2018

THIRD Quarter

PTC Newsletter

Polymer
Technology Center

UPCOMING EVENTS

Mark Your Calendars for the PTC Fall meetings!

Scratch Behavior of Polymers Consortium-SCRATCH	Polymer Technology Industrial Consortium-PTIC
Wednesday, October 10th, 2018 Noon—4:30pm After the TPO Conference-Troy, MI	October 18th - 19th, 2018 College Station, TX Texas A&M University

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PTC News & SPE Student Chapter

Introducing Kevlar® Aramid Nanofiber

Jodie L. Lutkenhaus
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Department of Materials Science and Engineering

Kevlar®, famously used for bullet-proof vests, is a fiber formed from a rigid-rod polyaramid of high tensile modulus and strength (185 GPa and 4 GPa, respectively).[1] The polymer within Kevlar® is poly(p-phenylene terephthalamide), PPTA. The high mechanical properties arise from the supramolecular structure within the polyaramid fiber in the form of organized crystalline domains, intermolecular interactions such as hydrogen bonding, and chain-stiffness from the aromatic rings.[1, 2]

In 2011, a new form of PPTA was introduced by which PPTA thread was treated in a strongly basic solution to yield **aramid nanofibers or ANFs**.[3] Under these conditions, protons were abstracted from the PPTA backbone, disrupting the hydrogen bonding interactions, and "unraveling" the original PPTA thread into ANFs. This represents a significant discovery because PPTA by other means is notoriously challenging to process; by accessing nanoscale PPTA structures, a whole new realm of nanocomposites becomes available. ANF composites have demonstrated extraordinary enhancement in mechanical properties (29.6 GPa elastic modulus, 209 MPa ultimate stress for a 5:1 ratio of reduced graphene oxide sheets to ANFs).[4]

In the Lutkenhaus Lab, we are investigating combinations of ANFs with reduced graphene sheets for the purposes of creating high stiffness capacitors and batteries. We have prepared these composites using layer-by-layer assembly[5] and vacuum filtration[6] to achieve electrodes with excellent mechanical properties. For the future, we envision that ANFs will enable a whole new form of composites, where ANFs will act as mechanical fillers, lending high stiffness or toughness to the composite matrix.

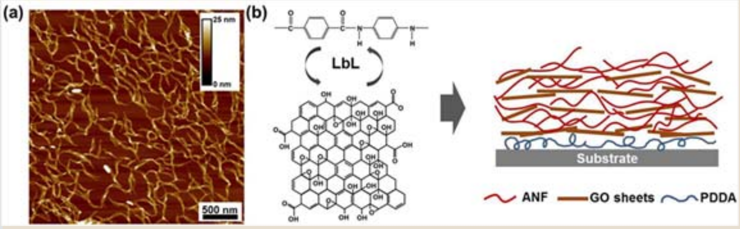

Figure. (a) An atomic force microscopy of solution-cast aramid nanofibers (ANFs). (b) Schematic of layer-by-layer (LbL) assembly) of ANFs with graphene oxide (GO). (c) Schematic of final LbL composite containing ANFs, GO, and a polyelectrolyte (PDDA). Images adapted from ref. 5.

References:
[1] H. G. Chae, S. Kumar, Journal of Applied Polymer Science 2006, 100, 791.
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Amir Asadi, PhD
Assistant Professor
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Cellulose is the most abundant polymer on the planet representing 1.5×10^{12} tons of the total annual biomass production.[1] Cellulose is a linear chain of ringed glucose molecules and has a flat ribbon-like conformation.[2] **Fig. 1** represents the hierarchical schematic of wood structure indicating that cellulose is the building block of all plants. Cellulose nanomaterials (CN) are cellulose-based nanoparticles that are obtained from plants, algae, bacteria and marine animals.[2-3] CN particles are generally grouped based on the cellulose source and the extraction methods, i.e. 1) mechanical processes such as high-pressure homogenizers, grinders/refiners, cryocrushing, high intensity ultrasonic treatments and microfluidization and 2) acid hydrolysis,[2] leading to various CN types, including cellulose nanocrystals (CNC), cellulose nanofibrils (CNF), algae cellulose (AC), bacterial cellulose (BC). **Fig.** 2 shows TEM images of CNC and CNF. One common trait with all CN types is the parallel stacking of cellulose chains along the particle length, and because of this feature the properties of the various CN are similar to each other, at least within the scatter of experimental testing or atomistic model predictions.[2] With this in mind, CN have a unique combination of characteristics that make them attractive for certain composite applications, i.e. low density (1.5 g/cm^3), high surface area and aspect ratio (10-100), self-assembly capability, tensile strength of 3-7.5 GPa, and elastic modulus of 110-220 GPa, surfaces with accessible hydroxyl side groups (e.g. –OH) that can be readily chemically modified, and low toxicity.[4] In addition, CN extracted from trees and plants have the potential to be produced at industrial scale quantities and reasonable price.[5]

Cellulose nanocomposites are being developed to be used as transparent-flexible substrates for electronic applications such as thin film transistors, organic-light emitting diodes, photovoltaic devices, printed foldable antennas and resistive touch screens and sensors.[6] **Fig.** 3 shows applications of CN nanocomposites, as a transparent matrix for an organic light-emitting diode (**Fig.** 3a) and as a thickening agent in a pen's ink (**Fig.** 3b). One of the major research and application areas of cellulose nanocomposites is the medical field due to cellulose's biocompatibility, biodegradability and low cytotoxicity. The use of these materials in drug delivery, tissue engineering, wound healing cartilage replacement and medical implants has been thoroughly investigated, as shown in **Fig.** 4.[7] For example, cellulose nanocomposites with adaptive stiffness have been developed as substrates for brain implants to improve the microelectrode biocompatibility and to minimize inflammatory response.[8-9] Cellulose nanocomposite hydrogels are also appealing as components of stimuli-responsive sensors and actuators, microfluidics, catalysis and separation devices as well as pharmaceutical applications.[10] In addition, cellulose nanocomposites have been used as electroacoustic devices, membranes for combustible cells (hydrogen), water purification, mineral and oil retrieving and additives for high quality electronic paper (e-paper).[11]

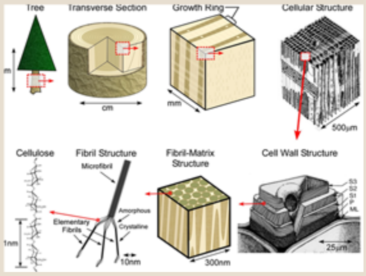

Figure 1: Hierarchical schematic of wood structure [2]

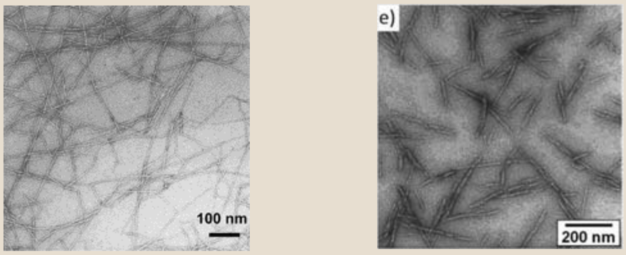

Figure 2: TEM images of (a) cellulose nanofibrils (CNF)[12] and (b) cellulose nanocrystals (CNC)[2]

Figure 3: (a) Luminescence of an organic light-emitting diode deposited onto a flexible, low-CTE and optically transparent wood–cellulose nanocomposite. [13](b) Mitsubishi Pencil's ballpoint pen, Uni-Ball Signo 307, with ink using CNF as a thickening agent (courtesy of Mitsubishi Pencil).

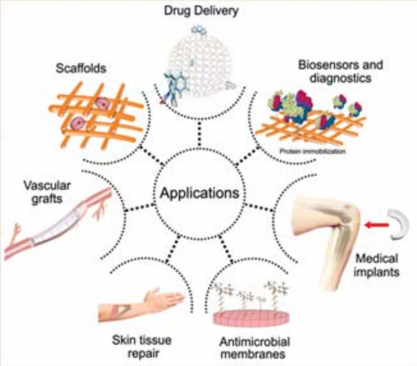

Figure 4: Cellulose nanomaterials in biomedical applications[7]

Due to their high specific modulus and strength, cellulose nanocrystals have also been used to reinforce polymer or polymeric fibers[10] and change sizing of conventional fibers, e.g. glass fibers (GF).[14-15] **Fig.5** indicates the high reinforcing potential of CN compared to other nanomaterials in polymer nanocomposites with data extracted from 84 studies.[16] It has recently been found that addition of 1 wt% CNC allows removing 15 wt% GF in automotive GF/epoxy composites containing 60 wt% GF, resulting in composites of similar specific strength, modulus and impact strength but 13% lower weight.[14, 17] These results show the potential of CN in lightweighting of automotive composites, biomedical and optical applications, and wearable electronics, enlightening a growing and sustainable future for these small but strong materials.

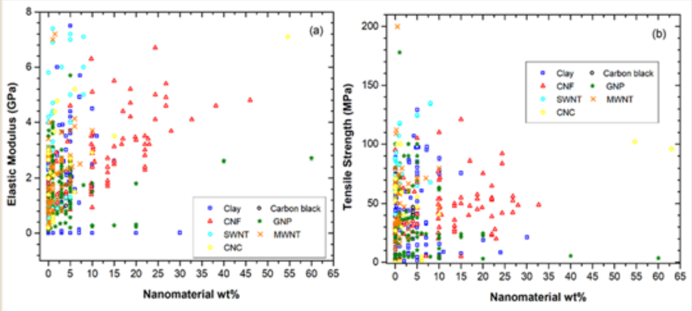

Figure 5: Effect of nanomaterials on (a) modulus and (b) strength of thermoset and thermoplastic nanocomposites. CNF: carbon nanofiber, GNP: graphite nanoplatelets, SWNT: single walled carbon nanotubes, MWNT: multi walled carbon nanotubes. Data are extracted from 84 studies listed in reference [16]

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2018 Young Investigator Award WINNER

De. Lei Fang, CHEMISTRY

Dr. Fang leads an independent research group as assistant professor at the Texas A&M University (TAMU). The multi-disciplinary research program in the Fang Group focuses on the bottom-up synthesis and processing of novel organic polymer materials—namely, ladder and coplanar polymers, as well as microporous polymer networks—for applications in electronics and energy conversion/storage. The group's thrust is to gain a profound understanding of the structure-property relationship of these materials at both, the molecular and the macroscopic levels, by employing the toolboxes of synthetic chemistry and device engineering. With this knowledge, they aim to establish a series of synthetically feasible, high performing, processable, organic carbon-based material systems for field effect transistors, light emitting diodes, solar cells, supercapacitors, and batteries, and to be at the forefront in the enhancement of their efficiencies. To date, Dr. Fang has co-authored over 29 articles and has received numerous awards.

Full story: http://www.mdpi.com/journal/polymers/awards.pdf/0/29_2018_2_P_2018YIAweb.pdf

Lutkenhaus selected as Kavli Frontiers of Science Fellow and named ACS Rising Star

Lutkenhaus presented a lecture titled, "Plastic Power: Organic Polymer Batteries," in which she discussed the functions and opportunities of energy storage platforms, primarily consisting of polymers. Along with presenting this lecture, Lutkenhaus was also named a Kavli Frontiers of Science Fellow.

Later in the month, Lutkenhaus received a tremendous honor from the American Chemical Society (ACS). She was named a Women Chemists Committee (WCC) Rising Star. According to the ACS, the WCC Rising Star Award recognizes women scientists "approaching mid-level careers who have demonstrated outstanding promise for contributions to their respective fields." Along with the award, all of the winners are invited to present at a symposium in their honor.

Full story: goo.gl/1Qm6J1

Tamamis receives the KANEKA Junior Faculty Award

Steve Skarke, (left) vice president of KANEKA Americas Holding, Inc., presents the award to Tamamis

On April 20th 2018, Dr. Phanourios Tamamis, assistant professor in the Artie McFerrin Department of Chemical Engineering at Texas A&M University, was awarded the 2018 KANEKA Junior Faculty Award for outstanding performance and dedication in his research. Dr. Tamamis was recognized by the Polymer Technology Center of the Texas A&M Engineering Experiment Station and the Kaneka Foundation.

Dr. Tamamis' research focuses on computational biophysics and biomolecular engineering, with the aim to address key challenges in amyloid diseases, amyloid biomaterials and the structural elucidation of key biological axes.

Full story: goo.gl/9XyjM8

Left to right: Simcha Felder, CHEM; Monica Hwang, CHEN; Glendy Molero, MSEN; and Dr. Hung-Jue Sue, Professor and PTC Director

Polymer Technology Industrial Consortium (PTIC) Student Poster Session			
April 20th, 2018			
MAJOR	PLACED	Student Name	Student Poster Title
MSEN	1st	Glendy Molero	"Effect of Crosslinking Density upon Scratch Resistance of Epoxy Resins"
CHEN	2nd	Monica Hwang	"High Production Rate fo High Purity, High Fedelity Nafion Nanofibers via Needleless Electrospinning"
CHEM	3rd	Simcha Felder	"The Development of Multifunctional Polymers from D-glucopyranoside"

We are pleased to announce that for the first time the recipients of the PTIC student poster competition were all Lady Aggies.

WHOOP!

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On April 20th, 2018 at the PTIC meeting the following students were recognized for being the recipients of the 2018 SPRING SPE and Kaneka scholarships.

Left to right: Dr. David Hansen, SPE Liason; Farhad Daneshvar, MSEN; Tianyu Yuan, MSEN; Ying-Hua Fu, CHEM

Left to right: Mr. Steve Skarke, Kaneka Vice President; Anja Krieger, MSEN; Yagmur Yegin; FSTC; Tan Nguyen, CHEM; Mohammed Haque, CHEN; Yiming Fan, MEEN; Michaela Pfau, BMEN

For information on becoming a member of the SPE student chapter at TAMU, please contact the below officers.

President	Fabian Arp	arpfabian@gmail.com
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Polymer Specialty Certificate Updates

Students that have applied for the Polymer Specialty Certificate	77
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For more information, please visit: http://ptc.tamu.edu/polymer-specialty-certificate/

Have Questions?

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