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Cimatu Studies Materials for Cornea Replacement

Physical Chemist and NQPI member Katherine Cimatu and her group focus on investigating the surface and interfacial properties of soft polymers. Polymers are substances made up of a chain of repeated monomers. Creating a multifunctional polymeric material involves combining the unique physicochemical and mechanical properties of individual polymers. Her group fabricated a copolymer and prepared polymer thin films to study their morphology, adhesion properties, and their chemical make-up at the polymer-air interface. These materials play an essential role in coatings, sensors, and biomaterials.

In their research, the copolymer thin films are made of a hydrogel and another substituted methacrylate-based polymer. A hydrogel is a polymeric material used in contact lenses, wound dressings, hygiene products, diapers, tissue engineering, and even drug delivery. Interestingly, this specific copolymer could be used as a material for artificial corneas in keratoprosthesis—a surgical procedure that replaces a diseased human cornea with an artificial one. This distinct combination of the two polymers improves their adhesion property. Hydrogels can retain and absorb water (suitable for biological surfaces) and the addition of the other polymer helps in attaching the material better to the same surface.

"I think what we are doing is important because the modifications we introduce and characterizations we perform help us learn about the structure-property relationships of relevant materials allowing us to design new

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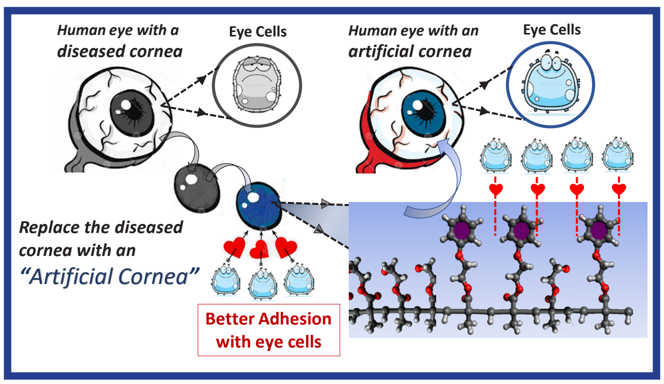

Surface properties of a HEMA and PhEMA copolymer are investigated using AFM and SFG Spectroscopy. This copolymer is an alternative hydrogel material for making artificial human corneas. Illustration: Tharushi Ambagaspitiya


Katherine Cimatu

Govorov Proposes Chiral Nanocrystals for Novel Uses

Physics & Astronomy Distinguished Professor of Physics and NQPI member Sasha Govorov and his group recently published a paper titled "Hot Electrons Generated in Chiral Plasmonic Nanocrystals as a Mechanism for Surface Photochemistry and Chiral Growth" in the Journal of the American Chemical Society (JACS). The paper focuses on photophysics and the physical chemistry of chiral light interacting with chiral nanocrystals.

A molecule is chiral when its mirror image, or enantiomer, is not superimposable upon the original molecule. The process of chiral separation has applications in many areas. In medicine for example, it is important because a drug's effectiveness relies upon a molecule's chirality. It is known that a given enantiomer may not exhibit the same medical properties as the molecule's original orientation.

The motivation for the study came from the idea of 'chiral photochemistry', a process where chemical compounds are electronically excited and molecular chirality is induced. Since biomolecules and drugs are mostly chiral at the molecular level, laser light can be used to separate molecules from their enantiomers. Still, this separation process has a rather low efficiency rate because light-matter interactions that involve chirality are usually weak at molecular scales. At the nanometer scale however, all optical processes are greatly enhanced and the corresponding efficiencies can be much larger.

The paper by Govorov's team proposed such path—the use of chiral nanocrystals for efficient separation using circularly polarized light. Due to this newly found versatility, the field of chiral nanocrystals has become extremely popular; many international research groups are developing new implementations for this technique.


Sasha Govorov

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Director's Corner

Dear Colleagues:

We hope this newsletter finds you safe and healthy. With the global spread of COVID-19, these past weeks and months have certainly been a challenging time. As our daily routines have been upended and our personal and professional interactions transformed, it is valuable to look back at the accomplishments of our colleagues not only to keep our connections but to remind us of the community we have and the collaborations we can look forward to. A special thank you to Jean Andrews, Ling Xin, Rachael Beardsley, Katelynn Nichols, and Nancy Sandler for their extraordinary efforts in putting together this newsletter during this unusual time. We hope you enjoy reading it.

I would first like to congratulate Andreas Weichselbaum, who worked with NQPI member Sergio Ulloa, receiving his Ph.D. in 2004, on his receipt of the 2019 Notable Alumni Award from the College of Arts & Sciences. It is always exciting to see the great accomplishments of our students and members.

It is a pleasure to welcome Faiz Rahman to NQPI. We are delighted that he chose to come back as a faculty member in the Russ College of Engineering and Technology following his time at OHIO as a Stocker Visiting Professor. His expertise in optoelectronics and photonics are a welcome addition to NQPI and will certainly build our strengths in this important area.

Even in the face of major disruptions, our members continue to produce exciting research results. Katherine Cimatu and her group have been investigating promising polymers for cornea replacement while Sasha Govorov and colleagues have published work on chiral plasmonic nanocrystals which provides insight into chiral photochemistry and may advance applications in biochemistry and drug development. Also, a team led by Sergio Ulloa has been investigating magnetic impurities in two-dimensional materials, and recent NQPI member Travis White and his group have reported on their exciting work on earth abundant photosensitizers. Such examples highlight the continued strength and impact of NQPI members.

Like many, we have had to cancel or postpone events such as the annual NQPI Poster Session and Retreat. Though this has been difficult, we are adapting and planning for when we can gather again. Until then, we continue to look for new ways to support our students, members, and colleagues.

Please enjoy the articles and visit our website to learn more. Stay safe!

Sincerely,

Eric Stinaff, NQPI Director

Rahman Blends Physics and Electrical Engineering

The Nanoscale and Quantum Phenomena Institute's newest member, Faiz Rahman, discovered his interest in Electrical Engineering early in his Physics career. Now, his research blends the two disciplines with a focus on electronics and photonics.

Rahman received a bachelor's degree in Physics as well as a master's degree in semiconductor science and technology. By the time he was working on his doctorate, Rahman had transitioned to Electrical Engineering, though still with a focus on Physics research.

"Semiconductor science is the area where Physics and Electrical Engineering meet," Rahman said. "So, people who are working in this field can claim to be either physicists or electrical engineers and be accepted as either."

Research on the interaction between light and matter, for instance, allows him to identify mechanisms to enhance the emission of light in devices. One example is Rahman's research on photonic crystal LEDs, where LED devices are made brighter by making nanometer sized holes on the surface of the material.

"Unlike in a laser, light is emitted in all directions inside an LED and some that are travelling horizontally gets trapped inside the crystal that the LEDs are made from; failing to exit the device vertically," Rahman said. "So what the holes do is act as a diffraction grating that change the direction of the light from horizontal to vertical so it can come out. That's how the LED becomes brighter. The Physics is somewhat more subtle than the holes simply allowing the light to escape."

"Using this device is like the difference between using a black and white camera and a color camera"

Rahman also studies hyperspectral detectors, or devices that sense and collect information from a wide range of color and light.

"Using this device is like the difference between using a black and white camera and a color camera," Rahman said. "The color camera gives us much more information that the black and white camera doesn't catch. The idea is that if we further broaden the wavelength range to light that exists beyond human vision capabilities, we can get even more information."

Rahman, who first came to Ohio University as a Stocker Visiting Professor from 2013 to 2016, came back to OU because he liked the university's environment.

"I liked the university, but also the people in the Physics department." he said. "There are other professors here working in similar disciplines, and we work well together."

Faiz Rahman

Stinaff Re-elected NQPI Director, Sets Goals for Next Term

Eric Stinaff has been re-elected to serve as the Institute's director for a third term (2020-2023). Stinaff, whose expertise is in experimental condensed matter physics and first became the NQPI director in 2014, has set out three main goals for the years to come.

The first is to increase the number of research proposals from NQPI. Stinaff is looking at ways to help support NQPI members with their grant applications and increase their competitive advantage. One of NQPI's missions is to develop interdisciplinary collaborations, so it is important to encourage the formation of multi-investigator teams. Stinaff plans to organize formal discussions on specific themes, such as plasmonics and surface chemistry where the members have shared expertise, and use NQPI resources to foster collaborative proposal submissions to funding agencies including the National Science Foundation and the Department of Energy.

Secondly, he wants to consolidate infrastructure and build a core facility which NQPI members can use with minimal or no cost for their research. Stinaff envisions this resource as a natural outcome of the construction of the new Chemistry building and the renovation of Clippinger Laboratories. He will encourage members to seek support from OHIO and external sources for purchasing new laboratory equipment or upgrading aging facilities.

The third is to build up an alumni and industrial network as a resource for current NQPI students as well as members. The "Bring OUr Alumni Back" seminar series is a good starting point which has already provided connections to OHIO alumni. In the future, using platforms like LinkedIn, NQPI graduates will be connected with current students to offer mentorship on internships, postdoc positions, or job opportunities in academia or the industry.

Since its inauguration in 2001, NQPI has provided "a good community for people working in or close to the field of nanoscience to pursue research and communicate with each other," said Stinaff. As of March 2020, the Institute has 35 faculty members from physics, chemistry, engineering and a few other departments, together with a total of 91 students.

Developing Copper Photosensitizers For A Greener Future

A team led by Ohio University chemist and NQPI member Travis White is working to advance our understanding of the basic processes involving copper photosensitizers to drive chemical reactions, which can shed light on efficient, economic, and stable renewable energy solutions for the future.

Photosensitizers, which absorb energy from light and use that energy to initiate chemical reactions, have attracted much attention as an alternative to mitigate our dependence on non-renewable fossil fuels. However, they are traditionally made of rare earth metals such as ruthenium and iridium, which are scarce and expensive.

Travis White

White and his team have pursued a different approach by using more earth-abundant elements, such as copper, to develop cheaper versions of photosensitizers. In a recent paper published in ACS Applied Energy Materials, they reported new observations about the fundamental process of copper photosensitization in solutions. Specifically, they studied how to select and design electron donors that facilitate electron transfer following light absorption by the copper photosensitizers. Their work provides insight into the factors that affect the rate of electron transfer from the donor to the copper photosensitizers, an important step in ultimately producing a fuel like hydrogen gas.

The published work is the third paper resulting from his copper photosensitizer research supported by OHIO startup funding, said White, who joined the University in 2016 and became an NQPI member in 2019. His team's next goal is to upgrade the experiments from a solution to a device, getting one step closer to the implementation of more affordable photosensitizers.

Outstanding Dissertation Award

The Nanoscale and Quantum Phenomena Institute announced Oscar Avalos Ovando and Dawei Zhai as co-winners of the 2018-19 NQPI Outstanding Dissertation Award.

Avalos Ovando was recognized for his work under Physics and Astronomy professor Sergio Ulloa entitled "Magnetic Interactions in Transition Metal Dichalcogenides," which theoretically studied magnetic induced effects on semiconducting transition metal dichalcogenides. He is currently a postdoctoral researcher at Ohio State University. Before joining Ohio State in March, he did a year of postdoctoral work with physics professor and NQPI member Alexander Govorov.

"It is a great honor to be awarded with this recognition," Avalos Ovando said. "It has been my pleasure to work in NQPI, and I appreciate their support throughout the years."

Oscar Avalos Ovando and Sergio Ulloa

Zhai, who is currently a postdoctoral fellow at The University of Hong Kong, worked with Physics and Astronomy Professor Nancy Sandler on his dissertation entitled "Studies on Electron Dynamics in Deformed Graphene." His work studied the separation of graphene electrons from different valleys, one of the prerequisites of utilizing valley index for information processing.

"It is an honor to receive the award," Zhai said. "I appreciate NQPI for the continuous financial support as well as offering various opportunities to present my research. The award gives me more confidence in continuing my academic career and motivates me to make more contributions to the community in the future."

Dawei Zhai and Nancy Sandler

Physicists Explore Magnetic Impurities

A team led by Ohio University physicist Sergio Ulloa has used numerical simulations to study different mechanisms behind the behavior of long chains of magnetic impurities, which could be potentially useful in the transmission of quantum information.

Magnetic atoms pinned onto the surface of a usually non-magnetic metal, acting as impurities, can significantly change the host material's properties under certain conditions. These atoms "talk to each other over a distance" through the spin of their electrons, and eventually line up to a state where all electron spins point to the same direction, said Ulloa. However, scientists have also discovered special cases in which magnetic atoms are not aligned in a parallel configuration but in different directions.

Ulloa and his former Ph.D. student Oscar Avalos Ovando, now a postdoctoral researcher at The Ohio State University, explored the non-parallel alignment of magnetic impurities in transition metal dichalcogenides such as molybdenum disulfide (MoS_2) and tungsten disulfide (WS_2). They found that via the manipulation of key parameters, the electron spins of neighboring magnetic atoms slightly tilted to the side along the chain, resulting in a helix structure resembling a gradually twisted ribbon.

Understanding how such a structure forms is relevant for device applications, said Ulloa. Till today, we use electric currents for the transmission of information, and the loss of energy is significant as the electrons move along the way with multiple scatterings. If scientists can precisely control magnetic interactions on the atomic level, information can be transferred much more efficiently through the twists in a helix – as in the case of these spin chains.

In a more recent study, Ulloa and Ávalos-Ovando were joined by Edson Vernek, the 2020 OHIO Glidden Professor from the Federal University of Uberlandia in Brazil. As a continuation of previous studies, they examined the behavior of longer chains of magnetic impurities through computer simulations. Their research simulated chains made up of as many as 200 magnetic impurities, and found a critical point at which the tilted structure would

Physicists Edson Vernek, Sergio Ulloa, and Oscar Avalos Ovando

quickly collapse, bringing about dramatic changes in the material's physical properties such as the loss of magnetism.

By examining long chains, the new study made the system "as macroscopic as possible," said Ulloa, shedding new light on lab experiments as well as possible practical applications. The next step of the research will go beyond the static scenario to look at the time evolution of the processes, namely how perturbations lead to changes in the structure over time.

Notable Ph.D. Alumnus Reflects on His OHIO Experience

Andreas Weichselbaum

Theoretical physicist and Ohio University alumnus Andreas Weichselbaum (Ph.D. 2004) returned to OHIO to deliver an NQPI colloquium on numerical techniques based on tensor network states. During his visit, the College of Arts & Sciences presented Weichselbaum with the 2019 Notable Alumni Award that honors alumni for broad career accomplishments, commitment to community service, and valuable contributions to the institution.

His career has had a remarkable trajectory. Upon graduation, Weichselbaum accepted a postdoc position at the Ludwig-Maximilians Universität in Munich, Germany. In 2008 he joined the University of California at Irvine as a visiting researcher before heading back to Munich for a 'venia docendi', a teaching and research position. He worked as an independent researcher since 2011, and was awarded a Heisenberg Fellowship in 2015 by DFG, the German Science Research foundation. In 2018, Weichselbaum joined the Condensed Matter Physics & Materials Science Department of Brookhaven National Laboratory as a staff scientist.

"I very much like Athens, for the environment because I really consider people being polite and nicer...it was five years that I very much enjoyed."

His work includes studies on condensed matter theory and the development of large-scale computational techniques to perform research on systems with strong correlations. Notably, his current research on material science could become a foundation for quantum computing, according to OHIO's College of Arts & Sciences.

When he arrived at OHIO as a student in 1999, Weichselbaum's transition to the US graduate system was like "a jump into cold water." During that first year at OHIO, he found himself drawn to theoretical physics and began working with physicist Sergio Ulloa. Soon after he came to appreciate the sense of independence fostered in Ulloa's group. Ulloa became a role model, particularly with respect to his communication skills in sharing his research with others.

As a graduate student he realized there were many things to figure out, but together with the other graduate students in the physics program, he quickly adjusted to life in the United States.

"It was a good experience that we had to figure out things together. There was a very good crowd, and I still have a great respect for many of the grad students then." He added, "I very much like Athens, for the environment because I really consider people being polite and nicer, including grad students. In terms of [my time here] it was five years that I very much enjoyed."

Cimatu Studies Continued from Page 1

materials with improved surface and interfacial properties," says Cimatu.

Cimatu and her group are interested in looking at testing the biocompatibility of these modified copolymers, which will be useful for developing polymeric materials not just for artificial corneas, but also for contact lenses and bio-adhesive tapes.

Writing, editing, interviewing and photos by Rachael Beardsley, Kate Nichols, and Ling Xing. Editing by Dr. Nancy Sandler and Jean Andrews. Please email nqpi@ohio.edu with comments.

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