At commencement on May 13, 2011, Clemson University’s Norris Medal was awarded to ChBE senior Jennifer Moffitt. The Norris Medal was established under the terms of the will of D.K. Norris, a life trustee of Clemson. The medal is given each year to the graduating student who is judged to be the best all-around by the university scholarships and awards committee.

Jennifer, from Spartanburg, SC, was also the recipient of a prestigious Barry M. Goldwater Scholarship and the Eastman Award for Excellence in Chemical Engineering. She participated in the Honors College EUREKA! summer research program and studied abroad at the University of Sussex, England, and in Belize, Southeast Asia, and The Netherlands.

She is a member of Tau Beta Pi and Alpha Lambda Delta Honor Societies and participated in Women’s Glee, CU Symphony Orchestra, and Women in Science and Engineering.

She conducted undergraduate research entitled “Phase Behavior of Cellulose Nanocrystal Dispersions” with Professor Christopher Kitchens and earned Calhoun College Honors. Her many community service activities have included teaching science and research to students at R.C. Edwards Middle School, Pickens County Election Poll Manager, co-ordinating Seismic Semi-formal to raise money for Haitian earthquake victims, and teaching safe behaviors to Clemson Freshmen.

Jennifer has accepted a position in Research and Development at the Eastman Chemical Company and plans to pursue a Ph.D. in Chemical Engineering while working.
Nanocomposites Derived From Renewable Resources: Mimicking Nature in the Design of Sustainable Materials

Dr. Kitchens’ research lies at the interface of Nanotechnology and Green Engineering. The primary distinction of Nanotechnology lies in the fact that many materials possess unique properties when their dimensions are restricted to less than 100 nanometers in length. These properties run the whole gamut of the materials world, from unique catalytic or optical properties to extremely high strength-to-weight composites. The primary motivation is to understand the nanoscale phenomena that control these properties and develop new synthesis and processing methodologies that lead to new advanced materials. Simultaneously, we focus on the principles of Green Engineering to ensure that our methods are effective and lead to a sustainable future. One project in particular takes a few cues from nature in order to design polymer nanocomposites that have process tunable properties. In our lab, we have isolated crystalline particles of cellulose from cotton linters or a loblolly pine Kraft pulp and used these rod-shaped nanoparticles as a nanofiller for polymers derived from renewable resources. These isolated cellulose nanocrystals (CNCs) are elongated nanoparticles with an average length of 130nm, width of 20.4nm, and height of 6.8nm, as determined from AFM and shown in Figure 1.

Cellulose is the most abundant polymer on the planet and all forms of cellulose contain crystalline cellulose, which can be isolated by controlled acid hydrolysis. In general, the size and orientation of CNCs varies within different species of plants and leads to different properties on cellulose fibers. For example, the crystalline cellulose components of hemp or ramie bast fibers are highly aligned and have a low microfibrillar spiral angle with respect to the fiber axis, while cotton has a higher microfibrillar spiral angle (MSA). As a result, bast fibers have a high tensile modulus while cotton has a higher elastic modulus. A high MSA is also found in juvenile wood which requires more elastic properties while a low MSA is found in mature wood that must be stronger to support the weight of the tree. This relationship between the natural fiber mechanical properties and the nanoscale structural orientation of cellulose crystals, specifically the MSA, is of significant interest from a polymer nanocomposite processing standpoint because it lends opportunity to control fiber mechanical properties by tailoring the self-assembly of nanoparticles within the polymer matrix. We have recently demonstrated the appearance of this structure-property relationship in CNC reinforced alginate fibers. By controlling the CNC weight fraction loading and the fiber wet-spinning properties, we can tailor the mechanical properties that correlate directly with the CNC spiral angle within the alginate fiber.

Alginate fibers have found many applications such as the preparation of dressings to treat exuding wounds, drug delivery, enzyme immobilization, etc.; however their use is limited due to their poor mechanical properties. Cellulose nanocrystals (CNCs) were isolated from cotton and introduced into calcium alginate fibers with the goal of improving their strength and modulus. The CNCs were mixed with an aqueous sodium alginate dope solution, and wet spun into a CaCl2 bath to form fibers [1]. It was found that when the apparent jet stretch (ratio of the fiber draw velocity to extrusion velocity) is kept constant, addition of the nanocrystals reduces the tensile strength and modulus of the material; however a small concentration of CNCs in the dope solution increases the toughness and enables an increase in the fiber spinning apparent jet stretch ratio by nearly two fold at up to 25% CNC loading; the maximum jet stretch ratio of 4.6 is observed at 25%wt CNC loading, as compared to a maximum of 2.4 for the native alginate. Mechanical testing showed a 38% increase in tenacity and a 123% increase in tensile modulus with 10%wt CNCs loading and an apparent jet stretch of 4.2.

Wide angle X-ray diffraction (WAXD) was used to determine the structure and orientation of CNCs within the alginate nanocomposite fibers and provide correlations with the resulting mechanical property enhancements [2]. The orientation of the CNC was determined from the azimuthal intensity distribution of the (2,0,0) reflection where the spread of the orientations increased with higher loads until the nanoparticles spiraled around the fiber axis. Increased fiber stretching retarded the appearance of a spiral assembly and increased CNC alignment, as depicted in Figure 2. A reduction of tenacity and modulus, and an increase in elongation at break and tensile energy to break coincided with the observation of the spiral orientation. These trends are analogous to those found in natural fiber and demonstrate our biomimetic design of CNC nanocomposite fibers.

Figure 1. Atomic Force Microscopy (AFM) image of CNCs isolated from a Kraft pulp obtained from a South Carolina pulp and paper mill. Image dimensions are 2.5 x 2.5 µm.

Figure 2. The microfibrillar spiral angle (MSA) can be determined from the 2-D wide angle X-ray diffraction pattern by isolating the cellulose I (2,0,0) peak and measuring the offset angle from two equivalent deconvoluted Gaussian peaks. The MSA is shown to increase with CNC loading and decrease with fiber stretching during spinning, which also correlates with the fiber mechanical properties.

Clemson’s Robert J. Rutland Institute for Ethics held the 10th Annual J.T. Barton Jr. Ethics Essay Scholarship Competition, with this year’s theme focused on the BP oil spill in the Gulf of Mexico. ChBE senior Allison Foreman was awarded third prize for her essay entitled, “What ethical obligations did BP have to protect workers like Ed when they were hired?”

Clemson’s National Scholars Program (NSP) provides a full scholarship to about a dozen top undergraduates annually who have applied to the University. It is a rigorous application and selection process, including an on-campus interview. The Department graduated three seniors this past May who were members of the NSP – Allison Foreman, Jennifer Moffitt, and Ray Smith.

Each year, the NSP invites seniors to present the National Scholars Program’s Awards of Distinction to the faculty and advisors who have served as mentors in helping the students develop intellectually, professionally, and personally. Allison and Jennifer presented their awards to Professor Charlie Gooding.

ChBE junior Adam Klett was selected to receive a research fellowship from the Atlantic Coast Conference Inter-institutional Academic Collaborative (ACCIAC) – he was one of only three Clemson students selected this year. Adam works with Professor Mark Thies on a research project focused on the Sulfur-Iodine Cycle to split water into hydrogen and oxygen, for the purpose of producing hydrogen as a fuel on a massive scale as a replacement for petroleum-derived fuels. The ACCIAC Fellows Program in Creativity and Innovation supports undergraduate student-driven research projects at the Atlantic Coast Conference campuses.

On the Honors and Awards Day in April, Charles McGill was awarded the Western S.C. Section AIChE Scholastic Achievement Award for the graduating senior with the highest scholastic average. For juniors, Courtney Rowe won the Dow Chemical Award; and sophomore, Jeremy Kearns, was awarded the 2010 Donald F. Othmer Sophomore Excellence Award. Congratulations to all!

Prof. Anthony Guiseppi-Elie, was a keynote presenter at the 2011 International Conference on Frontiers of Characterization and Metrology for Nanoelectronics, May 23-26, 2011, MINATEC Campus in Grenoble, France. His talk was entitled “Frontiers of More than Moore in Bioelectronics and the Required Metrology Needs.” He has also been named to the Board of Directors of the Council for Frontiers of Knowledge (CFK).

Professors Scott Husson and Chris Kitchens have received a 3-year grant from the National Science Foundation to run a 10-week summer research experience for undergraduates (REU) program for a talented and diverse group of undergraduates from across the nation. The intellectual focus of this REU site is Advanced Functional Membranes. The program will engage promising young students in research aimed at providing membrane-based solutions to grand societal challenges, from improving the quality and cost of healthcare, to producing a cleaner and safer environment, to improving materials for energy conversion and storage.
The Chemical & Biomolecular Engineering Department is proud to recognize the Senior Class of 2011. The students were honored at a Senior Reception on May 5th at the Marden Center, which was sponsored by Mansfield Oil Company out of Gainesville, Georgia. On graduation day, May 13th, the department hosted an Open House for the graduates and their families. The faculty and staff of ChBE want to wish all of our graduates the best of luck in all your future endeavors! Congratulations!

Dr. Esteban Ureña-Benavides on graduation day with his Ph.D. advisor, Dr. Chris Kitchens.

2011 Graduation Candidates
Bachelor of Science Degree in Chemical & Biomolecular Engineering

Jason Michael Abd
Rahel David Allen
Teresa T. Armistead
Chad C. Carpenter
Collin J. Connors
Leslie E. Cheek
Kristin Marie Coles
Daniel E. Crandall
Johnathon A. Criggott
Austin C. Day
Jonathan D. Parker
Ashley Hughes Dill
Allison L. Ermstone
Robert B. Forderinger
Leila J. Goodbey
Jennifer C. Graves
Philip B. Harris
Donald J. Hanner
Ashlee T. Hukker
Michael L. Eshem
Lucas C. Ingham
William R. Johnson
Peter Knudsen
Jacob L. Lauder
Bradford Scott Long
Joseph M. Marrion
Peter Wagner Nabiof
Michael D. Martin, Jr.
Charles E. McGill
Jonathan A. McKeel
Chad M. Miller
Jennifer C. Miller
Jacob Daniel Morris
Eileen Q. Moskowitz
Kenneth M. O’Connor
William Lane Petty
Mark F. Reiners
Christopher Powell
John R. Powell III
Matthew G. Proctor
Robert A. Rasmussen
Brendan J. Sale
Elizabeth A. Savage
Bennett E. Smith
Ryan Michael Snow
William R. Storer
Charlotte V. Twomey
Stephanie C. Voss
Hunter R. Winkler
Michael E. Wierzbiczki
The ChBE Class of 1963 held their Class Reunion at Earle Hall on May 19th and 20th. The reunion was organized by their fellow classmate, Dr. James Rushton. They had attendees from as far away as Montana. One of their Chemical Engineering professors, Dr. William Barlage, was also able to attend. Some of the attendees had not been in Earle Hall for over 48 years, so it was enjoyable looking at old pictures and reminiscing with classmates.

While they were here, they were able to tour our lab facilities and were updated on current research, renovations, and future goals by our Department Chair, Dr. Doug Hirt. They also were able to have an in-depth tour of the Athletic facilities on campus and other points of interest around Clemson during their stay.

It was a pleasure hosting the Class of 1963!! We hope to see you again next year!!


Standing in front of Earle Hall on May 20th were (left to right) Wade Ponder, Al Tolson, Jim Rushton, Cliff Hattaway, John Cromer, Jerry Richardson, and John Elsey. Attending but not available for this picture were Larry Murdoch, Terry Kinard, and Dr. Barlage.
Dr. Esteban Ureña-Benavides
Dissertation: “Cellulose Nanocrystals Properties and Applications in Renewable Nanocomposites”
Advisor: Dr. Christopher Kitchens
Current Position: Post Doc
Auburn University
Auburn, Alabama

Dr. Kitiya Hongsirikarn
Dissertation: “Effect of Impurities on Performance of Proton Exchange Membrane Fuel Cell Components”
Advisor: Dr. James Goodwin
Current Position: Research Analyst
Nexant Asia Limited
Bangkok, Thailand

Dr. Gregory White
Advisor: Dr. Christopher Kitchens
Current Position: Post Doc
Sandia National Laboratories
Albuquerque, New Mexico