
770-321-4166
ken.matthews@akzonobel.com

Ken Matthews is Community of Practice Leader, Renewable Raw Materials - Research, Development & Innovation at AkzoNobel Chemicals. He is a professional paper chemist who started working in a mill in the early eighties. He joined Eka Chemicals in 1994 in technical sales, and after five years in the South of England, moved to Seoul, South Korea, as the Technical Manager for a newly established Eka Chemicals business. He returned to the UK to head up the sales efforts and support the integration into a European-focused business.

In 2007, he joined the North America technical marketing group before taking the role as Business Development Manager, responsible for new technology opportunities as well as technology scouting. Through his involvement with the nascent Bio-Refinery movement, he took on a corporate R&D role for the parent company, AkzoNobel, heading up the Community of Practice for Renewable Raw Materials. He rejoined Eka Chemicals (now AkzoNobel Pulp and Performance Chemicals) in 2013 to lead the marketing team in North America.

Don McConnell
404-407-6199
donald.mcconnell@gtri.gatech.edu

Don McConnell serves as Georgia Tech’s Executive Director of Industry Strategy and Commercialization in the office of Dr. Steve Cross, the Georgia Tech Executive Vice President for Research, and as an Associate Director for Industrial Research and Commercialization at the Georgia Tech Research Institute. He joined Georgia Tech in October, 2012 having served as a consultant to GTI and GTRI over the last 18 months focused on enhancing and expanding the scope and economic impact of research for industry.

Prior to joining Georgia Tech, McConnell served as a senior executive and corporate officer of the Battelle Memorial Institute, the leading independent research and development organization with annual research revenues of $6.5 billion. His career spanned the full spectrum of research, development and deployment of innovations for government and industry. He established Battelle’s energy, medical product, automotive and consumer products businesses, returning over $4 million in net earnings annually to Battelle’s research and charitable purposes.

He also served as the Chair of the Battelle’s venture fund, Battelle Innovation Partners, serving as a Board member of several Battelle spin-out ventures. Most notably, he led Battelle’s successful efforts to monetize Battelle’s joint venture with Mitsubishi and Nippon Telephone and Telegraph, Photonic Integration Research Inc. (PIRI), a manufacturer of photonic multiplexing and splitters. PIRI was sold for cash and stock valued at $2.2 billion.
Sandeep Mora
sxm3645@gatech.edu

Sandeep Mora is a Ph.D. student and graduate research assistant, working under the direction of Dr. Sujit Banerjee. It was recently shown by John Reye that cationic polymers can significantly accelerate both cellulose mediated hydrolysis of bleached paper fiber and the amylase catalyzed hydrolysis of cornstarch. Further studies will be conducted to explore the effect of polymers on corn starch and cellulose hydrolysis. Different kinds of cationic polymers will be used in the current project and their mechanisms will be studied. Sandeep’s expected graduation date is December 2013.

Sten Nilsson
+46 (225) 381 02
stenbnilsson@gmail.com

Dr. Sten Nilsson was Leader of the Institute of Forest Products Industry Market Studies and Professor in Economic Planning at the Swedish University of Agricultural Sciences. During 1983-84, Professor Nilsson was appointed by the Canadian Government to set up new strategies for the forest sector in Canada. In 1985, he headed two commissions for the Swedish government concerning intensified research in the forest sector in Sweden.

Professor Nilsson joined the International Institute for Applied Systems Analysis (IIASA) in January 1986, becoming Leader of the Forestry Program in 1990. Between 1998 and 2002 he was Counselor to the Director, and was appointed Deputy Director from July 2002 to May 2008. From May to December of 2008, he was Acting Director of IIASA. He currently holds a visiting affiliation with IIASA and can be reached at IIASA nilsson@iiasa.ac.at or at stenbnilsson@gmail.com.

A native of Sweden, Professor Nilsson has had a distinguished academic career in forest sector analysis with emphasis on policy analysis. He received his MSc in forestry from the Royal College of Forestry in Stockholm in 1971 and his PhD in economic planning from the same college in 1975. In 1976, he became Professor in economic planning at the Swedish University of Agricultural Sciences. He is a working member of the Royal Swedish Academy of Agriculture and Forestry as well as of the UN Scientific Committee of Academia Istropolitana Nova, Slovakia; an Academician of the International Academy of Informatics, Russia; and more recently, Foreign Member of the Lithuanian Academy of Sciences.

Professor Nilsson has authored and co-authored over 350 scientific publications. He has held a number of consultancies in organizations such as The World Bank, FAO, OECD, European Commission, and SIDA.
Dr. Arthur Ragauskas, Professor of Chemistry and Biochemistry at Georgia Tech, held the first Fulbright Chair in Alternative Energy and is a Fellow of the International Academy of Wood Science and TAPPI. His research program at Georgia Institute of Technology is seeking to understand and exploit innovative sustainable bioresources. This multifaceted program is targeted to develop new and improved applications for nature’s premiere renewable biopolymers for biomaterials, biofuels, biopower, and bio-based chemicals. His research program is sponsored by NSF, USDA, DOE, GA Traditional Industry Program, a consortium of industry partners, and several fellowship programs. His Fulbright-sponsored activities at Chalmers University of Technology, Sweden were focused on the forest biorefinery and new biofuel conversion technologies for lignocellulosics.

Qining Sun
qsun32@gatech.edu

Qining Sun is a Ph.D. student and PSE fellow in the School of Chemistry and Biochemistry at Georgia Tech working under Dr. Arthur Ragauskas. His research project is about the analysis of chemical structures of celluloses and hemicelluloses, and focuses on the isolation and novel nanocomposite film prepared from Glucomannan. His expected graduation date is December 2014.

Beril Toktay
404-385-0104
beril.toktay@scheller.gatech.edu

Dr. Beril Toktay is Professor of Operations Management and the Brady Family Chairholder at Georgia Tech. Her primary research area is sustainable operations. She is also interested in the management of information and risk in supply chains. Professor Toktay's research has been funded by several National Science Foundation grants and has received distinctions such as the 2010 Brady Family Award for Faculty Research Excellence, first prize in the 2005 and 2006 Production and Operations Management Society (POMS) Wickham Skinner best unpublished paper competitions, and finalist in the EURO 2003 paper competition.

Professor Toktay served as the Coordinator of the Georgia Tech Focused Research Program on Closed-Loop Production Systems, an interdisciplinary group of faculty from Management, Engineering and Public Policy interested in sustainable manufacturing. She was formerly Associate Professor of Operations Management at INSEAD. She currently serves as the President of the Manufacturing & Service...
Operations Society and the VP of Finance of the POM Society. At Georgia Tech, she serves as the Scheller College of Business ADVANCE Professor, a role that is focused on supporting the advancement of women in academia.

Professor Toktay has taught Supply Chain Management courses at the PhD, MBA, and Executive Education levels, as well as Operations Management and Operations Research courses at the PhD level. She currently teaches Business Strategies for Sustainability in MBA and executive education programs.

**Tyrone Wells**
twells7@gatech.edu

Tyrone Wells is a Ph.D. student and PSE fellow in the School of Chemistry and Biochemistry at Georgia Tech working under Dr. Arthur Ragauskas. His work consists of the microbial upgrading of pyrolysis oils and biomass to lipids using oleaginous strains of bacteria. His expected graduation date is December 2013. Tyrone has received a grant from the Gunnar Nicholson Fellowship Program and IPST to study for a year at Chalmers University of Technology in Sweden, working with Professor Hans Thielander at the Department of Chemical and Biological Engineering to investigate means of optimizing carbon fiber production.
STUDENT POSTER SESSION

The following are abstracts of the research work currently being conducted by a sampling of the Paper Science and Engineering graduate students. Funding for these students is largely provided by the industry-generated endowment fund. The students are members of a multi-disciplinary education and research program for the pulp and paper industry and are pursuing degrees through the mechanical engineering, chemical and biomolecular engineering, materials science and engineering, and the chemistry and biochemistry schools of the Georgia Institute of Technology.
Student Poster Abstracts

**Functional Polymer – Polymer/Carbon Nanotube Bi-component Fibers**

Author: An-Ting Chien, Prabhakar V. Gulgunje, Han Gi Chae, Aniruddha Joshi, Jaeyun Moon, Bo Feng, G. P. Peterson, Satish Kumar

Email: achien3@gatech.edu

Advisor: Satish Kumar

**Abstract:** Bi-component fibers typically combine two or more functions arising from two distinct components. Bi-component fibers can incorporate carbon nanotubes, which can impart specific and controllable mechanical, electrical, and thermal transport properties to the fibers. Using gel spinning, sheath-core polya crylonitrile–polyacrylonitrile/carbon nanotube (CNT) bi-component fibers with a diameter of less than 20 µm and carbon nanotube concentrations of up to 20 wt% have been processed. In these fibers, Polya crylonitrile/carbon nanotube composites can be located in the sheath or core components. The results indicate that the carbon nanotubes were well dispersed and aligned along the fiber axis with a 15 ~ 20 nm polya crylonitrile interphase on the carbon nanotube surface. The fibers exhibited a tensile strength as high as 700 MPa, tensile modulus as high as 20 GPa, as well as enhanced electrical and thermal conductivities.

This type of new material has the potential to replace traditional wires and cables, serve as sensors or wearable electronics that transmit electrical signals, or introduce novel applications for thermal management. These bi-component fibers can also be made with forest products such as lignin, cellulose nano crystals etc. For example in a lignin core - polyester sheath fiber can be a relatively low cost textile fiber, while a lignin/CNT core – polyester sheath can be a relatively low cost functional textile fiber. Similarly other nano materials can be used to impart other functionalities to the fibers which can be made using a variety of forest products in conjunction with synthetic polymers.

**Interactions of Biomass Molecules with Heterogeneous Catalysts in Aqueous and Vacuum Environments**

Author: John Copeland; Carsten Sievers

Email: jrc5062@gmail.com

Advisor: Carsten Sievers

**Abstract:** Aqueous phase catalytic processes for biomass conversion are promising because many biomass-derived compounds are soluble in water and because water is an abundant and environmentally friendly solvent. The current study investigates the fundamental interactions of biomass derived oxygenates with catalysts and supports. Specifically, the interactions of ethylene glycol, 1,2-propanediol, 1,3-propanediol, glycerol, with g-Al2O3, TiO2 anatase, ZrO2, MgO and 5 wt% Pt on g-Al2O3 were studied.

Transmission IR was used to investigate surface interactions between the various biomass derived oxygenates and the metal oxides. This analysis showed interactions with specific surface hydroxyls and alkoxide bond formation on Lewis acid sites as a function of co-adsorbed water.

Reforming kinetics of glycerol solutions over a 5 wt% Pt on g-Al2O3 catalyst were studied using a flow ATR-IR setup. This study showed that the formation kinetics of hydrogen and carbon monoxide on the Pt surface is dependent on the catalyst layer pretreatment used.
Microstickies Removal and Measurement Methods by Model System

Author: Xiaotang Du  
Email: dxttony@gatech.edu  
Advisor: Jeff Hsieh

Abstract: Microstickies can pass through a 150 micrometer screening plate while macrostickies are retained on the screen. Pressure sensitive adhesive is the main source of microstickies in the paper mill, which mainly coming from four families: acrylics, butyl rubber, ethylene-vinyl acetate and natural rubbers. Polyvinyl acetate and polybutadiene are widely used in pressure-sensitive adhesives with a large difference in glass transition temperature and are chosen as model system to study their structure-adhesive relationship and removal methods. Current microstickies measurements include image analysis, thermogravimetric analysis, membrane separation, extraction, pyrolysis-gas chromatography-mass spectroscopy and polymer film adsorption. Microstickies would cause serious problems after agglomeration and deposition. Thus the most accurate method is not to measure all the microstickies in the system, but only those that would deposit onto fibers or the machine. However, the complexity of fiber surface prevents us from obtaining meaningful data and we use simple model surface for our study in order to obtain useful data. A series of surface characterization methods like ATR-FTIR, XPS, SEM, AFM could provide both quantitative and qualitative information about deposition. Some microstickies can be effectively treated by enzyme, adsorption, electric field flotation, cationic polymers. Our liquid plasma technology treats alkene bonds microstickies for increasing its particle size for easy removal after microfiltration. Our preliminary experiments have shown the particle size of some polymers was increased by 20 to 100X. Increased size of microstickies reduces the difficulty of its removal through use of separation technology.

Carbide-Derived Carbons for Adsorptive Removal of VOCs from Air Streams

Author: Michael Dutzer  
Email: mrdutzer@gatech.edu  
Advisor: Krista Walton

Abstract: The pulp and paper manufacturing process produces volatile organic compounds (VOCs) for which release into the external environment is limited by Federal and State regulations. While many VOCs are produced, this research focuses on the removal of methanol and formaldehyde. Novel removal methods, including adsorption processes, are being researched to allow the industry to become more energy efficient and to decrease emissions. Carbide-derived carbons (CDCs) offer the possibility of using an adsorbent to remove these VOCs from emission streams. Tunable pore size, a narrow range of pore sizes, and chemical selectivity make CDCs ideal for this process. These properties of CDCs are achieved through removing the metal within the carbide using a high temperature chlorination process. This selective etching leaves behind a narrow distribution of pore sizes in a carbon complex. The chlorine flow rate, temperature level, and chlorination times can be varied to achieve the optimum high surface area, pore size distribution, and level of residual metal. Titanium carbide-derived carbon (TiCDC) has excellent potential to be tuned for high adsorption interactions with methanol and formaldehyde. Breakthrough testing will ultimately determine the amount of adsorption of the TiCDCs and the ability to recover these VOCs. By adsorbing these VOCs instead of destroying them, they can potentially be used in other applications. A TiCDC adsorber has the potential to offer low costs, low emissions, and, as a result, great business opportunities.
Biotransformation of Phytosterols under Anoxic and Anaerobic Conditions

Author: Christy Dykstra; Spyros G. Pavlostathis, Sujit Banerjee
Email: cdykstra6@gatech.edu; hgiles3@gatech.edu
Advisors: Sujit Banerjee and Spyros Pavlostathis

Abstract: Phytosterols are steroid-based compounds that are produced by plants for a number of important biological roles. They serve as precursors to plant hormones and help regulate cell membrane permeability. Phytosterols have been linked to endocrine disruption in marine species and small mammals, with effects seen at concentrations as low as 10 µg/L. Untreated wastewater from the pulp and paper industry typically contains phytosterol concentrations ranging from 0.3 to 3 mg/L. Aerated stabilization basins are commonly used by pulp and paper mills as biological treatment systems, which expose wastewater to a range of redox zones. The hydrophobicity of phytosterols favors partitioning to sediment layers, where their fate under the anoxic or anaerobic conditions is unclear. The biotransformation of phytosterols under denitrifying, sulfate-reducing and methanogenic conditions was assessed using semi-continuously fed cultures over 16 weekly feeding cycles. Phytosterol removal was observed under denitrifying and sulfate-reducing conditions, but not under fermentative/methanogenic conditions. Stigmaster-4-en-3-one was identified as a potential intermediate of phytosterol biotransformation under sulfate-reducing conditions, likely produced by the action of dehydrogenases/isomerases, which have previously been reported to act on cholesterol under aerobic and denitrifying conditions. Further study of the biotransformation of phytosterols under anoxic and anaerobic conditions is necessary to identify the conditions that enhance biodegradation for the development of effective biological treatment systems of phytosterol-containing wastewaters.

Characterization and Use of Pollen as a Biorenewable Filler for Polymer Composites

Author: Timi Fadiran
Email: ofadiran3@gatech.edu
Advisor: Carson Meredith

Abstract: Pollen grains have the potential to be effective biorenewable fillers in polymer matrices in part due to their high mechanical strength, chemical stability, and extraordinary architectures. These features are likely to enhance interactions with polymer chains compared to conventional ceramic fillers, e.g., silica and calcium carbonate, with simple geometries. In addition, pollen-polymer composites are attractive because they could form the basis for a new class of lightweight, high strength materials with a sustainable plant-based filler displacing petroleum-derived material. In this work, we expand upon preliminary work done with using pollen as a filler in polymer composites by exploring routes for optimizing the wetting and adhesion of pollen fillers in a polymer matrix. In one scheme, pollen grains are chemically modified with silane coupling agents with functional groups that can interact with a polymer matrix through free radical polymerization. In another scheme, pyrolysis is used to produce carbon microspheres while maintaining pollens unique morphology, and then incorporated into the polymer matrix via a solution casting method. The effectiveness of modified pollen as fillers in polymer matrices is characterized by determining mechanical properties, glass transition temperature, and interfacial morphology of pollen-polymer composites as a function of pollen loading. We investigate the effect of modified pollen as a reinforcing filler in poly(vinyl acetate) (PVAc), a common commercial polymer. PVAc was chosen because of its amorphous nature, which could potentially increase interfacial interactions with pollen fillers.
FTIR Study of Glycerol Dehydration on Niobium Oxide

Author: Guo Shiou Foo
Email: fooguoshiou@gmail.com
Advisor: Carsten Sievers

Abstract: The study focuses on the spectroscopic study of glycerol dehydration on niobium oxide. The catalysts are calcined at different temperatures to vary the ratio of Brønsted to Lewis acid sites. The catalysts are characterized to determine the morphology of the surface and to quantify the acidic sites. Glycerol is impregnated on niobium oxide and the self-supported wafer is heated up in an IR cell to examine the in-situ dehydration reaction. It is hypothesized that Lewis acid sites are needed to dehydrate the primary hydroxyl groups while Brønsted acid sites dehydrate the secondary hydroxyl groups. Glycerol is able to form alkoxy bond with Lewis acid sites on niobium oxide at room temperature and water vapor has no effect on how glycerol binds to the surface. Upon heating, new peaks start to appear from 100 °C and they are assigned as dehydration intermediates and products such as hydroxyacetone and 3-hydroxypropionaldehyde. Water vapor is needed to activate amorphous niobium oxide to form acrolein as some of the Lewis sites are converted to Bronsted sites. The remaining surface species at 350 °C are unreacted glycerol, dehydration intermediates and products that poison the surface as they are strongly bound to Lewis acid sites. To maximize the selectivity of acrolein and minimize the deactivation of catalyst, there should be a high concentration of Bronsted acid sites and low concentration of Lewis acid sites.

Computational Modeling for Optimization of Black Liquor Evaporation Systems

Author: Aaron Howell
Email: ahowell7@gatech.edu
Advisor: Cyrus Aidun

Abstract: Falling-film evaporators are an effective method to concentrate black liquor, due to their high heat transfer rate and short residence time. The potential of these evaporators is reduced by scales that form on the heat transfer surface. To fully describe the scale formation process, an understanding of the hydrodynamics and heat transfer in the liquid film is needed. This work seeks to accurately model the flow structure and transport in the black liquor evaporation process. The two fluids in the evaporator, black liquor and steam, are modeled as a single fluid using the Volume of Fluid technique. The flow domain is finely discretized and the Finite Volume method is employed to solve the conservation equations for the single fluid system. Black liquor fluid properties are modeled using experimental correlations, and a phenomenological model is used for the rate of crystallization. The computational model has been used to determine that the transport in the backflow regions is enhanced by crosswise convective fluxes. The main heat transport mechanism was identified by the model to occur in a thin film region that forms preceding the intermediate wave front. Modeling the characteristics of black liquor has shown that fouling occurs in the thin film regions due to wave induced transport. The model is to be expanded to include the non-Newtonian rheological effects of black liquor for high dry solids content. Other evaporation methods will be explored, such as a thin film falling under gravity surrounded by an envelope of steam, which eliminates the possibility of scale formation.
Novel Carbon Fibers and Films Using Lignin and Carbon Nanotube Precursors

Author: Liu (Clive) Hsiang, Yaodong Liu, Satish Kumar
Email: hliu322@gatech.edu
Advisor: Satish Kumar

Abstract: Carbon fibers are currently being used in aerospace structures, wind-mill blades, for sports goods, as well as for automobile applications. The carbon fiber market is growing annually at the rate of 10 to 12%. Currently there are two major driving forces for the carbon fiber research and development: (1) to achieve carbon fiber mechanical properties closer to their theoretical potential. (2) to reduce the raw material and production cost of carbon fiber. To increase fiber mechanical properties, carbon nanotubes (CNT) are being added in the carbon fiber precursor such as polyacrylonitrile (PAN). To reduce cost, there is significant research and development activity to produce carbon fibers from lignin. To balance cost and mechanical properties, carbon fibers can also be produced with blends of PAN, CNT, and lignin. In this project, hardwood lignin (HWL), polyacrylonitrile (PAN), and CNT blend fibers are being spun using gel spinning at various HDL, PAN, and CNT ratios. Other spinning approaches such as melt and solution spinning will also be considered. The precursor fibers will be stabilized and carbonized in the batch process under appropriate conditions. The overall objective of the project will be to assess the effect of various material compositions and processing parameters on the development of the structure, morphology and properties of the precursor fiber, the final carbon fibers, as well as their intermediate products.

Pseudo-lignin Chemistry and Its Impact on Enzymatic Hydrolysis

Author: Fan Hu
Email: hufanandyhu@gmail.com
Advisor: Art Ragauskas

Abstract: Pseudo-lignin (Humins), which has recently been confirmed to form during dilute acid pretreatment of poplar holocellulose, was isolated and characterized. To evaluate the inhibition effects of pseudo-lignin to enzymatic hydrolysis of cellulose in comparison to lignin, enzymatic mild acidolysis lignin (EMAL) was isolated from poplar after an 8 min pretreatment at 170 °C using 0.5% H₂SO₄. Holocellulose was treated with varying amounts of pseudo-lignin and/or EMAL dissolved in p-dioxane and then dried. The treated and control holocellulose was then treated to a standard cellulase treatment and the results from enzymatic hydrolysis of these samples showed that dilute acid pretreated lignin inhibited hydrolysis in the initial stage but had a negligible impact on the overall cellulose-to-glucose conversion yield. In contrast, pseudo-lignin significantly reduced the overall enzymatic conversion yield of cellulose to glucose. This study suggests that pseudo-lignin formation needs to be avoided since it is more detrimental to enzymatic hydrolysis of cellulose than dilute acid pretreated lignin.

Effect of Mixing of Zeolite on the Pyrolysis of Kraft Lignin

Author: Fang Huang
Email: huangfanghg@gmail.com
Advisor: Art Ragauskas

Abstract: Research efforts were directed at evaluating the effectiveness of mixtures of zeolites to enhance catalytic pyrolysis. Our previous studies indicated the FAU (Y) type zeolite could significantly improve the cleavage of methoxyl-aromatic and ether bonds in the lignin and yield a pyrolysis oil that has a ‘gasoline’ range molecular weight. The MOR (M) type zeolite could more efficiently decompose the carboxyl groups which will reduce the acidity of pyrolysis oils and make
In our present study, we will mix the Y and M type zeolites to pyrolyze kraft lignin (L). These pyrolysis results (pyrolysis oil yield and structure characterizations) will be compared with the individual zeolite Y or M assisted pyrolysis of kraft lignin. A blank pyrolysis test (pyrolysis of kraft lignin without zeolite) was also conducted for comparisons.

**Fabrication of Conductive Paper in the Gerhardt Group**

Author: Salil Joshi, Chunqing Peng, Lianghui Huang, Rachel Muhlbauer, Rosario Gerhardt
Email: salil.joshi@gatech.edu
Advisor: Rosario Gerhardt

**Abstract:** Paper and cellulose-based materials may be used in electrical/electronic applications either as a flexible, insulating, low dielectric constant substrate or as a conductive medium in the form of a composite or impregnated sheet. Various research initiatives in the Gerhardt group in the School of Materials Science and Engineering have been carried out to create conductive paper using techniques such as layer-by-layer deposition, vacuum filtration or other capillary based methods, exploring the use of surfactants and conducting materials like indium tin oxide (ITO), antimony tin oxide (ATO) and carbon nanotubes (CNT). In addition, research is also being done to understand the effects that different processing parameters have on the deposition and formation of conductive films on paper-based materials. Varying parameters such as solution conditions, substrate properties, and drying conditions have all shown to result in very different electronic properties and structures both within the paper substrate and on its surface.

**Crystallinity – A Rate-determining Parameter for Pretreated Lignocellulosic Biomass**

Author: Yuzhi Kang
Email: ykang41@gatech.edu
Advisor: Andreas Bommarius

**Abstract:** Steam explosion is one of the most effective pretreatment methods in disrupting lignocellulosics structure and enhancing its accessibility. The effects of steam explosion on woody biomass and agricultural residues (i.e. bagasse, wheat straw and loblolly pine) are evaluated. The key operational parameters including temperature, residence time and acid concentration have pronounced effects on crystallinity index (CrI) of the feedstock. The CrI of steam-pretreated lignocellulosic biomass was calculated from X-ray diffractometry with the method of Least-squares and was found to decrease as pretreatment severity increases. A series of steam-exploded lignocellulosic samples with varying CrI was generated and the significance of CrI is confirmed by a linear relationship between initial hydrolysis rates and CrI. The present study provides evidence that the CrI is one of key parameters determining the enzymatic hydrolysis rate of pretreated lignocellulosic biomass. To more fully explore the connection between accessibility, hydrolyzability and reactivity, we have undertaken experiments with phosphoric acid swollen Avicel® at different levels of conversion. We will present the quantitative trends between the rate of conversion and these underlying substrate properties.

**Sustainable Pulping and Papermaking Technology Using Blends of Woodchips with Agricultural Residue**

Author: Mikhail Levit
Email: mikhail.levit@gatech.edu
Advisor: Art Ragauskas

**Abstract:** A new approach to pulping agricultural residue is presented where wood chips are pulped together with wheat straw and corn stover in one digester. The availability and cost of virgin fiber are often limiting the mill’s productivity hence utilization of compatible agricultural
residue may at least partially solve the problem as well as establish new products with modified and improved properties. This study employs annual crop residues as biorenewable resources that can be substituted for 10, 15 and 20% of woodchips without special changes in pulping conditions. The benefit of using agricultural residues is their low cost and wide availability. Slightly higher yields and increase in Kappa number are observed for brownstock while mechanical properties of handsheets are improved significantly. Bleaching of pulps made from blends containing agricultural residue and hardwood chips was also investigated by applying a relatively mild sequence to achieve target brightness ISO 89. Overall a maximum increase in tensile index was 29% and 12% in tear index for unrefined samples containing wheat straw in comparison to hardwood-only control sample. Viscosities of pulps and carbohydrate profiles were traced throughout the pulping and bleaching process and black liquor analysis was performed. Physical properties development is attributed to higher levels of xylan that is introduced with agricultural fiber and an attempt is made to correlate xylan content to the strength of handsheets.

Designing Superamphiphobic Paper Surfaces

Author: Lester Li
Email: lesterl@gatech.edu
Advisor: Victor Breedveld

Abstract: Superoleophobic surfaces are of substantial interest due to their ability to control fluid-surface interactions. While superhydrophobic surfaces have been achieved on a wide variety of substrates with a range of processes, superoleophobicity has proven to be more elusive because of the lower surface tension of the liquids and more stringent requirements on surface properties. Creation of these surfaces requires the establishment of both the appropriate surface chemistry and surface structure, with a specific combination of the two needed to achieve high droplet contact angles. Through the use of plasma etching and deposition, we generate the first reported paper surfaces that are both superhydrophobic and superoleophobic. Paper, composed of cellulose fibers, has inherent roughness on the micron length scale. The oleophobicity of a surface is strongly reliant on the spacing between the surface structures, in this case, the fibers. Through variation in the refining levels of the pulp during paper formulation, the spacing between fibers can be controlled. However, on our experimental substrates, microstructure alone yields hexadecane contact angles no higher than ~125°. To further increase the contact angle, surface nanostructure is established on the fibers. Using an oxygen plasma, we selectively etch/remove the amorphous phase of cellulose, leaving the crystalline nanophase and thus nanoscale roughness on the fiber. Subsequent deposition of a thin fluoropolymer layer yields a paper substrate that maintains hexadecane CAs >150°.

Processing-Structure-Property Design Space of CNC/PHB Nanocomposites

Author: Stephanie Lin
Email: steph.j.lin@gmail.com
Advisor: Meisha Shofner

Abstract: The metastable semi-crystalline structure formed in CNC/PHB composites upon fast heating and cooling will be characterized to understand interfacial structure. To accomplish this, samples of the anti-solvent compression molded CNC/PHB composites will examined and then the solvent cast CNC/PHB composites processed with the CNC suspension in ethanol will be examined. The faster heating and cooling rates of the Flash DSC would allow for the kinetics of crystallization and recrystallization of these CNC/PHB systems to be studied. Experiments performed on the Flash DSC would provide information regarding how the presence of CNCs affects the polymer chain dynamics of PHB.
Optimal Resource Balancing and Factory Loading for Energy Cost Reduction

Author: Yitao Liu  
Email: yliu410@gatech.edu  
Advisor: Jianxin Jiao

Abstract: This research is focusing on the energy consumption analysis and solution. We will adopt an Industrial Systems Engineering approach to total energy management in pulp and paper production. The key research tasks include: 1) develop energy flow chain network programming decision models; 2) factory load planning and balance for energy scheduling; 3) process analysis and energy optimization; 4) energy planning software tools, including factory load planning to predict energy consumption, economic flow network model to balance energy consumption and supply, linear programming/mixed integer programming optimization to solve economic flow network models, and what-if scenarios and simulation to evaluate and compare alternative operational strategies. This allows site engineers to play “what if,” by implementing projects in the computer model, to check the effect on overall mill energy consumption. Further dynamic simulation should be support to allow the unsteady-state behavior of the system to be analyzed so that the effect of a process change on behavior during upsets can be evaluated. The aimed solution will be an individual equipment-level energy management, as well as plant-wide integrated strategies, covering all aspects of energy planning, operation and reporting. The vision of this research has the potential to sustainably reduce energy consumption along with fresh water intake throughout the manufacturing process.

Synthesis of Mixed Metal Oxides for Hydrodeoxygenation of Pyrolysis Oil for Alternative Fuel Production

Author: Sarah McNew, Tiorra Ross  
Email: semcnw@gmail.com  
Advisor: Carsten Sievers

Abstract: Transportation energy in the United States comes primarily from nonrenewable, petroleum sources, and it is important to find alternative feedstocks to produce transportation fuels. Waste streams from the forest products industry can be pyrolyzed, but further upgrading must be applied before the bio oil has properties comparable to petroleum based fuels. Hydrodeoxygenation (HDO) of the bio oil using a heterogeneous catalyst is the method of upgrading used in this work. HDO can be performed with traditional hydrodesulfurization catalysts, but this requires the use of expensive metals or co-fed H2S. Preliminary work has shown that HDO can be performed on model compounds with metal free, sulfur free, ceria-zirconia mixed metal oxides with a low conversion. The work proposed here examines the necessary requirements for HDO on mixed metal oxides and correlates properties with reactivity to improve selectivity and conversion. The two main requirements for oxide-based HDO catalysts are the presence of defect sites to reversibly bind oxygenates to activate a carbon-oxygen bond in the feed and the ability to adsorb and dissociate hydrogen on the surface of the catalyst to break the carbon-oxygen bond and remove oxygen from the surface as water. Defects site formation is characterized with temperature-programmed reduction (TPR) of the catalyst surface. Hydrogen-deuterium (HD) exchange is used to understand the kinetics of hydrogen adsorption/ dissociation. The key properties of highly active HDO catalysts are identified and used to design catalysts that perform HDO on model compounds with a higher conversion and selectivity towards HDO products.
Assessing Cellulose Accessibility of Lignocellulosic Biomass before and after Pretreatment

Author: Xianzhi Meng
Email: xmeng30@gatech.edu
Advisor: Art Ragauskas

Abstract: Renewable fuels derived from lignocellulosic biomass offer a promising alternative to conventional fuels. However, this bioconversion process is significantly hindered by the recalcitrance of biomass and thereby requires a pretreatment stage. Dilute acid pretreatment, and steam explosion are two of the leading pretreatment technologies and future improvements require a better understanding of the fundamentals of biomass recalcitrance. The accessibility of the cellulose to cellulase enzymes has been proposed as a key factor for efficient enzymatic conversion of lignocellulosic biomass to fermentable sugars. Herein, we have utilized a Simons’ Stain technique for the determination of the available surface area of native and pretreated Poplar along with Nuclear Magnetic Resonance (NMR) cryoporometry to determine pore size distributions as it changes during dilute acid pretreatment and autohydrolysis.

Water-based Processing Method for Polymer/CNC Nanocomposites

Author: Cait Meree
Email: cmeree#@gatech.edu
Advisor: Meisha Shofner

Abstract: The presented research seeks to develop a water based processing method using traditional shear processing on an aqueous gel composed of cellulose nanocrystals (CNCs) and a water-soluble polymer. In this study, the rheological behavior of aqueous polyvinyl alcohol (PVA) gels and PVA gels loaded with CNCs is studied. The effect of aging at 1 day, 3, days, and 5 days after preparation is also examined. From these data, aging of neat PVA samples is seen to increase viscosity and network behavior while PVA/CNC loaded samples do not experience increased network behavior with time. A shift from Newtonian to shear thinning behavior is also seen through the addition of CNCs. It is anticipated that these data will help in future advances in the shear processing of CNC loaded water soluble composites.

Chemical Modification of Cellulose Nanofibrils by Graft Polymerization

Author: Arie Mulyadi
Email: arie.mulyadi@ipst.gatech.edu
Advisor: Yulin Deng

Abstract: Achieving homogeneous dispersion of cellulose nanofibrils in a broad range of polymer matrices has grown to great importance with the current development in nanocomposites processing. Well-distributed cellulose nanofibrils filler and improved filler/matrix interfacial adhesion are some of the major factors that would lead to optimal nanocomposite properties. Surface treatment of cellulose nanofibrils was prepared by grafting with maleated styrene copolymer. The grafted styrene groups alternated cellulose nanofibers from hydrophilic to hydrophobic which could improve the both the dispersibility of nanofibrils in organic solvents and in the matrix of hydrophobic polymers. This surface modification opens the door for the use of cellulose nanofibrils for non-polar polymer reinforcement. The effects of incorporating the modified nanofibrils into polystyrene matrix on the properties of their nanocomposite film were investigated by means of thermogravimetric analysis and mechanical test via tensile testing. The films were obtained using solvent casting from tetrahydrofurans. The compatibility and distribution of nanofibrils in the polymer matrix was shown using scanning electron microscopy. The results will be described with a discussion on challenges and opportunities for future research.
A Detailed Study of High-Pressure Biomass Pyrolysis in an Entrained-Flow Reactor

Author: Gautami Newalkar; Pradeep Agrawal; Kristiina lisa; Carsten Sievers
Email: gnewalkar3@gatech.edu
Advisor: Pradeep Agrawal

Abstract: A major advantage of biomass gasification is that any lignocellulosic material can be converted to syngas and subsequently to bio-fuels. In a gasifier, pyrolysis and char gasification steps are known to occur in series. Thus it becomes important to study the characteristics of pyrolysis products such as chars, gases and tars, since these have an effect on the char gasification kinetics.

In this work, pyrolysis of pine and switchgrass was performed in an entrained flow reactor at high temperatures (600-1000 °C) and high pressures (1-20 bar). Heating rates as high as 10⁴ K/s were achieved with solids residence time from 3-20 s. Analytical techniques such as SEM and N₂ Physisorption, micro-GC and GC-MS were used to analyze the pyrolysis chars, gases and tars respectively as a function of pyrolysis variables. The present study will provide a basis for improved understanding of the biomass pyrolysis and lead to mathematical modeling of char gasification based on meaningful descriptors.

Design of a Cellulose-based Nanocomposite as a Potential Polymeric Scaffold in Tissue Engineering

Author: Parisa Pooyan
Email: parisa.pooyan@gatech.edu
Advisor: Cyrus Aidun, Hamid Garmestani

Abstract: Design of a functional material by imitating nature and utilizing biomimetic structure from renewable resources has received much of the research attention these days. The fascinating behavior of the systems found in nature typically relies on their very complex hierarchical architecture. This highly organized arrangement has been well-established in man-made design such as Eiffel tower and Geodesic dome. With the recent advances in nanotechnology however, the length-scale of a hierarchical design has further extended down into a nano-sized array. Inspired by the two hierarchical assemblies found in nature – cellulose and collagen – we have designed a collagen-reinforced material by well-dispersed nano-sized cellulose whiskers to effectively enhance the rigidity of collagen and to better mimic the morphology and profile features existed in biological tissues. The successful grafting of cellulose nanowhiskers (CNWs) within the collagenous medium has introduced a viscoelastic improvement of about twofold increase at small amount of filler content, 3 wt.%. The tendency of CNWs to interconnect with one another through strong hydrogen-bonding confirmed the formation of a three-dimensional rigid percolating network, fact which imparted excellent mechanical/thermal stability to the entire nanocomposite system at such low filler concentration. The biocompatibility of the nanocomposite has also been confirmed by encapsulating human mesenchymal stem cells (MSCs) on the material surface, where the invasion and proliferation of MSCs were clearly evidenced at 8 day of culture. We believe that our biocompatible nanohybrid material not only could expand the biomedical applications of renewable materials but also could provide a potential scaffold for tissue engineering.
Chemical Changes of Acid-modified Activated Carbons in Hot Liquid Water

Author: Benjamin Sauk
Email: bsauk3@gatech.edu
Advisor: Carsten Sievers

Abstract: With the increased interest in biomass reforming, catalyst stability in hot liquid water is becoming an important issue. Acid-functionalized activated carbons are promising catalysts for biomass conversion. In this work, their stability in liquid water at 200 °C and 17 bar is evaluated. Exposure of acidified activated carbons to hot liquid water greatly decreases the concentration carboxylic surface groups, as measured by Boehm titration. Carbons acidified with H2SO4 and HNO3 retained the most acidity under these conditions. Boehm titrations indicate that the majority of the chemical changes in the activated carbon occur in the first four hours of exposure to the hot aqueous environment and that an increase in exposure temperature results in a decrease in concentration of all surface sites. XPS and TPD-MS indicate that acidification with H2SO4 imparts a large amount of sulfonic acid groups on the carbon, a portion of which are removed upon exposure to the hot liquid water. Acidification with HNO3 was found to impart nitro groups on the carbon surface, a portion of which are retained upon exposure to 150 °C water but lost at higher temperatures. SEM and nitrogen physisorption show negligible morphological changes in the carbon upon either acidification or exposure to hot liquid water.

High-Barrier Films Made from Cellulosic Nanofibrils

Author: Sudhir Sharma
Email: ssharma61@gatech.edu
Advisor: Yulin Deng

Abstract: The effect of heat treatment on the barrier properties, crystal structure and mechanical properties of Micro Cellulose Fiber (MCF) films is reported. The samples were then heat treated in an oven for 2 hours each at (100°, 125°C, 150°C, 175°C) and then subsequently conditioned in a 23°C/50% relative humidity chamber for 24 hours before testing. In comparing the 175°C sample to the untreated sample, oxygen and water vapor permeability of the samples decreased by 95.5% and 63.5% respectively, while the films also significantly shrank (24% in area). Water retention value decreased 63.5% while the contact angle increased from 61.2° to 89.3° indicating increased hydrophobicity. The crystallinity index of the cellulose films increased by 5.74%, whereas the size of crystallites increased by 46.85%. The tensile modulus decreased by 58.35% for the 175°C sample as compared to the untreated sample. The changes in properties were attributed to changes in crystallinity and hornification.

Xylan Reinforcement on Poplar Cellulose Nanowhiskers Films

Author: Qining Sun; Marcus Foston; Art Ragauskas
Email: gsun32@gatech.edu
Advisor: Art Ragauskas

Abstract: The ever-increasing global demand for materials and international dependency on conventional petroleum resources plus the environmental concern call for alternative sustainable sources and greener technologies. In this study novel films were prepared by depositing xylan on poplar cellulose nanowhiskers via pH adjustment. The mechanical properties, water vapor transmission properties, surface morphology and chemical components of the films were evaluated and characterized using tensile testing, wet cup method, AFM, 3D Opto-digital Microscope and HPAEC-PAD under controlled temperature and humidity conditions. Addition of 8 % xylan improved the film tensile strength to the largest extent, increasing the tensile strength by 90 %. In addition, pH adjusted films were significantly better at improving physical properties than the controlled group without pH adjustment.
Deconstructing the Auxetic Behavior of Cellulose-based Fiber Networks of Paper

Author: Prateek Verma  
Email: pverma@gatech.edu  
Advisor: Meisha Shofner

Abstract: We report here the auxetic (negative Poisson’s ratio) response of cellulose based fiber networks. Auxetic materials grow fatter when stretched and are extremely rare in nature. It has been reported that fibrous paper increases in thickness when stretched in planar direction. Recently, researchers have also induced auxetic behavior in polyurethane foams, expanded PTFE and ultra-high-molecular-weight polyethylene. By measuring the thickness variation with stretch in different types of paper, we determined their Poisson’s ratio to be negative (0 to -3.0). We propose that the mechanism of this auxetic response stems from the non-woven network structure of cellulose fibers having rich hydroxyl surface. During compressive stages of papermaking, hydrogen bonding between fibers locks them into a crumpled microstructure which expands when stretched. Auxetic behavior arising from surface chemistry of polymeric fiber networks is a novel concept that can potentially be applied to new material designs and product development techniques.

Antimicrobial Composite Microcapsules from Double Emulsions Stabilized Solely by Particles

Author: Hongzhi Wang  
Email: hwang97@gatech.edu  
Advisor: Sven Behrens

Abstract: Colloidosomes are semipermeable microcapsules with external shell formed by colloidal particles, providing promising technique for encapsulations with controllable permeability, mechanical properties and bio-compatibility. Our work explores double surfactant-free emulsions, stabilized solely by particles, as precursors to synthesize anti-microbial composite microcapsules for triggered and sustainable release control with envisioned applications in agriculture solutions and biomedical aspects. The stepwise fabrication process includes three phases. We first generate microcapsules from double emulsions stabilized solely by silica particles. Secondly, the permeability of such microcapsules is reduced in order to encapsulate small antimicrobial molecules via interfacial polymerization. Finally, pH responsive composite microcapsules are developed by the incorporation of pH-responsive polymeric particles.

Effect of White Water Chemistry on Passivation Behavior of 304L Stainless Steel

Author: Yushu Wang  
Email: ywang.gatech@gmail.com  
Advisor: Preet Singh

Abstract: Stainless steel 304L is widely used for paper machines in the pulp and paper industry. The paper machines are exposed to a white water environment containing various concentrations of chlorides, sulfates and thiosulfate ions, all of which are known to affect pitting corrosion of stainless steels. In this paper, an electrochemical polarization technique is combined with scratch tests to study the effects of white water chemistry on the passivation and repassivation behavior of SS 304L and its susceptibility to localized corrosion.
Chitin-based Bio-inspired Optical Materials for Sustainable Paper and Paint Industry

Author: Jie Wu, Carson Meredith
Email: jwu71@gatech.edu
Advisor: Carson Meredith

Abstract: White coloration plays a significant role in both nature (bird feathers, flowers and insects) and in commercial products (paper and paint). For example, paper and paperboard require significant whiteness and brightness so that printed images and text can achieve maximum optical contrast with faithful color reproduction. Mineral fillers are one of the primary materials used in paints and coatings to attain high whiteness and brightness. However, the required coating thickness and high-density minerals add weight to the final products that negatively impacts energy use and greenhouse emissions during transportation. Thus, there is increasing interest in finding more sustainable whitening agents. One example of unusually high whiteness found in nature is the ‘white beetle’ of the genus Cyphochilus, where the whiteness of the insect’s scales is caused by non-periodic nanostructures within a ~ 5 µm thick cuticle. These fibrillar nanostructures are constructed primarily of chitin and some protein content. In the present study, by utilizing chitin - the second most abundant biopolymer in nature as a precursor, we developed novel white and bright materials with structures inspired by the white beetle scales. These innovative optical materials can be potentially applied in paint and paper areas.

Flexible and Transparent Paper-Based Ionic Diode

Author: Xiaodan Zhang
Email: zxd200563008@gatech.edu
Advisor: Yulin Deng

Abstract: Supercapacitors are among the main energy storage devices and are key technological enablers ranging from transportation to customer electronics. Compared to their competitors—batteries, supercapacitors have superior cycling life, higher power densities, faster charge and discharge rate. But most of the supercapacitors are liquid-based, which gives them a lot troubles, such as the sealing problems and space constraints. Hereby we report a solid-state, flexible, high-strength, environmental-friendly paper-based supercapacitor made mainly by micro-fibrillated cellulose(MFC) and multi-walled carbon nanotubes(CNTs). The specific capacitance of thus-made supercapacitors is calculated to be 28F/g (180.9mF/cm2) from cyclic voltammetry at 40mV/s. The free-standing electrode paper sheets have a mechanical tensile strength and Young's modulus of 1MPa and 123 MPa. The paper-based supercapacitors have great potential for flexible and portable electronics and may inspire a new way for developing high-performance supercapacitors.

High-Strength, Light-Weight Cellulosic Foams

Author: Yi Zhang
Email: yzhang642@gatech.edu
Advisor: Sven Behrens

Abstract: High-strength, low-weight foams are important in a variety of applications, ranging from thermal insulation to packaging, and biocompatible foams are desired as drug delivery vehicles and scaffolds for tissue engineering. A series of lightweight foams were prepared by drying aqueous foams stabilized by particles made of polymers or surface modified cellulose. Confocal micrographs and SEM images show that these particles can adsorb at the air-water interface and prevent the foam from collapsing. In preliminary experiments foam porosities above 90% were achieved after water removal from the aqueous foam.
Lignin-cellulose Nanocomposite Films

Author: Zhe Zhang
Email: zhe.zang@ipst.gatech.edu
Advisor: Yulin Deng

Abstract: Lignin is amorphous and poly-aromatic in nature. It comprises 20~35% of biomass, however, until now, most lignin is burnt directly as fuel. My research is focused on novel usage of lignin and cellulose. This project focuses on the formation mechanism of lignin nanoparticles through both physical and chemical methods. The physical properties of lignin nanoparticles will be well characterized. The lignin-cellulose nanocomposite will be prepared and their physical chemistry properties in nano-scale will be investigated. The composite films as barrier package application will be studied.

Renewable Nylon 6 Precursor from Lignin Fragments by Catalytic Hydrogenation

Author: Xiaojuan Zhou
Email: zxoux2@miamioh.edu
Advisor: Pradeep Agrawal, Chris Jones

Abstract: The gas-phase hydrogenation of monomeric lignin fragments guaiacol, 4-methylguaiacol and diphenyl ether to cyclohexanol and substituted cyclohexanol has been investigated on Ni/SiO2 catalyst (8.4 % w/w Ni) in a fixed-bed flow reactor at 300 C and 100 PSI to assess the feasibility of using monomeric lignin-derived monomers for renewable Nylon 6 production in comparison with using cyclohexanol made from petroleum. Reactivity of catalyst was studied and steady-state products for each reaction were analyzed. The main hydrogenation steady-state products for guaiacol, 4-methylguaiacol and diphenyl ether are 2-methoxycyclohexanol and 2-methoxycyclohexanone, 4-methylcyclohexanol and p-cresol, and benzene and cyclohexanol, relatively. The study showed that initially guaiacol was mainly converted to cyclohexanol but deactivated quickly to yield 2-methoxycyclohexanol and 2-methoxycyclohexanone, indicating that the hydrogenation of the aromatic ring was faster than the hydrolysis of the methoxy group, while 4-methylguaiacol and diphenyl ether showed a much higher selectivity consistency to their steady-state products. It was found that the hydrolysis of the methoxy group in 4-methylguaiacol is easier than that in guaiacol. Spent catalyst was characterized and analyzed for deactivation study. The pseudo-first-order rate constants were calculated to be 1.69/WHSV-1 for guaiacol and 3.00/WHSV-1 for 4-methylguaiacol. These results can be used to estimate conversions for large scale hydrogenation reactions.
IPST ACADEMIC AND RESEARCH FACULTY, STAFF AND STUDENTS
<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Phone Numbers</th>
<th>Email Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pradeep Agrawal</td>
<td>Associate Chair Academic, Chemical and Biomolecular Engineering</td>
<td>(404) 894-2825</td>
<td><a href="mailto:pradeep.agrawal@chbe.gatech.edu">pradeep.agrawal@chbe.gatech.edu</a></td>
</tr>
<tr>
<td>Sujit Banerjee</td>
<td>Professor, Chemical and Biomolecular Engineering</td>
<td>(404) 894-7797</td>
<td><a href="mailto:lenong.allison@ipst.gatech.edu">lenong.allison@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Sven Holger Behrens</td>
<td>Associate Professor, Chemical and Biomolecular Engineering</td>
<td>(404) 385-5134</td>
<td><a href="mailto:sven.behrens@chbe.gatech.edu">sven.behrens@chbe.gatech.edu</a></td>
</tr>
<tr>
<td>Andreas S. Bommarius</td>
<td>Professor, Chemical and Biomolecular Engineering</td>
<td>(404) 385-5134</td>
<td><a href="mailto:andreas.bommarius@chbe.gatech.edu">andreas.bommarius@chbe.gatech.edu</a></td>
</tr>
<tr>
<td>Victor Broedveld</td>
<td>Associate Professor, Chemical and Biomolecular Engineering</td>
<td>(404) 385-5134</td>
<td><a href="mailto:victor.broedveld@chbe.gatech.edu">victor.broedveld@chbe.gatech.edu</a></td>
</tr>
<tr>
<td>Kylie Bucalo</td>
<td>Research Technician II, Forest Biology</td>
<td>(404) 385-5134</td>
<td><a href="mailto:kylie.bucalo@ipst.gatech.edu">kylie.bucalo@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Michael Buchanan</td>
<td>Research Scientist II</td>
<td>(404) 385-5134</td>
<td><a href="mailto:micheal.buchanan@ipst.gatech.edu">micheal.buchanan@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Yulin Deng</td>
<td>Professor, Chemical and Biomolecular Engineering</td>
<td>(404) 385-5134</td>
<td><a href="mailto:yulin.deng@ipst.gatech.edu">yulin.deng@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Andrei G. Fedorov</td>
<td>Professor, Mechanical Engineering</td>
<td>(404) 385-5134</td>
<td><a href="mailto:andreifedorov@me.gatech.edu">andreifedorov@me.gatech.edu</a></td>
</tr>
<tr>
<td>Hamid Garmestani</td>
<td>Professor, Materials Science and Engineering</td>
<td>(404) 385-5134</td>
<td><a href="mailto:hamid.garmestani@mse.gatech.edu">hamid.garmestani@mse.gatech.edu</a></td>
</tr>
<tr>
<td>Rosario Gerhardt</td>
<td>Professor, Materials Science and Engineering</td>
<td>(404) 385-5134</td>
<td><a href="mailto:rossario.gerhardt@mse.gatech.edu">rossario.gerhardt@mse.gatech.edu</a></td>
</tr>
<tr>
<td>Anselm Griffin</td>
<td>Professor and Co-Chair, Materials Science and Engineering</td>
<td>(404) 385-5134</td>
<td><a href="mailto:anselm.griffin@mse.gatech.edu">anselm.griffin@mse.gatech.edu</a></td>
</tr>
<tr>
<td>Dennis Hess</td>
<td>Professor and Thomas C. DeLoach, Jr. Chair, Chemical and Biomolecular Engineering</td>
<td>(404) 385-5134</td>
<td><a href="mailto:dennis.hess@chbe.gatech.edu">dennis.hess@chbe.gatech.edu</a></td>
</tr>
<tr>
<td>Jeffery S. Hsieh</td>
<td>Director, Multidisciplinary Pulp and Paper Engineering Group, Chemical and Biomolecular Engineering</td>
<td>(404) 385-5134</td>
<td><a href="mailto:jeffery.hsieh@chbe.gatech.edu">jeffery.hsieh@chbe.gatech.edu</a></td>
</tr>
<tr>
<td>Name</td>
<td>Title / Position</td>
<td>Phone / Email</td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Jianxin (Roger) Jiao</td>
<td>Associate Professor, Mechanical Engineering</td>
<td>(404) 894-9633 <a href="mailto:roger.jiao@me.gatech.edu">roger.jiao@me.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>Christopher Jones</td>
<td>Professor and J. Carl &amp; Sheila Pirkle Fellow,</td>
<td>(404) 385-1683 <a href="mailto:cjones@chbe.gatech.edu">cjones@chbe.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>Dong-Ho Kim</td>
<td>Research Technician III</td>
<td>(404) 894-7797 <a href="mailto:dong.ho-kim@ipst.gatech.edu">dong.ho-kim@ipst.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>Bernard Kippelen</td>
<td>Professor, Electrical and Computer Engineering</td>
<td>(404) 385-5163 <a href="mailto:bernard.kippelen@ece.gatech.edu">bernard.kippelen@ece.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>Satish Kumar</td>
<td>Professor, Materials Science and Engineering</td>
<td>(404) 894-7550 <a href="mailto:satish.kumar@mse.gatech.edu">satish.kumar@mse.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>Tuan Le</td>
<td>Research Technician III</td>
<td>(404) 894-6630 <a href="mailto:tuan.le@ipst.gatech.edu">tuan.le@ipst.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>Steve Lien</td>
<td>Research Coordinator II</td>
<td>(404) 894-0674 <a href="mailto:steve.lien@ipst.gatech.edu">steve.lien@ipst.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>Jamshed Mahmood</td>
<td>Mechanical Engineer II</td>
<td>(404) 894-5647 <a href="mailto:jamshed.mahmood@ipst.gatech.edu">jamshed.mahmood@ipst.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>Sheldon May</td>
<td>Regents Professor, Associate Director, Chemistry</td>
<td>(404) 894-4052 <a href="mailto:sheldon.may@chemistry.gatech.edu">sheldon.may@chemistry.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>Norman F. Marsolan</td>
<td>Professor of the Practice and Director, Institute</td>
<td>(404) 894-2082 <a href="mailto:norman.marsolan@ipst.gatech.edu">norman.marsolan@ipst.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>J. Carson Meredith</td>
<td>Associate Professor, Chemical and Biomolecular</td>
<td>(404) 365-2151 <a href="mailto:carson.meredith@chbe.gatech.edu">carson.meredith@chbe.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>Shaobo Pan</td>
<td>Research Scientist I</td>
<td>(404) 894-7858 <a href="mailto:shaobo.pan@ipst.gatech.edu">shaobo.pan@ipst.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>Spyros Pavlostatthis</td>
<td>Professor, Chemical and Biomolecular Engineering</td>
<td>(404) 894-9367 <a href="mailto:spyros.pavlostatthis@ece.gatech.edu">spyros.pavlostatthis@ece.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>Roman Popil</td>
<td>Senior Research Scientist</td>
<td>(404) 894-9722 <a href="mailto:roman.popil@ipst.gatech.edu">roman.popil@ipst.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>Yunqiao Pu</td>
<td>Senior Research Scientist</td>
<td>(404) 894-9712 <a href="mailto:yunqiao.pu@ipst.gatech.edu">yunqiao.pu@ipst.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>Gerald S. Pullman</td>
<td>Professor, Biology</td>
<td>(404) 894-5307 <a href="mailto:gerald.pullman@ipst.gatech.edu">gerald.pullman@ipst.gatech.edu</a></td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Position and Research Area</td>
<td>Phone</td>
<td>Email</td>
</tr>
<tr>
<td>--------------------</td>
<td>----------------------------------------------------------------</td>
<td>-------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Art Ragauskas</td>
<td>Professor, Chemistry and Biochemistry</td>
<td>(404) 894-9701</td>
<td><a href="mailto:art.ragauskas@ipst.gatech.edu">art.ragauskas@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Matthew Realff</td>
<td>Associate Professor, Chemical and Biomolecular Engineering</td>
<td>(404) 894-1334</td>
<td><a href="mailto:matthew.realff@chbe.gatech.edu">matthew.realff@chbe.gatech.edu</a></td>
</tr>
<tr>
<td>Ronald Rousseau</td>
<td>School Chair, Chemical and Biomolecular Engineering</td>
<td>(404) 894-2867</td>
<td><a href="mailto:ronald.rousseau@chbe.gatech.edu">ronald.rousseau@chbe.gatech.edu</a></td>
</tr>
<tr>
<td>Tabassum Shah</td>
<td>Research Coordinator I, Chemical and Biomolecular Engineering</td>
<td>(404) 894-9710</td>
<td><a href="mailto:tabassum.shah@ipst.gatech.edu">tabassum.shah@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Meisha L. Shofner</td>
<td>Assistant Professor, Polymer, Textile &amp; Fiber Engineering</td>
<td>(404) 385-7216</td>
<td></td>
</tr>
<tr>
<td>Carsten Sievers</td>
<td>Assistant Professor, Chemical and Biomolecular Engineering</td>
<td>(404) 385-7385</td>
<td><a href="mailto:carsten.sievers@chbe.gatech.edu">carsten.sievers@chbe.gatech.edu</a></td>
</tr>
<tr>
<td>Scott Sinquefield</td>
<td>Senior Research Engineer, Chemical and Biomolecular Engineering</td>
<td>(404) 385-0241</td>
<td><a href="mailto:scott.sinquefield@ipst.gatech.edu">scott.sinquefield@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Preet Singh</td>
<td>Professor, Materials Science and Engineering</td>
<td>(404) 894-6541</td>
<td><a href="mailto:preet.singh@ipst.gatech.edu">preet.singh@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Mohan Srinivasarao</td>
<td>Professor, Materials Science and Engineering</td>
<td>(404) 894-9348</td>
<td><a href="mailto:mohan.srinivasarao@ptfe.gatech.edu">mohan.srinivasarao@ptfe.gatech.edu</a></td>
</tr>
<tr>
<td>Krista Walton</td>
<td>Associate Professor, Chemical and Biomolecular Engineering</td>
<td>(404) 894-5254</td>
<td><a href="mailto:krista.walton@chbe.gatech.edu">krista.walton@chbe.gatech.edu</a></td>
</tr>
<tr>
<td>Rallming Yang</td>
<td>Research Scientist II, Chemical and Biomolecular Engineering</td>
<td>(404) 894-7862</td>
<td><a href="mailto:rallming.yang@ipst.gatech.edu">rallming.yang@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Xiaoyan Zeng</td>
<td>Research Scientist I, Chemical and Biomolecular Engineering</td>
<td>(404) 894-9398</td>
<td><a href="mailto:xiaoyan.zeng@ipst.gatech.edu">xiaoyan.zeng@ipst.gatech.edu</a></td>
</tr>
</tbody>
</table>
## IPST Support Staff

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Phone</th>
<th>Fax</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charles Brookshire</td>
<td>Operations Manager</td>
<td>(404) 545-1840</td>
<td>(404) 884-6682</td>
<td><a href="mailto:charles.brookshire@ipst.gatech.edu">charles.brookshire@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Juan Chevere</td>
<td>Project Coordinator I</td>
<td>(404) 713-4083</td>
<td>(404) 894-4778</td>
<td><a href="mailto:juan.chevere@ipst.gatech.edu">juan.chevere@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Bob Davies</td>
<td>Web Author</td>
<td>(404) 545-1841</td>
<td>(404) 884-6682</td>
<td><a href="mailto:bob.davies@ipst.gatech.edu">bob.davies@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Steve Forsyth</td>
<td>Communications Manager</td>
<td>(404) 894-4778</td>
<td>(404) 884-6682</td>
<td><a href="mailto:steve.forsyth@ipst.gatech.edu">steve.forsyth@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Jean Gunter</td>
<td>Associate Director for Administration</td>
<td>(404) 894-6908</td>
<td>(404) 884-6301</td>
<td><a href="mailto:jean.gunter@ipst.gatech.edu">jean.gunter@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Lavon Harper</td>
<td>Administrative Manager</td>
<td>(404) 894-6700</td>
<td>(404) 884-5301</td>
<td><a href="mailto:lavon.harper@ipst.gatech.edu">lavon.harper@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Virginia Howell</td>
<td>Education Curator</td>
<td>(404) 894-5726</td>
<td>(404) 884-4773</td>
<td><a href="mailto:virginia.howell@ipst.gatech.edu">virginia.howell@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Jerry Nunn</td>
<td>Facilities Manager</td>
<td>(404) 275-0834</td>
<td>(404) 355-0577</td>
<td><a href="mailto:jerry.nunn@ipst.gatech.edu">jerry.nunn@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Henry (Major) White</td>
<td>Senior Security Guard</td>
<td>(404) 894-6700</td>
<td></td>
<td><a href="mailto:henry.white@ipst.gatech.edu">henry.white@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Shirley Whitfield</td>
<td>Receptionist</td>
<td>(404) 894-4773</td>
<td></td>
<td><a href="mailto:shirley.whitfield@ipst.gatech.edu">shirley.whitfield@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Lloyd Williams</td>
<td>Business Operations Manager</td>
<td>(404) 894-6672</td>
<td>(404) 884-4773</td>
<td><a href="mailto:lloyd.williams@ipst.gatech.edu">lloyd.williams@ipst.gatech.edu</a></td>
</tr>
<tr>
<td>Teri Williams</td>
<td>Director</td>
<td>(404) 894-6663</td>
<td>(404) 884-4773</td>
<td><a href="mailto:teri.williams@ipst.gatech.edu">teri.williams@ipst.gatech.edu</a></td>
</tr>
</tbody>
</table>
Traditional electric degradation of organic molecule is energy intensive and long hours. It is necessary to develop some novel technology to remove microstickies, fatty acid and ink at low energy level Microstickies cause deposits in paper making recycling processes, which lowers the paper product quality. Microstickies are in size range of 100-150 micrometers or lower. Current methods of its removal include microfiltration, pressure screening, and flotation. The experiments using mill stickies containing samples did not provide a complete mechanism understanding due to its very complex compositions, which kept us from developing effective removal methods. This study is focused on the buildup of model system, investigation of structure-property relationship and catalytic methods. From our previous research results liquid plasma could generate free radicals for polymerization and increase the particle size of polymers with alkene bonds. Thus, novel technology like liquid plasma, ionic liquid, and electric field, combined with traditional pressure screening could be effective method for removal.

Separation of fatty acid from white water vegetable oil and biodiesel acid is also an important problem. Industry uses ion oxide nanoparticles to adsorb fatty acids with its separation from the solution using a magnet. Previous results of liquid plasma could increase the particle size and reduce the amount of nanoparticles. Other novel technologies like electric field may also be a possible method for separation.

Flotation deinking has had difficulties in removing hydrophilic ink due to their affinity to water and submicron size. Surface treatment to change its property and increase their size could improve the performance of traditional flotation. Liquid plasma could irreversibly increase the size of ink particles via free radical polymerization. The polymerized ink could also be separated by filter paper. In addition, electric field could help removing ink from fiber network.

Overall, the project focused on new separation technology for microstickies, fatty acid and residual ink. Furthermore, scientific investigation about separation mechanism is also necessary for application.
Michael Dutzer
Chemical and Biomolecular Engineering
PSE Grad Student as of Spring 2013
Expected completion: Spring 2017
mdutzer@gatech.edu

Strategic Area: Operations Excellence
Thesis: Corrosion-Resistant Carbide-Derived Carbons for Adsorptive Removal of VOCs from Air Streams
Advisor: Kristo Walton

Carbide-Derived Carbons (CDCs) offer the possibility of using a low-power adsorbent to remove volatile organic compounds from the paper-making process. CDCs are ideal for this process as they allow tunable pore size, a narrow range of pore sizes, and chemical selectivity. These properties of CDCs are achieved through the selection of a metal carbide followed by etching away the metal within the metal carbide with a high temperature halogenation process leaving behind a carbon complex with a narrow distribution of pore sizes. The goal of this proposal is to finely tune this adsorption process for specific VOC emissions important to achieving the paper industry’s environmental goals.

Christine Dykstra
Civil & Environmental Engineering PSE Grad (minor) Student as of June 2012
Expected completion: May 2016
dykstra5@gatech.edu

Strategic Area: Operations Excellence
Thesis: Fate and Biotransformation Potential of Phytosterols in Pulp- and Paper Wastewater Treatment Systems
Advisor: Sujit Banerjee
Spyros Pavlostathis

Phytosterols are naturally-occurring compounds that are produced by plants and serve a structural and regulatory function in the cell membrane, as well as acting as a precursor to the synthesis of plant growth hormones. The phytosterol structure is based on a four-ring steroid molecule that is decorated with a hydroxy group and a side chain. Similar in structure to cholesterol, phytosterols differ by the attachment of functional groups and/or the presence of double bonds on the alphatic side chain. Phytosterols have been linked to endocrine disruption in both aquatic and terrestrial animals, which may be a concern when released in elevated concentrations to a receiving body of water. During the pulping process, phytosterols are freed from wood fibers and released into wastewater, which is commonly treated in aerated stabilization basins (ASBs). Within a typical ASB, there is a range of redox conditions from aerobic near the aerated zone, to anaerobic within the sediment layers. There is evidence of phytosterol biotransformation under aerobic and denitrifying (anoxic) conditions but less is known about their fate under anaerobic conditions or within systems containing multiple redox zones. Additionally, the hydrophobicity and limited solubility of phytosterols indicate significant partitioning to solids may occur, resulting in a possible accumulation of phytosterols in ASB sediment. This research aims to examine the fate and biotransformation potential of the three most prevalent phytosterols (beta-sitosterol, stigmasterol and campesterol) under variable redox conditions and evaluate the potential for different treatment conditions to reduce endocrine disruption linked to pulp mill wastewater.
Jessica Ewbank  
Chemical and Biomolecular Engineering  
PSE Grad Student as of Oct 2010  
Expected completion: Sep 2014  
Graduate Research Assistant  
jle3@gatech.edu

Strategic Area: Biorefining  
Thesis: Development of Sulfur Resistant Catalysts for Tar Removal from Biomass Derived Syngas

Advisor: Carsten Sievers

My research focuses on tar reforming of biomass derived syngas. Syngas derived from biomass offers the chance to produce renewable, carbon neutral fuels. Tars are currently defined as condensable aromatics and are found in a much higher concentration in biogas than syngas derived from coal. Tar reforming is the bottleneck in utilization of biomass derived syngas. Tars can clog process lines, foul equipment, and hinder further processing of syngas. My work focuses on rational design of catalysts used for this application in order to successfully correlate catalytic activity with tar reforming capabilities. Tar reforming is being investigated under closely modeled syngas compositions and long on-stream studies are a major focus.

Timi Fadiran  
Chemical and Biomolecular Engineering  
PSE Grad Student as of Oct 2010  
Expected completion: Sep 2014  
Graduate Research Assistant  
ofadiran3@gatech.edu

Strategic Area: Biomaterials  
Thesis: Pollen as an Advanced Material and Additive

Advisor: Carson Meredith

Resume

Directed assembly of cellulose and chitin nanofibers.
Zack Heidemann
Mechanical Engineering
PSE Grad Student as of Jan 2008
Expected Completion: Dec 2012
Graduate Research Assistant
zackheidemann@gatech.edu

Strategic Area: Operations Excellence
Advisor: Cyrus Aidun

Somatic embryogenesis (SE) is widely considered to be the only feasible system to meet future needs for large scale production of elite plants for agricultural and forestry practices (Von Arnold and Cipapham 2007). Somatic embryogenesis is the process by which somatic cells in the plant are removed and are coaxed into forming an embryogenic callus. From which the cells can be matured and regenerated into full plants (Von Arnold and Cipapham 2007). Efforts are underway to improve the laboratory protocols for proliferation and maturation of somatic embryos. Important contributions can be made by applying engineering solutions to facilitate growth and development of somatic embryos, and establish a platform for automation of the SE process.

For proper development into a plant, the somatic embryos require nutrients and growth regulators that are supplied by the culture medium. The most efficient method for delivering these chemicals is via liquid suspension culture versus culture on gelled medium. However, plant somatic embryos in vitro are adversely affected by the mechanical stress from the liquid suspension culture. The rotating and deforming liquids destroy the polarity of multiplying somatic embryos that is required for successful embryo maturation (Sun et al 2010). Efficient scale-up of processes producing mature embryos in liquid culture bioreactors is thus not possible.

Encapsulation of a single embryonic cell or cluster in a “micro-environment” allows greater control of the environmental signals the embryo(s) receive. An enclosed system not only would simplify handling of SE, it could also serve as an artificial seed provide that could be planted directly.

Aaron Howell
Mechanical Engineering
PSE Grad Student as of Sep 2011
Expected Completion: Spring 2014
Graduate Research Assistant
ahowell7@gatech.edu

Strategic Area: Operations Excellence
Thesis: Development of a Black Liquor Evaporation Method to Eliminate Fouling
Advisor: Cyrus Aidun

Black liquor is a valuable source of energy in the paper mill. But as it leaves the pulper, black liquor is not fit to be burned because it contains far too much water. The current solution is to condense the black liquor in a falling film or rising film evaporator. In either of these arrangements, scale deposits on the heat transfer surfaces. The fouling of the surfaces reduces the effectiveness of the heat transfer requiring additional energy, and effort must be periodically taken to clean the evaporator surfaces.

This project seeks to determine a method for evaporating the black liquor as a suspended liquid, by applying hot air or superheated steam directly on the liquor. The elimination of the heat transfer surface removes the potential for scale formation and will allow the evaporator to operate in a more consistent manner.
PAPER SCIENCE AND ENGINEERING STUDENTS

Fan Hu
Chemistry and Biochemistry
PSE Grad Student as of Jul 2008
Expected completion: Aug 2013
Graduate Research Assistant
mu5@cornell.edu
Strategic Area: Biomaterials
Thesis: Pseudo-Lignin Chemistry
Advisor: Art Ragauskas

It is generally accepted that incorporation of polysaccharide destruction products into lignin forms a lignin-like material termed pseudo-lignin during dilute acid pretreatment (DAP). My research has demonstrated that pseudo-lignin can be generated from cellulose and hemicellulose without a significant contribution from lignin during DAP. My thesis contributes to said acquisition of knowledge by providing characterization of extruded pseudo-lignin from pretreated hemicellulose and cellulose, proposing possible mechanisms of pseudo-lignin generation, and providing the reaction conditions (temperature, acid concentration and the presence of oxygen) associated with the mechanisms in order to diminish the amount of pseudo-lignin generation. More importantly, the formation of pseudo-lignin spherical droplets on the surface of prototreated carbohydrate reveals the possibility that those droplets may occlude pore structure and block enzyme accessibility or even bind to enzymes. Therefore, the study of pseudo-lignin-enzyme interaction will be significant for enzymatic deconstruction of cellulose and the determination of pretreatment conditions.

Sall Joshi
Materials Science & Engineering
PSE Student as of Jan 2008
Graduate Research Assistant
sall@joshi.cornell.edu
Strategic Area: New Products
Thesis: Effect of Plasma Processing and Annealing on the Electrical and Optical Properties of Colloidal Indium Tin Oxide Films
Advisor: Rosario Gerhardt

Indium Tin Oxide is widely used as a transparent conductor for optoelectronic applications. However, current deposition methods are unsuitable for fabricating inexpensive devices based on flexible and low-k substrates such as paper, PET, and cellulose based substrates. Using inks made from colloidal Indium Tin Oxide (ITO) is a potential route to fabricating transparent and conductive coatings on such substrates. By methods such as inkjet printing, microcontact fabrication, spin coating, etc. We have synthesized non-agglomerated ITO nanoparticles with a narrow size distribution. Although these can be fabricated into coatings, the challenges to be overcome when using this method is to be able to remove passivating organic coatings on the as-prepared ITO nanoparticles and to be able to density the films at temperatures low enough to be used on non-heat resistant substrates. We have demonstrated that using appropriate plasma treatments can help achieve significant conductivity in spin-coated ITO films with only moderate heating. It is hoped that with further optimization of the processing and deposition techniques, it would be possible to fabricate transparent circuits with very minimal heating, and as a result facilitate the fabrication of ITO-conducting films, and other device circuits on paper and other heat sensitive and inexpensive substrates.
Yuzhi Kang
Chemical and Biomolecular Engineering
PSE Grad Student as of Aug 2009
Expected completion Aug 2013
Graduate Research Assistant ykang41@gatech.edu

Strategic Area: New Products
Thesis: Engineering of Cellulose Binding Domain
Advisor: Andreas Bommarius, Matthew Reilff, Jay Lee

Yuzhi Kang’s area of research includes expression, characterization and protein engineering of cellulose binding domain and its biological functionality study for biofuel application. Her research would also include characterization of pretreated biomass.

Mikhail Levit
Chemistry and Biochemistry
PSE Grad Student as of Aug 2009
Expected completion May 2014
Graduate Research Assistant mikhail.levit@gatech.edu

Strategic Area: Biorefining
Thesis: Study of Alkaline Depolymerization of Biomass Accompanying Production of Ag-reinforced Kraft Pulps
Advisor: Art Ragauskas

Mikhail’s research focuses on kraft pulping of hardwoods with agricultural residue which leads to improvement of physical properties of bleached and unbleached pulps and paper. Studies employ different substitution levels of wood chips with Ag-resource and the investigation is directed at tracing the fate of hemi-celluloses and cellulose during the process. Advanced characterization of lignin and testing of various properties of pulps and handsheets are performed.

Lester Li
Chemical and Biomolecular Engineering
PSE Grad Student as of Aug 2009
Expected completion Aug 2013
Graduate Research Assistant lester@gatech.edu

Strategic Area: New Products
Thesis: Fluid Control on Plasma Modified Paper
Advisor: Victor Breedved

The understanding of the physical and chemical interactions between a surface and fluid have yielded the production of superhydrophobic and superoleophobic substrates. The goal of this proposal is to investigate and advance the control of fluid/surface interactions on plasma modified paper surfaces through the control of physical and chemical surface properties. This goal will be achieved through fabrication and testing of substrates designed for microfluidic devices and design and investigation of both physically and chemically-induced oleophobic surfaces on paper.
PAPER SCIENCE AND ENGINEERING STUDENTS

Stephanie Lin
Materials Science & Engineering
PSE Grad Student as of Jan 2011
Expected completion: Dec 2013
Graduate Research Assistant
stephanie.lin@caton.edu

Strategic Area: Biomaterials
Thesis: Crystalization Kinetics of Cellulose-Based Nanocomposites
Advisor: Meisha Shofner

This research seeks to process and characterize cellulose-based nanocomposites to further explore the structure-property design space available in these materials. Specifically, the research will be structured to test the effect of high aspect ratio cellulose nanocrystals on the crystalization kinetics of the semicrystalline biopolymer matrix polyhydroxybutyrate (PHB), thus increasing the mechanical modulus and toughness commensurately. If successful, this research will lead to the development of new materials with reduced environmental impact and unique combinations of properties that are unavailable in other materials. Additionally, the specific materials proposed will provide opportunities to increase the application range of PHB polymers and more fully describe the impact of the nanofiber aspect ratio on crystalization and mechanical properties. This fundamental understanding will provide insight into other types of polymer nanocomposites and provide guidelines for nanofiber composite design.

Hsiang-Hao Liu
Materials Science & Engineering
PSE Grad Student as of Oct 2012
Expected completion: May 2016
hlui322@gatech.edu

Strategic Area: Biomaterials
Thesis: Novel Carbon Fibers and Films using Lignin and Carbon Nanotube Precursors
Advisor: Satish Kumar

Carbon Fibers are currently being used in aerospace structures, wind-mill blades, for sports goods, as well as for automobile applications. Carbon fiber market is growing annually at the rate of 10 to 12%. Currently there are two major driving forces for the carbon fiber research and development: (1) to achieve carbon fiber mechanical properties closer to their theoretical potential. (2) To reduce the raw material and production cost of carbon fiber. To increase fiber mechanical properties, carbon nanotubes (CNT) are being added in the carbon fiber precursor such as polycrylonitrile (PAN). To reduce cost, there is significant research and development activity to produce carbon fibers from lignin. To balance cost and mechanical properties, carbon fibers can also be produced with blends of PAN, CNT, and lignin. In this project, hardwood lignin (HL), polycrylonitrile (PAN), and CNT blend fibers are being spun using gel spinning at various HLD, PAN, and CNT ratios. Other spinning approaches such as melt and solution spinning will also be considered. The precursor fibers will be stabilized and carbonized in the batch process under appropriate conditions. The overall objective of the project will be to assess the effect of various material compositions and processing parameters on the development of the structure, morphology and properties of the precursor fiber, the final carbon fibers, as well as their intermediate products.
Yitao Liu
Mechanical Engineering
PSE Grad Student as of Aug 2012
Expected completion: Spring 2015
yliu410@gatech.edu

Strategic Area: Manufacturing Systems
Advisor: Roger Jiao

This research will adopt an industrial systems engineering approach to total energy management in pulp and paper production. The goal is to sustainably reduce energy consumption and fresh water intake throughout the manufacturing process, along with alleviation of carbon emissions. The technical approach is to develop advanced operations research and production planning optimization models, algorithms, and simulation tools to optimize factory loading allocation while balancing energy usage. The focus will be an individual equipment-level energy management, as well as plant-wide integrated strategies, covering all aspects of energy planning, operation, and reporting. The deliverable will be energy planning software tools, including factory load planning to predict energy consumption, economic flow network model to balance energy consumption and supply, linear programming/mixed integer programming optimization to solve economic flow network models, and what-if scenarios and simulation to evaluate and compare alternative operational strategies.

Jacob Lucrezi
Chemistry and Biochemistry
PSE Grad Student as of Jan 2010
Expected completion: Summer 2013
Graduate Research Assistant
jlucrezi3@gatech.edu

Strategic Area: Biomaterials
Thesis: Factors Stimulatory towards Germination of Loblolly Pine Somatic Embryos; Investigation of Novel Anti-inflammatories
Advisor: Sheldon May, Gerald Pullman

Jacob Lucrezi is a PhD candidate in the School of Chemistry and Biochemistry at Georgia Tech. His research covers a range of topics from the effect of signaling molecules and redox potential on Loblolly Pine (LP) somatic embryo germination, drug delivery of novel anti-inflammatory and investigation of inflammatory macrophage pathways. Loblolly Pine is the major source of timber in the US and is a valuable resource. Clonal propagation by somatic embryogenesis of LP embryos would allow a rapid reforestation of genetically superior high-value trees. Currently, LP somatic embryos do not fully mature and fail to germinate. Zygotic LP embryos contain a seed storage organ, the female gametophyte (FG), which is not present in somatic embryos. A water extract of mid-stage FG-stimulated LP somatic embryos to germinate fueling the hypothesis that the FG contains an active agent which promotes embryo germination. Through use of bioassays and many analytical methods the active agent in the FG is being identified. Similarly, the effect of redox potential on somatic embryo germination is also being investigated.
PAPER SCIENCE AND ENGINEERING STUDENTS

Nazmul Huda Al Mamun
Mechanical Engineering
PSE (minor) Grad Student as of Aug 2006
Graduate Research Assistant
Email: mamun3@gatech.edu

- Strategic Area: Operations Excellence
- Thesis: Synchronization of Plant Embryo Development
- Advisor: Cyrus Aidun

Production of clonal propagules from selected superior penicillia has been playing a vital role in large scale production of high value plants for forestry, agricultural applications, biofuel production, ornamental purposes, or molecular pharma within the pharmaceutical sector. Among different techniques, somatic embryogenesis has shown potential in clonal propagation of many ornamental, medicinal, and agricultural plant species because of its advantages in terms of formation of matured embryos, embryo preservation, and propagation of the process, etc. However, the implementation of somatic embryogenesis for large scale clonal propagation of plants and agricultural goods is affected by the non-synchronous development of somatic embryos. It can be assumed that the cells in a cluster of somatic embryos receive different levels of nutrients due to their location within the cluster; thus, it causes the asynchronous embryo development. Hence, the focus of this research is to gain insight into the role of mechanical stress in synchronized development of somatic embryos in liquid culture medium. Our efforts are directed towards developing a technology based on mechanical stress delivered by fluid dynamics to disintegrate the clusters, thereby providing a more predictable dispersion in favor of synchronization of embryo development.

Sarah McNew
Chemical & Biomolecular Engineering
PSE Grad Student as of May 2010
Graduate Assistant
Email: smcnew@gmail.com

- Strategic Area: Biorefining
- Thesis: Production of High-Octane Fuels from Pyrolysis Oils
- Advisor: Caraten Sievers

My research focuses on understanding chemical engineering principles and reaction mechanisms to design catalysts to upgrade pyrolysis oils by hydrodeoxygenation. These oils can be produced from any kind of organic feedstock including waste streams from the forest products and agricultural industry. However, many compounds in these mixtures are not stable enough to be transported and the resulting mixture contains chemicals that will impede direct use of the mixture as a fuel. I am working on synthesizing sulfur-free heterogeneous catalysts to increase the stability and improve the quality of the bio-crude oil. The synthesis method and composition of the catalysts will be optimized based on characterization with a variety of physico-chemical techniques. Promising catalysts are tested on model compounds and the products are analyzed as the operating conditions of the reaction vary. These catalytic reactions are performed in a continuously operated fixed bed reactor.
PAPER SCIENCE AND ENGINEERING STUDENTS

Caitlin Meree  
Materials Science & Engineering  
PSE Grad Student as of Aug 2011  
Expected completion: May 2015  
cmareas@gatech.edu

Strategic Area: Noncomposite Processing Strategies  
Thesis: Water-Based Processing Strategy for Cellulose/Polymer Nanocomposites  
Advisor: Meisha Shofer

The aim of this project is to develop a water-based processing method using traditional shear processing on an aqueous gel composed of cellulose nanocrystals and a water-soluble polymer. It is believed that hydrogen bonding leading to physical crosslinking will hold the gel together and allow for bond breakage and reformation between the polymer and filler during processing. This goal will be accomplished through rheological, mechanical, thermal, and optical characterization to determine material compatibility and feasibility with traditional melt processing equipment as well as performance after processing.

Sandeep Mora  
Chemical & Biomolecular Engineering  
PSE Grad Student as of Aug 2009  
Expected completion: Aug 2013  
Graduate Research Assistant  
sm3645@gatech.edu

Strategic Area: Biorefining  
Thesis: Polymer-Aided Enzymatic Conversions of Cellulosic Sludge to Energy  
Advisor: Sujit Banerjee

It was recently shown by John Raye that cationic polymers can significantly accelerate both cellulose mediated hydrolysis of bleached paper fiber and the amylase catalyzed hydrolysis of cornstarch. Further studies will conduct to explore the effect of polymers on cornstarch and cellulose hydrolysis. Different kinds of cationic polymers will be used in the current project and their mechanisms will be studied.

Wei Mu  
Chemical & Biomolecular Engineering  
PSE Grad Student as of Aug 2009  
Expected completion: Aug 2013  
Graduate Research Assistant  
mw0@gatech.edu

Strategic Area: Biorefining  
Thesis: Degradation of Biomass and its Conversion into Biofuel  
Advisor: Yulin Deng

My research focuses on understanding chemical engineering principles and reaction mechanisms to design catalysts to conversion any kind of organic feedstock into biofuel. Due to the complex composition of the biomass, the mechanism of the reaction is hard to describe. The catalyst will be optimized according to the reaction result. These catalytic reactions are performed in a autoclave batch reactor.
<table>
<thead>
<tr>
<th>Name</th>
<th>Field</th>
<th>Thesis Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gautami Newalkar</td>
<td>Chemical &amp; Biomolecular Engineering</td>
<td>The goal of my study is to investigate the gasification behavior of three different biomass candidates: loblolly pine, switchgrass, and corn stover. These three biomass species differ in their composition, particularly in the ash content which plays a catalytic role in the gasification of char. The aim is to optimize gasifier design and conditions for syngas production from these feedstocks while minimizing tar and hydrocarbon contaminants in raw product gas. It is anticipated that the results from this work would provide a set of guidelines for other biomass candidates as well. The proposed work will provide a new option to produce value-added products from by-products in the paper and forest products industry, including branches, bark and forest residue.</td>
</tr>
<tr>
<td>Parisa Pooyan</td>
<td>Mechanical Engineering</td>
<td>Designing a cellulose-based nanocomposite reinforced by crystalline nanowhiskers which create a three-dimensional percolating network and impart an excellent mechanical/thermal stability to the entire structure at only 0.2 wt%. We believe this could not only expand the biomedical applications of cellulose but also could be a potential scaffold material in cardiovascular tissue engineering.</td>
</tr>
<tr>
<td>Sudhir Sharma</td>
<td>Chemical and Biomolecular Engineering</td>
<td>My research is focused on the development of new green and biodegradable barrier materials based mainly on nanocellulosic fibers. These materials will be used as packaging for foods, pharmaceuticals, medical items and even dry goods such as paper as well. The barriers will protect against water, oil and grease, oxygen and aroma. In some cases the barriers will also have excellent gas resistance.</td>
</tr>
</tbody>
</table>
PAPER SCIENCE AND ENGINEERING STUDENTS

Qining Sun
Chemistry and Biochemistry
PSE Grad Student as of Jan 2011
Expected completion: Dec 2014
gsun32@gatech.edu

Strategic Area: Biomaterials
Thesis: Utilization and Characterization of Nanocomposite Film from Biomass
Advisor: Art Ragauskas

Qining Sun's research project is about the analysis of chemical structures of celluloses and hemicelluloses, and focuses on the isolation and novel nanocomposite film prepared from Glucomannan.

Hongzi Wang
Chemical and Biomolecular Engineering
PSE Grad Student as of Aug 2009
Expected completion: Aug 2013
Graduate Research Assistant
hwang57@gatech.edu

Strategic Area: Biomaterials
Thesis: Design of Robust and Smart Antimicrobial Microcapsules from Double Pickering Emulsions for Applications in Paper and Packaging
Advisor: Sven Behrens

In a two-pronged approach, we investigate the fundamentals of emulsification with colloidal particles and apply the obtained insights to the design of emulsion-templated microcapsules with customizable properties for antimicrobial modification of paper and packaging materials. The fundamental part of the project focuses on understanding the prerequisites for decorating and stabilizing emulsion droplets with charged colloidal particles. Such particle-covered droplets are used, in the applied part of the project, as precursors for a new type of microcapsules suitable for efficient encapsulation of antimicrobial substances. The investigated capsules are designed to withstand the pressure, shear and thermal stresses encountered in papermaking and printing processes, while offering the benefit of sustained release or triggered release of their antimicrobial cargo in response to external stimuli such as pH, temperature, or possibly, microbial attack. Specifically, the suitability of such microcapsules for the post-production functionalization of packaging surfaces by flexographic printing shall be explored.

Yushu Wang
Materials Science & Engineering
PSE Grad Student as of Oct 2011
Graduate Research Assistant
yswang@gatech.edu

Strategic Area: Operations Excellence
Thesis: Corrosion of Stainless Steels in Closed Paper Machine Environments
Advisor: Preet Singh

Closed or partially closed chemical process system helps reduce fresh water usage as well as process water discharge in the pulp and paper industry. However, water properties change due to the recycling of process water, which promotes corrosion of existing equipment. Higher temperature, change in pH along with higher levels of residual chemicals, additives, and suspended solids all aggravates the corrosion. Different kinds of corrosion happen at the same time, such as pitting, stress corrosion, microbial, and erosion-corrosion, etc. The purpose of this research is to understand the corrosion behavior of 304L, 316L, and duplex stainless steels in white-water system. The understanding of fundamental mechanisms of corrosion and stress corrosion cracking in white water system will lead to possible process optimization or facility improvement such as corrosion inhibitor or change of metal used in equipments.
PAPER SCIENCE AND ENGINEERING STUDENTS

Tyrone Wells
Chemistry & Biochemistry
PSE Grad Student as of Jan 2010
Expected completion: Dec 2013
Graduate Research Assistant
twells7@gatech.edu

Strategic Area: Operations Excellence
Thesis: Microbial Treatment of Lignin and Upgrading of Pyrolysis Oils
Advisor: Art Ragauskas

Tyrone Wells is a PhD student and PSE fellow in the School of Chemistry and Biochemistry at Georgia Tech. Due to their corrosive nature, pyrolysis oils provide complex containment difficulties to industry. His work analyzes and optimizes the treatment of corrosive pyrolysis oils via microbial upgrading. His goal is to generate less-corrosive, high-quality lipids using oleaginous microbes on pyrolyzed lignin.

Jie Wu
Polymer, Textile & Fiber Engineering
Materials Science & Engineering PSE (minor) Grad Student as of Aug 2008
Expected completion: Aug 2013
Graduate Research Assistant
jwu71@gatech.edu

Strategic Area: New Products
Thesis: Optical Coatings via Biomimicry for Sustainable Paper and Paperboard Products
Advisor: Carson Meredith

Paper and paperboard require significant whiteness and brightness so that printed images and text can achieve maximum optical contrast with faithful color reproduction. Traditional approaches to attain that goal have included lignin extraction, addition of mineral fillers and bleaching treatments that involve energy-intensive processes that produce additional waste streams and add additional mineral mass in the final product. A recent discovery indicates that a three-dimensional random network structure makes the white beetle have high whiteness and brightness. The project goal is to develop assembly methods for reproducing this white beetle scale structure synthetically and extend this approach to coat paper and paperboard products.
Prosthetic heart valves have been used for over 50 years to replace diseased native valves. The most widely implanted design is the bileaflet mechanical heart valve (BMHV) due to superior flow hemodynamics and blood damage performance. However, BMHVs still lead to severe complications such as hemolysis, platelet aggregation, and thromboembolic events. These problems have been linked to non-physiological shear stresses on blood elements. In order to reduce the severity of the complications and improve valve design, the blood damage that occurs in BMHV flows must be well understood. Computational fluid dynamics solvers can be used to model blood damage in pulsatile flows through BMHVs and ultimately improve valve design.

The numerical simulations of this study employ a fluid-solid coupling method that combines the lattice-Boltzmann Method (LBM) with the novel external boundary force (EBF) method. The LBM solution for fluid flow converges to the solution of the Navier-Stokes equations. In addition to being accurate, the LBM employs spatially local calculations due to roots in kinetic theory, making it optimal for parallel computing. The motion and orientation of suspended solid particles are captured solving the Newtonian dynamics equations. Fluid-solid coupling is computed using the EBF method by enforcing no-slip conditions on all solid surfaces. A linear shear stress-exposure time damage accumulation model can be used to quantify platelet damage.

Nano thin films are made by layer-by-layer assembly of cellulose-based materials. Cellulose whiskers are prepared from wood pulp by hydrolysis and then modified with positive charge or negative charge. By dipping a substrate alternately into positively charged and negatively charged cellulose materials, thin films are thus made through static electrionic force.
PAPER SCIENCE AND ENGINEERING STUDENTS

Yi Zhang
Chemical and Biomolecular Engineering
PSE Grad Student as of Fall 2012
Expected completion: Summer 2015
yzhang642@gatech.edu

Strategic Area: Biomatertials
Thesis: High-Strength, Low-Weight Cellulosic Nanocomposites by Colloidal Assembly

Advisor: Sven Behrens
Carson Meredith

High-strength, low-weight foams are important in a variety of applications, ranging from thermal insulation to packaging, and biocompatible foams are desired as drug delivery vehicles and scaffolds for tissue engineering. However, traditional polymer foams based on petroleum are neither renewable nor biodegradable. Cellulosic foams, however, can fulfill these requirements. My goal is to develop a novel method to produce high-strength, low-weight cellulosic foams from colloidal assembly.

Zhe Zhang
Chemical Engineering
PSE Grad Student as of Nov 2012
Expected completion: Sep 2015
zhe.zhang@pse.gatech.edu

Strategic Area: 
Thesis: Novel Fiber and Sheet Composites of Lignin and Cellulose

Advisor: YuLin Deng

Xiaojuan Zhou
Chemical and Biomolecular Engineering
PSE Grad Student as of Aug 2011
Expected completion: Jun 2013
zhoux@gatech.edu

Strategic Area: Catalysis
Thesis: Renewable Nylon 6 Precursor from Lignin Fragments by Catalytic Hydrogenation

Advisor: Chris Jones, Pradeep Agrawal

The purpose of this study is to investigate the conversion of monomeric lignin fragments into cyclohexanols for use as a source of lignin-derived monomers for renewable Nylon 6 production. A specific goal is to transform lignin-derived monomeric phenolic species to their cyclohexanol analogs via selective catalytic hydrogenation. A fixed-bed flow reactor is used to evaluate the selective hydrogenation of individual model phenolic species (guaiacol, etc.). The initial catalyst composition studied is Ni/SiO2, which was previously shown to form cyclohexanol as an intermediate from phenol. In parallel a Parr reactor will be used to study hydrogenation of phenolic species such as catechol and substituted catechols with commercial Raney catalysts. A primary focus is on tuning the reaction conditions to form desired products, while avoiding the formation of byproduct species which can be precursors to catalyst deactivation, or fully hydrogenated products of lower value. An understanding of the reaction products from lignin-derived monomers to substituted cyclohexanols will allow assessment of the feasibility of using lignin as a renewable source of raw material in comparison with using cyclohexanol made from petroleum with price of $1000/MT for Nylon 6 production. Based on the products, catalyst compositions and/or reaction conditions that target selective production of cyclohexanol and substituted cyclohexanols will be identified.
IPST TESTING SERVICES
Analytical and Testing Services
IPST – Georgia Tech

Contacts
Analytical: Mike Buchanan
404/894-5338
mike.buchanan@ipst.gatech.edu
Pulping & Bleaching: Rallming Yang
404/894-7862
rallming.yang@ipst.gatech.edu
Chemical Recovery & Gasification: Scott Sinquefield 404/385-0241
scott.sinquefield@ipst.gatech.edu

- Chemical analysis
- Microscopy-- optical, and scanning and transmission electron microscopes
- Product physical analysis
- Corrosion diagnosis
- Chemical recovery process elements
- Gasification: black liquor gasification pilot plant
- Pulp Analysis: pilot digester; high-shear bleaching mixers with ozone injection; screens for contaminant analysis

For Further Information: www.ipst.gatech.edu/testing_services
IPST Testing Services

IPST at Georgia Tech Testing Services include chemical analysis, gasification, microscopy, paper physical analysis, materials analysis, pulp analysis and chemical recovery. Our Testing Services team oversees all activities related to research testing services for both internal and external customers. The multidisciplinary capabilities of the team make it uniquely qualified to address customers' technical needs in the areas of process and product development and quality control. Our professional scientists and engineers work together to provide information and offer solutions required by a rapidly changing market. Where appropriate, testing services personnel will involve faculty and other staff experts to arrive at the best possible solution.

**Chemical Analysis Laboratory (Mike Buchanan)**
The activities of the Chemical Analysis Group range from routine testing services to research. Some specific areas of experience include machine deposit, evaporator scale and product contaminant chemical characterization; wood, pulping liquor, pulp and paper chemical analysis; product defect analysis; and methods development. To support this variety of analytical service projects, the group employs numerous instrumental analysis techniques including gas and liquid chromatography, mass spectrometry, infrared spectroscopy, emission spectroscopy and capillary electrophoresis. Classical wet chemistry techniques including titrimetry, gravimetry and calorimetry are also used routinely.

**Paper Physical Analysis Laboratory (Dr. Roman Popil)**
Paper Board/Box Testing at IPST has more than 5600 square feet of dedicated lab space with the testing equipment required to perform all standard TAPPI tests. Through our various research programs, we have also developed specialized testing equipment and methods that are not available elsewhere. We test strength, optical, surface and structural properties, and provide special services in areas such as environmental simulations and accelerated aging. Tests include:

1. Precision paper grinding or sheet splitting to produce specific thickness sections
2. Score cracking of linerboards: measurement of crack angle by IPST method or cracking propensity by the AF&PA method
3. Needle abrasion testing to predict relative slitter and knife blade wear caused by abrasive components in both base sheet and coating materials
4. Optical 3D Moiré surface topography and processing software for the measurement of curl or cockle
5. An automated double-backer simulator that can fabricate 12 x 2" corrugated board samples for evaluating adhesive efficacy and application
6. A torsion pendulum that can measure the out-of-plane corrugated board shear rigidity, which is a sensitive measure of board crush on board physical properties in complement to the acoustic resonance “BQM” method
7. Large-platen 4' x 5' box compression tester (BCT) up to 20,000 lbs
8. A 12-channel ECT creep measuring apparatus available for evaluating lifetime performance of corrugated boards
9. A programmable walk-in humidity chamber fitted with 8 accelerated creep measuring stations for corrugated box lifetime studies
10. Stained fiber microscopy analysis to identify furnish type, species, hard/softwood mix ratio
11. State of the art ultrasonic testing capability: TSO and Sonisys in-plane and out-of-plane including ultrasonic testing for tissue softness complemented by ‘handle’ by the Handle-o-meter.

Synergistic collaboration with IPST Chemical Analysis and Pulping Laboratories provides an unparalleled trouble-shooting capability to address any industry quality or production issue. Three large walk-in environmental chambers cover high and low temperature and varied controlled or cyclic humidity conditions.

The IPST paper testing lab is backed up by the research and industry expertise of the Institute. Research-based answers are included with every report. We interpret data from a big-picture perspective, going beyond the surface symptoms to analyze root cause issues, providing substantial answers for process improvements. Our analyses can support the entire range of a company’s business objectives, including R&D, product development, process improvement, runnability, quality issues and disputes.

**Pulping, Bleaching and Chemical Recovery Laboratory**
(Rallming Yang, Scott Sinquefield, Steve Lien)

The Pulping, Bleaching and Chemical Recovery group at IPST has well equipped laboratories for testing and analysis of raw materials and pulps. Standard methods for chip analysis and most pulp quality tests are available. Special capabilities include a computer-controlled handsheet press with heated platens, a corona discharge instrument for surface modification of paper sheets, and a 50-liter Pfaudler reactor for acid treatment of biomass. Simulations of most pulping and bleaching processes can also be conducted to enable informed decisions about mill operations. Raw materials for pulping studies can be prepared with a Carthage chipper and Rader™ or ChipClass™ chip screens. Several pulping systems are available including a multi-unit mini-digester and a digester system with 4 liquor vessels for simulation of new batch and continuous cooking technologies. Almost all bleaching technologies can be performed in our lab in high-shear mixers. Pulp processing capabilities include laboratory screens, Valley Beater, PFI mill, and handsheet-making.

In the chemical recovery area, a bench-top evaporator is used to concentrate weak black liquor and determine when soluble scale precipitates. After crystallization, filtered samples of the crystals can be collected for chemical analysis and determination of the crystal species. This information can help diagnose scaling problems in multiple effect evaporators. During an evaporation run, we monitor the particle size distribution of the precipitates and the boiling point rise. We also have the capability to measure liquor viscosity over a range of solids and temperatures.

63
For combustion chemistry, a Laminar Entrained Flow Reactor (LEFR) is used to burn small particles (~100 microns) of black liquor, biomass and other materials. The LEFR allows tight control over temperature, residence time, and gas composition in order to study kinetic rates. A thermo-gravimetric analyzer (TGA) is also used to study gasification and combustion. Gas analysis is performed with a gas chromatograph.

**Corrosion and Materials Chemistry Laboratory (Professor Preet Singh/ Jamshad Mahmood)**

Reliable performance of materials is very important for any industrial process, and especially for manufacturing high quality products in any industry, including the chemical process and pulp & paper industries. Material selection is generally based on the required material properties, low initial capital investment, and minimum maintenance. Changes in the process parameters to improve products can often lead to higher corrosion susceptibilities of the plant materials. Corrosion science and engineering research includes understanding the basic mechanisms involved in material degradation in given environments and using that knowledge to develop a mitigation strategy against environment-induced failures.

Research activities of the Corrosion and Materials Chemistry Research Laboratory (CMCRL) at the School of Materials Science and Engineering and the Institute of Paper Science and Technology at the Georgia Institute of Technology are focused on corrosion, stress corrosion cracking, high temperature oxidation, and other forms of environmentally induced degradation of metallic materials. Analytical and characterization tools needed for corrosion research are either available in our laboratory or in the School of Materials Science and Engineering at Georgia Tech. Software for thermochemical calculations is used for thermodynamic predictions and modeling of corrosion processes.

CMCRL at Georgia Tech is equipped with the following test facilities:

1. **General Corrosion Tests** (Room temperature up to 200°C)
2. **Electrochemical Tests for Corrosion and Surface Chemistry:**
   a. Potentiodynamic Polarization
   b. Electrochemical Impedance Spectroscopy (EIS)
   c. Cyclic Voltammetry
   d. Electrochemical Noise Measurements
   e. Autoclaves and pressure balanced reference electrodes for electrochemical tests up to 200°C
3. **Erosion Corrosion – Rotating Cylinder Tests**
4. **Stress Corrosion Cracking and Corrosion Fatigue Testing**
   a. Slow Strain Rate Test rigs for room temperature and high temperature stress corrosion cracking tests at temperatures up to 350°C.
   b. Corrosion Fatigue test facility (MTS Model 810 machine with Teststar II® control system with environmental chamber) for crack growth and endurance limit study
5. **High Temperature Gaseous Corrosion** (Oxidation/Sulfidation Tests of Metallic Alloys)
a. Single and mixed gases over a range of temperatures, cyclic gases, and cyclic temperature capabilities (up to 1100°C)
b. Thermogravimetric microbalances for high temperature gaseous corrosion testing
6. Molten Salt Corrosion Tests
7. Fog Chamber Tests
8. Heat treatment, with inert atmosphere capability (up to 1300°C)
9. Metallography and Image Analysis, Microhardness Measurements
10. Failure Analysis

Other Research Laboratory Capabilities

Green Bioprocessing Laboratory (Professor Art Ragauskas)
Our research program focuses on green chemistry of biopolymers including cellulose, hemicellulose, and lignin. Through the use of green chemistry, biotechnology, and cold plasma, our research group is looking at new ways to synthesize novel biomaterials, biocomposites, and biofuels from nature’s renewable biopolymers. An exciting aspect of this research is the development of new nanocellulose- and hemicellulose-based materials. Such innovative research approaches allow researchers to synthesize new biomaterials that could be used for smart-polymers, controlled release, and enhanced barrier properties for health care, packaging, and security applications. Our research program is also renowned for its fundamental oxidative chemistry and structural elucidation of polysaccharides and lignin. Students involved in these studies utilize our state-of-the-art NMR and MS facilities.

An active field of research that presents vast opportunities is the use of cellulose to develop new biocomposites. An example of this is the biocomposite being prepared from polysaccharides and polylactic acid, a unique product that exhibits far greater performance than either material alone. This research involves a great deal of physical chemistry at the surface of differing materials including surface grafting reactions, polymer chemistry, and surface analysis employing ESCA, AFM, and SEM.

Another area of carbohydrate research lies in the creation of biofuels, which are being developed through the depolymerization of biomass. The substitution of imported hydrocarbons with bio-based fuels and chemicals offers a tremendous opportunity to develop new renewable green chemistry processes that exhibit substantially improved environmental performance properties and net reductions in CO₂ emissions. Currently, we are examining unique catalytic chemistries and biotechnologies (i.e., laccase, peroxidase, endoglucanase) in ionic liquids that will convert lignocellulosics into valuable biofuels. Student research is conducted in a multidisciplinary environment with several projects involving collaborative efforts with other groups on campus, nationally, and internationally.
**Surface Characterization Testing Laboratory (Professor Yulin Deng)**

The group’s research interests are nanomaterial synthesis and self-assembling biofuel and biomass-based materials, colloid and surface science and engineering, polymer synthesis, and papermaking and paper recycling. In nanomaterial synthesis and characterization, one-dimensional nanomaterials, including ZnO, TiO$_2$, Mg(OH)$_2$, Au, polyaniline, and two-dimensional nanomaterials with ordered patterns have been some of the research projects. The unique applications of such one- and two-dimensional nanomaterials as a sensor, solar cell and super-capacitors have been studied. The one-dimensional nanomaterials synthesized in our lab have also been used as reinforcement materials in polymer nanocomposite material. Cellulose nanowhiskers, which are biodegradable one-dimensional materials, have been used as reinforcement nanomaterials in our high-strength fiber preparation. Hollow-structure inorganic materials, such as TiO$_2$ and polymer materials, such as poly(iso-propyl acrylamide) have been synthesized. These unique nanomaterials can be used in many applications including for example drug delivery and solar cells. Nanocomposites such as polymer/nanoclay hybrids are engineering materials that have great potential in many industries. Recent research indicated that exfoliated nanoclay could be encapsulated in polymer latices. The water-based polymer-nanoclay suspension is a great candidate for painting and paper coating. In biofuel research, the group has been developing a novel pretreatment of lignocellulose for biofuel production. Catalytic depolymerization of lignin, including chemical and photocatalytic conversion of lignin into fuel, is one of the current active research projects within the research group.

**Nano Visualization Laboratory (Professor Zhong Lin Wang)**

We are a leading group in nanoscience and nanotechnology in the Georgia Institute of Technology.

Our current research focuses on the fundamental science in the physical and chemical processes in nanomaterials growth, unique properties, fabrication of novel devices, and their unique applications in energy science and biomedical science. Our research is in following directions:

1. Nanogenerators for converting mechanical energy into electricity;
2. Nanopiezotronics and its applications;
3. Nano-enabled technology for solar-cells;
4. Integration of nanosystems with biomedical science and cancer detection;
5. Self-powered nanosystems;
6. Fundamental electron microscopy and its applications;
7. In-situ measurements in TEM
IPST Membership Options
Full participation
Directed research
Consortium membership

For further information, please contact Norman Marsolan, Director (norman.marsolan@ipst.gatech.edu)

Leadership and Giving

The support of our companies, loyal alumni, and friends drives IPST’s success in realizing our vision as the world’s leading research and educational enterprise supporting the global forest products and related industries. IPST is in a unique position to help educate the future leaders of the industry and to provide new knowledge and create solutions to the technical, economic and strategic issues facing the industry.

Guide to Giving:

To give a gift by cash or check, simply make your check payable to the Georgia Tech Foundation, state that your gift is intended for the benefit of the Institute of Paper Science and Technology, and mail it to:

Georgia Tech Foundation
760 Spring Street NW, Suite 400
Atlanta, Georgia 30308

Please include a short note with your check stating that the purpose or designation of your gift is to the Institute of Paper Science and Technology and note the purpose on the memo line of your check. Your gift will be recorded and receipted promptly on behalf of the Institute of Paper Science and Technology.

To make a gift by credit card or wire transfer, please contact the Georgia Tech Foundation at (404) 894-6130 or the Office of Development at (404) 894-5544 to inform Georgia Tech of your coming gift to ensure that your transfer is credited properly. Please contact the Director of Gift Accounting to make a gift by credit card. State that your gift is intended for the benefit of the Institute of Paper Science and Technology.

For more information, please visit our website (www.ipst.gatech.edu)