NJIT New Jersey Institute of Technology

COLLEGE OF SCIENCE & LIBERAL ARTS

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Please send news and other contributions to:
Dr. Chris DeSantis, Editor
christopher.a.desantis@njit.edu

Chair's Message

By Dr. Wunmi Sadik, Distinguished Professor and Chair

Omowunmi "Wunmi" Sadik, Ph.D.
Distinguished Professor and Chair
Chemistry and Environmental Science

Greetings, Alumni, Faculty and Friends

I am pleased to present another exciting edition of the CES Newsletter. Since starting my tenure as department chair in September 2019, I have been fortunate to work with an outstanding group of faculty, staff and students. With their passion, dedication and commitment to student excellence, we have accomplished so much!

Congratulations to the class of 2023 graduates. Sean Larmore received the CSLA Outstanding Undergraduate Award. Mitun Boumick, a Ph.D. student working with Professor Mitra, who was recognized as the 2023 CSLA Outstanding Graduate Student. In addition, the Department hosted a wide range of visitors on campus, including the 2019 Nobel Laureate in Chemistry, Professor M. Stanley Whittingham whom delivered the keynote address at the 2023 CSLA Awards Ceremony, Dr. John Warner co-inventor of Green Chemistry, and Dr. David T. Allen, Gertz Regents Professor in the Department of Chemical Engineering, The University of Texas at Austin and Editor-in-Chief, ACS Sustainable Chemistry and Engineering. Others include Professors Timothy Swager-MIT, Terry Collins, Carnegie Mellon, Sarah P. Preheim, Johns Hopkins, Graham Cooks, Purdue University, and Dr. Dora Chiang, Senior Vice President and Global Technical Leader for Environmental Remediation.

The Department also hosted the 2023 Association of Environmental Engineering & Science Professors (AEESP) Workshop on April 14, 2023, with Dr. Lijie Zhang as the event organizer. I'm pleased to note that the NJ Annual Chemistry Olympics has returned to its usual face-to-face format. The 35th annual NJ Chemistry Olympics was held on May 4, 2023, with Dr. Miriam Gulotta as the event committee chair. Several CES faculty and staff served as judges to over 200 High School students who participated in eleven scientific events. In addition, CESAB (CES Advisory Board) Meeting was held on February 24, 2023.

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As you can see from this edition of the CES Newsletter, CES has continued its upward trajectory in research, teaching, and student focus. Our recent successes include a landmark $2.6M NIH grant to train students, multiple NSF grants, USDA, New Jersey Health Foundation, Merck, and Colgate-Palmolive grants. In addition, CES students and affiliates received two NSF graduate research fellowships and recognitions. Our enrollment numbers have continued upward: AY 22 total number of undergraduate majors by degree program is now 223 compared to 90 during AY 19 when I took over as Chair. Our Biochemistry and Forensic Science majors are currently at 152 students—our graduate numbers are 104 for MS and Ph.D. degrees. At the graduate level, the most significant increase has been seen in our MS Pharmaceutical Chemistry program.

With the help of our student volunteers, faculty and staff, CES has continued to see a large turnout at the Open House. I want to acknowledge our faculty and staff's dedicated efforts for the year—including our outreach committee's efforts. In particular, our undergraduate and graduate student volunteers at the Open Houses, Chemistry Olympics and Graduate Recruitment efforts: Jose Antunes, Md Tanim-Al Hassan, Rupak Avinash Kulkarni, Emma Bitar, Cami Augustine, Mira Sapozhnikov, Peter Lim, Rupak Avinash Kulkarni, Joel Duzha, Egor Demidov, Michael Biondi, Cassandra Auletta, and Stephen Kurilla. Special honorable mention includes Dr. Chris DeSantis, CES Newsletter Editor, office staff, advisors, and lab personnel.

All CES alums, we are eager to hear about you, your accomplishments, your ventures, and how your training at NJIT is impacting the world. So please complete our brief survey and if you like, we'll share your stories in future issues of the CES Newsletter.

Sincerely,

Wunmi Sadik
Distinguished Professor & Chair
Chemistry and Environmental Science

Sadik is a co-PI on a landmark $2.6M NIGMS URISE (T-34) Grant

Sadik has received a National Institute of General Medical Sciences (NIGMS) T-34 grant (with Bryan Pfister (PI), D. Soares, P. Shekhar, and A. Borgoonkar). This $2,697,640, 5-year Undergraduate Research Training Initiative for Student Enhancement (U-RISE) scholars program is the first at NJIT. This training grant aims to combine the strengths of the NJIT Biomedical Engineering, Biological Sciences, and Chemistry and Environmental Science Departments to support seven undergraduate students per year to participate in a three-year biomedical research immersion program. The fellowship is open to rising sophomores who attend NJIT full-time with a major related to the biomedical sciences (including Biomedical Engineering, Biology, Chemistry, and Biochemistry) and plan to pursue a Ph.D. and a career in biomedical Science. As a U-RISE Scholar, students receive support that includes full fall and spring tuition at NJIT plus mandatory fees, a generous stipend, as defined by Federal standards, support for summer research experiences, travel funds for approved scientific meetings, extensive academic and career advising support, required courses in scientific writing, and research ethics and integrity, seminars and various activities, and guidance in applying to graduate school.

STEM NJIT Research Mentor Training for BME, Biology, Chemistry & Environmental Science faculty in Tiernan 373 on May 17, 2023.

In preparation for the first cohort of NJIT U-RISE Scholars, Wunmi Sadik, and Bryan Pfister conducted a 1-day STEM Research Mentor Training for leaders on May 17, 2023 (See picture). At this workshop, 23 NJIT leaders and mentors received the CIMERS Training Curriculum program. They committed to mentoring students and training to prepare them as a future professional community member. Wunmi Sadik has also received a new grant from the USDA National Institute of Food and Agriculture (NIFA) entitled: *PARTNERSHIP: Crop exposure to micro-nanoplastics and potential impact on human nutrition and health.* The project is in partnership with Rutgers University.

NJIT Forensic Anthropologist Investigates New Leads to Identify the Nameless

Dr . Sara Zapico studying DNA based techniques to help identify victims.

Written by: Jesse Jenkins

Ever since police ended the 40-year hunt for the Golden State Killer and identified Joseph DeAngelo by uploading crime scene DNA to a popular genealogy website in 2018, advances in DNA forensics have sparked an explosion in once-unsolvable criminal cold cases being resurrected and cracked after a generation. Yet, for the missing and unidentified, it is another story — often referred to as the "nation's silent mass disaster."

NJIT forensic anthropologist and biochemist Sara Zapico is at the forefront of research establishing new DNA-based techniques that may soon help investigators overcome daunting challenges of naming the unidentified, in some instances from a single tooth, or decades after their death.

These methods would be key for identifying partial remains in the wake of mass disasters — an area where Zapico is an expert as a member of Interpol's Disaster Victim Identification Forensic Genetic Subgroup and American Academy of Forensic Science Standards Board, Disaster Victim Identification Consensus Body.

"When facing human remains, forensic anthropologists must create a biological profile, or a determination of a person's sex, ancestry, height and age," explained Zapico. "However, age estimation in adults is particularly difficult, because it is based on degenerative changes in bones and teeth that occur with age, and this can be affected by environmental factors, pathological conditions and fragmentary remains.

"Our current anthropological assessments can give us age estimates in adults with a window of plus or minus 10 years, but that isn't accurate enough, especially if we are comparing remains with missing persons database profiles. If we can reduce this window, we reduce the pool we must search through to make an ID."

To narrow the window, Zapico is homing in on certain chemical molecules that attach to DNA which modify and turn genes on or off throughout life. She says studying this process, or epigenetic DNA methylation, can offer a more precise timestamp in terms of how old a person is at death, because the patterns of DNA methylation change with age.

"One of the so-called letters of our DNA's code, cytosine, sometimes has a label, or methyl group, that can signal to the cell to stop the conversion into RNA and production of proteins," she said. "We've found that as a person has aged, some genes have more labels and other genes have less labels, and the combination of these patterns gives us an estimate of a person's age."

The initial breakthrough for Zapico came in 2015 when she was a visiting scientist at Catholic University Leuven, Belgium, as a research collaborator with the Smithsonian Institution. She and colleagues became the first to demonstrate a link between DNA methylation and age in tooth dentin tissue. This year, she followed with new findings of significance to the field of forensic anthropology: the identification of three gene markers in DNA extracted from pulp tissue of adult molars, which offer much more precise age estimates.

"We analyzed methylation patterns in these genes in pulp tissue, and we found we were able to estimate within 1.5-2.13 years of a person's actual age," said Zapico. "It is a great improvement compared to current anthropological methodologies."

"Until now, there has been much more forensic identification research done with body fluids rather than teeth or bones, and that's because of its benefit in criminal cases to catch perpetrators. But what happens if we only find a single tooth to identify a person after a disaster?" said Zapico. "Teeth are the hardest structures in our bodies, so even if the skeletal remains are too damaged, teeth often remain, and the DNA is preserved. The methylation patterns in pulp and dentin DNA may give us answers for these cases."

Until 2017, Zapico was a forensic specialist at the International Committee of the Red Cross, building the organization's missing persons databases and assisting in the Red Cross's first Falkland Islands (Malvinas) humanitarian

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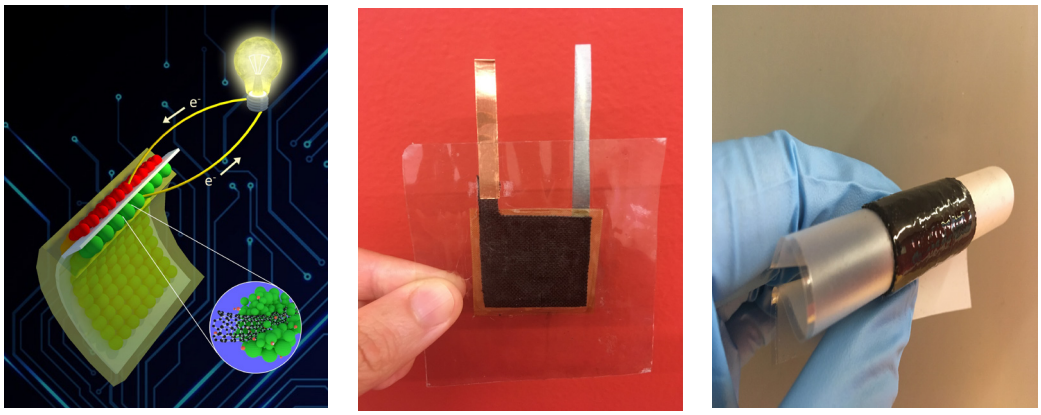
mission to identify Argentinian soldiers buried in Darwin Cemetery, nearly four decades since the Falklands War.

Because dental DNA can withstand temperatures of more than 400°C, Zapico says the epigenetic techniques she is exploring could prove to be particularly useful for identifying those in armed conflicts, natural disasters or in events such as plane crashes that involve burnt remains where only teeth can be analyzed.

"Currently, the best biochemical techniques we have to identify remains using teeth cannot be applied to corpses that have been significantly burnt," said Zapico. "The next step in my research is to confirm that it is possible to see same age-related methylation patterns we've already demonstrated, but in tooth remains exposed to fire."

"At the Red Cross, we encountered an overwhelming number of missing persons cases and mass graves with unidentified bodies," Zapico said. "The Argentine Forensic Anthropology Team would like to apply this epigenetics research to the work they are doing to identify bodies in other mass grave sites around the world. My hope is that it can help identify these people and that we continue to increase public awareness of this issue worldwide."

NJIT Researchers Develop New Flexible, 3D Printable Batteries.



Left: Schematic showing how periodate based batteries generate electricity through reduction and oxidation. Center: A 3D printed battery with customizable shape based on needs of the end user. Right: Image shows the flexibility of the 3D printed batteries.

Drs. Zhiqian Wang and Somenath Mitra have received a patent for their breakthrough in developing high-capacity, iodine-based batteries. Traditional consumer batteries, such as the alkaline AA cells, use MnO_2 as their positive electrode material and deliver fewer electrons per molecule compared to periodate materials, which are a class of materials containing high-valence iodine. MnO_2 has a capacity of around 300 milliampere hours per gram (mAh/g), whereas periodates have demonstrated capacities as high as 750 mAh/g. Compared to the conventional materials at the same weight, the new materials have 2.5 times longer capacity, which is particularly important in applications where long battery life is critical, such as in medical devices and remote sensors. In general, this is great for fabricating light weight, long life time batteries.

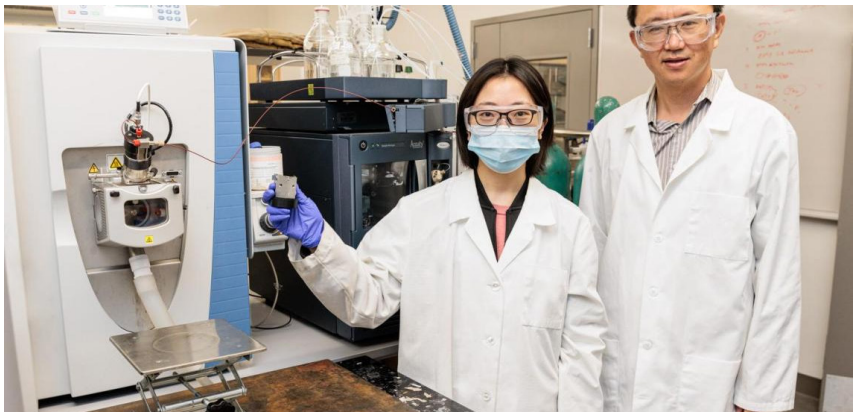
The researchers tested various materials to assess their redox properties, focusing on voltages and how many electrons could be involved in the reactions. They also tested the physical properties to ensure stability and compatibility with other battery components. Mitra, a distinguished professor of chemistry and environmental science, and Wang, who was a research associate in the group, were initially searching for new materials for reserve batteries that could be activated upon adding water, but they found that periodates had high capacities for storing and releasing electrical charge, making them ideal materials for batteries of various types.

These batteries generate similar voltages as alkaline cells, so they can be used where D, AA, and AAA batteries are used for both domestic and military applications. While studies on Li and Na batteries for large machines, such as electric vehicles, are popular, the improvements in batteries for small consumer devices, including remote controls, toys, and flashlights, have been overlooked.

Moreover, the invented batteries are highly customizable. Wang and Mitra fabricated reusable battery casings using 3D printing techniques. The components, particularly electrodes, can be easily replaced when depleted. Thanks to 3D printing techniques and nano technology, batteries can be made into different shapes and dimensions for various applications. The scientists even fabricated the periodate batteries in forms of conformal/flexible thin-film batteries, which have great potentials in wearable and portable device applications.

The research team behind the new battery is optimistic about its potential and is currently exploring its various applications.

NJIT Researchers Unlock a New Method for Testing Protein-Based Drugs



Dr. Hao Chen and graduate student Yongling Ai.

Written by: Jesse Jenkins

New Jersey Institute of Technology (NJIT) researchers have unveiled a new lab technique they say represents a "paradigm shift" in how pharmaceutical laboratories test and produce new protein-based drugs, such as therapeutic monoclonal antibodies being developed to treat a variety of diseases, from cancers to infectious diseases.

Researchers say their electrochemistry-based approach, described in the journal Analytical Chemistry, could allow for safety and quality testing of up-and-coming biotherapeutics to be done at a fraction of the time required by conventional methods, which typically require the lengthy and costly production of certain biomaterials used for sample testing.

The study was conducted in collaboration with researchers from Merck, Johnson & Johnson and Ohio University, and was supported by a $379,397 grant from the National Institutes of Health.

"This method we've developed at NJIT has the potential to have a major impact in quantitative proteomics, and it represents a paradigm shift in pharmaceutical industry in terms of monitoring biopharmaceutical product and process impurities for quality control," said Hao Chen, the paper's corresponding author and professor at NJIT's Department of Chemistry and Environmental Science.

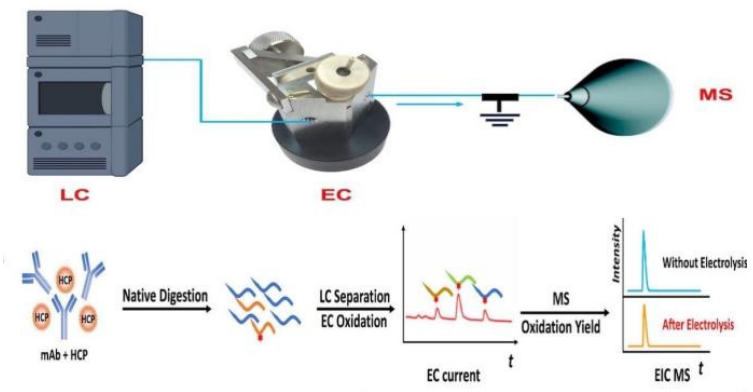
"With this study, we've now demonstrated an approach that can quantify drug product and process impurities much more quickly and accurately than had been possible. …We expect it to become very useful to facilitate therapeutic protein and vaccine development for treatment and prevention of different diseases in the future."

Traditionally such testing, or protein quantitation, involves time-consuming preparation of synthetic isotope-labeled peptides which are used as internal standards to measure total protein concentrations in a sample — helping researchers actively monitor the efficacy and safety of therapeutic protein components throughout the drug development process.

To overcome this limitation, Chen's lab developed a coulometric mass spectrometry (CMS) approach for absolute quantitation of proteins without the use of standards. The method instead applies liquid chromatography-mass spectrometry and an electrochemical flow cell to rapidly quantify and detect changes in target proteins or peptides based on electrochemical signatures.

"Instead of waiting for weeks to obtain standards or reagents in traditional approaches, one could carry out CMS quantitation experiments right away. Thus, it would facilitate tracking drug impurities discovered during the process and ensure their effective clearance with process optimization and control," said Chen.

"Such an apparatus allows us to separate peptides after protein digestion with liquid chromatography, monitor peptide oxidation in the electrochemical flow cell to produce an electric current, and measure the oxidation yield with mass spectrometry," explained the paper's first author and NJIT Ph.D. student Yongling Ai. "The combination of electric current signals along with the oxidation yield provides sufficient information for absolute quantitation of peptides and proteins."



Above: Workflow of the NJIT team's CMS method, combining liquid chromatography (LC), electrochemical oxidation (EC) and mass spectrometry (MS)-based quantitative measurement of protein abundance. Credit: NJIT

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NJIT RESEARCHERS TAKING THEIR MESSAGES TO THE MEDIA REALM OF PODCASTS

How can scientists ensure their messages are being received by colleagues and the greater public? Podcasts. These bite sized, on demand recordings allow scientists and public alike to access information about problems and proposed solutions at their leisure. Researchers at NJIT are using this particular type of media to reach a greater audience. Dr. Omowunmi Sadik recently participated in a November ACS webinar entitled "Chemistry Tools to Help Achieve Zero World Hunger" and presented on ChemBiosensors and nanotechnology to combat plant-based microbes (https://www.acs.org/acs-webinars/library/zero-world-hunger.html). Dr. Somenath Mitra also took to the digital airwaves with Bloomberg Businessweek to address issues in green energy and climate adaptation (https://www.bloomberg.com/news/audio/2022-10-26/njit-s-green-energy-and-climate-adaptation-panel-podcast). Be on the look out for more media content from CES researchers!

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In their study, the team demonstrated its CMS method by achieving absolute quantitation of multiple proteins (β-lactoglobulin B, α-lactalbumin and carbonic anhydrase) in a mixture in one run, without using any standards.

Notably, the team also showcased the method's capabilities for detecting protein deamidation — a common degradation event in therapeutic proteins resulting from physical or chemical stresses throughout the manufacturing process and storage.

The team successfully quantified several protein degradation products, including a key intermediate of protein degradation — the formation of succinimide — which has never been done before with absolute quantification due to lack of standards, according to the study's authors.

"The lack of standards is caused by the challenges in their de novo synthesis," said Chen. "Being able to accurately quantify the deamidation products and intermediates could provide better understanding of therapeutic protein degradation, and potentially create a new way to investigate disease pathologies and aging processes."

Now, Chen's lab plans to apply their new method for largescale quantitation of thousands of proteins in one run. They also plan to improve the sensitivity of their CMS analysis to allow quantifying very low levels of proteins in complex biological samples, which could benefit research efforts ranging from clinical diagnostics and drug discovery to precision medicine for which identification and quantitation of samples at the molecular level is necessary.

"As proteins perform a vast array of functions within organisms, the importance of absolute protein quantitation is hard to overstate," said Chen. "CMS should speed up processes for disease diagnosis, drug discovery and development, and it now opens a new door for biologists and biochemists to explore quantities of proteins in the human body that may serve important biological functions or roles as disease biomarkers and drug targets."

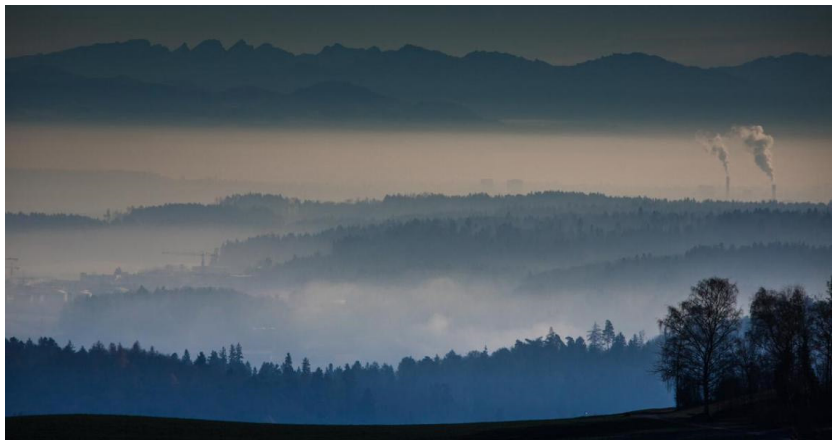
The study, supported by a National Institutes of Health grant (1R15GM137311-01), has also laid the foundation for a new project proposal that has recently been awarded a National Science Foundation grant (CHE-2203284). The paper's other contributors include Harsha P. Gunawardena from Johnson & Johnson, Merck scientist Xuanwen Shawn Li, professor Howard Dewald at Ohio University and NJIT professor Yong-Ick Kim. currently exploring its various applications.

North Jersey ACS Section wins at ChemLuminary Awards for New Jersey Chemical Olympics

In Augst 2022, the North Jersey ACS Section won the Outstanding High School Student Program ChemLuminary Award for the 2021 2nd virtual New Jersey Chemistry Olympics at the 24th Annual ChemLuminary Awards. Lead by NJIT's own Dr. Miriam Gulotta, the NJACS put on a fantastic Chemistry Olympics in spite of the COVID pandemic preventing an inperson experience. The group also won for Outstanding U. S. Nat'l Chemistry Olympiad, Outstanding HS Student Program Award, Outstanding Local Section Industry Event, and Outstanding Performance by a Local Section – Large Size Category Award. Congratulations to the group's fantastic work!

(pictured) Amjad Ali, Mirlinda Biba, Sandra Keyser, Miriam Gulotta, Diane Krone, and many more volunteers contributed to the effort! Image take from September 2022 Indicator published by North Jersey ACS Local Section (NJACS)

NJIT Researchers Awarded $620k Grant to Study Climate Change Impact of Soot



Written by: Jesse Jenkins

NJIT researchers have received a $620,000 grant from the National Science Foundation to advance our understanding of the way in which soot particles from combustion of fossil fuels are driving climate change in the Earth's atmosphere.

Associate Professor of Chemistry Alexei Khalizov (pictured) and Associate Professor of Chemical and Materials Engineering Gennady Gor will lead the project, "A Multiscale Model for Restructuring of Atmospheric Soot Particles".

Researchers say the new three-year project aims to improve ways of describing soot nanoparticles in atmospheric models, while advancing atmospheric scientists' fundamental understanding of the complex microphysics that govern how soot particles travel and change their composition in the atmosphere.

The results could also aid policymakers in developing more effective control strategies for soot pollution in the future.

"Soot is a potent climate-forcing agent with a warming contribution as much as one third of that from carbon dioxide, yet there is still much uncertainty over exactly what impact these particles are having in our atmosphere compared to carbon dioxide," said Khalizov. "Our project will help reduce this uncertainty by improving the ability of models to describe the evolution of these particles in the atmosphere and produce more accurate predictions of climate warming caused by soot."

Soot nanoparticles are typically released through combustion, produced by burning fuels or during forest fires for example. Once in the atmosphere, they absorb solar light, converting it into heat and warming the air. The particles also engage in condensation-evaporation cycles with trace gas chemicals and water vapor.

Khalizov and Gor say that through this process, the transport and optical properties of the particles can be drastically altered — in turn, changing their impact on air quality and climate in a way that can be hard to predict using existing modeling approaches.

"Soot particles have complex lacy structure and can be best described as fractal aggregates of graphitic spherules. …But in the atmosphere, these aggregates collapse into compact globules, altering the optical and gas transport properties of soot," explained Gor. "Existing models cannot capture such changes because they represent these complex particles in a highly simplified way, most often as single spheres."

The team is now developing a new model that explicitly considers the complex morphology of soot particles in the atmospheric environment, with the scope of the project spanning atomic-level simulations of gas-surface interactions and advanced microscopy, performed at NJIT's Otto H. York Center for Environmental Engineering and Science and Brookhaven National Lab's Center for Functional Nanomaterials.

Once developed, the research will be incorporated into a larger atmospheric model at University of Illinois–Urbana Champaign (UIUC), called PartMC-MOSAIC, through collaboration with UIUC Atmospheric Sciences Professor Nicole Riemer.

"These collaborative efforts to enhance our modeling capabilities should lead to a much clearer picture of soot pollution's impact on our climate, our air quality and human health overall," said Khalizov.

The project was initiated with support from the NJIT Faculty SEED award, and builds on research themes from Khalizov's previous NSF project, "Kinetics and Mechanism of Restructuring of Atmospheric Soot and Associated Impact on Light Absorption".

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Interested in a degree offered by CES?

CES undergraduate programs include:

- B.S. Biochemistry
- B.S. Chemistry
- B.S. Environmental Science
- B.S. Forensic Science - Forensic Biology, Forensic Chemistry, and Digital Forensics concentrations

More information can be found at: https://catalog.njit.edu/undergraduate/science-liberal-arts/chemistry-environmental-science/

Science Serving Justice

On Monday, December 5, 2022, students from the forensic biology class had the opportunity to visit the largest public DNA laboratory in the world, the Department of Forensic Biology from the New York City Office of Chief Medical Examiner (NYC-OCME) in Manhattan.

Guided by Dr. Craig O'Connor, Deputy Director and Technical Leader of the lab, the students learnt about the history of the OCME, the day to day operations of the forensic biology lab, the type of samples processed, the current efforts related to the identification of the 9/11 victims, as well as the research carrying out to improve forensic identification techniques. The visit ended with a tour around the lab facilities, as Dr. O'Connor explained the forensic DNA workflow from the detection of the biological evidence to the DNA profiling. Dr. O'Connor also talked about his career path and how to become a forensic biologist. Thanks to this visit the students had the chance not only to see first-hand the operations of a forensic biology lab, they received advice regarding future career opportunities.

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Through the course of the grant, the project will also provide interdisciplinary training for a postdoctoral researcher, as well as offer cutting-edge research experience for graduate, undergraduate and high school students, including students from low-income families (via the ACS SEED program).

NJIT students recently involved in the team's related NSF-supported projects include chemical and materials engineering (CME) graduate Ogochukwu Enekwizu, now a postdoctoral researcher at Brookhaven National Laboratory; Ali Hasani, NJIT Ph.D. student joining the U.S. FDA as a postdoctoral researcher; Ella Ivanova, a CME Ph.D. student involved in theoretical and computational work; Egor Demidov, an undergraduate CME student and two-time Provost Summer Research awardee; and Divjyot Singh, an NJIT math and physics double major and two-time Provost Summer Research awardee who joined Los Alamos National Laboratory as a post-baccalaureate researcher.

Meet the Newest Faculty at CES

CES is growing and we would like to introduce our newest faculty!

Dr. Mieke Peels started as a university lecturer at NJIT in the fall 2022 semester. They teach general and physical chemistry lectures. Their PhD is from Penn State, where they studied theoretical physical chemistry. Their dissertation research was on the topic of integral and derivative techniques in quantum chemistry software. As a graduate student, Mieke was very involved as a teaching assistant in general chemistry labs, where they discovered a passion for teaching. After graduating, they stayed at Penn State for another two years as a full time TA in general and organic chemistry labs. Prior to graduate school, they attended Purdue University Fort Wayne for their Bachelor's degree in chemistry with minors in math and physics.

Mieke was born in the Netherlands and moved to the United States when they were three years old. Their last name comes from de Groote Peel, which is a peat bog to the south between the provinces of Limburg and North Brabant. Outside of work, Mieke's hobbies include playing video games, listening to music, and visiting zoos and art museums.

Dr. Cassandra Diaz-Allen is a University Lecturer known for her visual aids, fun review games, love for chemistry, and most of all, for having the cutest class pet, Simba. Dr. Diaz-Allen received her Ph.D. at The Ohio State University in Pharmaceutical Sciences, specializing in Medicinal Chemistry and Pharmacognosy. She has previously worked as a teaching assistant covering a variety of chemistry courses at The Ohio State University, Stetson University, and Johns Hopkins' Center for Talented Youth.

Big News From Professor Hao Chen's Group

Dr. Hao Chen obtained one NSF grant, one NIH R21 grant, one grant from New Jersey Health Foundation (NJHF), one Merck Co. grant, and one new grant from Colgate-Palmolive Company, since April 2022. In addition, one of the group's papers published in Analytical Chemistry titled "Rapid Characterization of Antibodies via Automated Flow Injection Coupled with Microdroplet Reactions and Native Mass Spectrometry" in collaboration with Johnson&Johnson (Anal. Chem., 2023, 95, 6, 3340–3348) was selected as a supplementary cover. Another paper in Journal of Organic Chemistry titled "One-Step Regio- and Stereoselective Electrochemical Synthesis of Orexin Receptor Antagonist Oxidative Metabolites" in collaboration with Merck Co. (J. Org. Chem., 2022, 87, 22, 15011–15021) was selected as a supplementary cover. NJIT news coverage for this work is: https://news.njit.edu/njit-researchers-unlock-new-method-testing-protein-based-drugs. Furthermore, Dr. Chen's student Dr. Qi Wang (pictured) received the International Journal of Mass Spectrometry (IJMS) Best Student Paper Award (with cash award of $2,000) showing Qi receiving the award from Editor-in-chief Prof. Julia Laskin in ASMS Conference 2022). Another PhD student of Dr. Chen, Yongling Ai, won three awards in 2022: the 2022 CASMS conference lightening talk award, the ASMS Fall Workshop Student Travel Award, and the ASMS Student Travel Award from the Delaware Valley Mass Spectrometry Discussion Group. Finally, one high school researcher in Dr. Chen's group, Jeffrey Xu, from Livingston High School coauthored one paper with Dr. Chen (J. Am. Soc. Mass Spectrom., 2022, 33, 1238–1249) and was admitted to Princeton University for his undergraduate study!

Above: Professor Hao Chen, Professor Julia Laskin and Dr. Qi Wang

CES Students Finding Success in Research

Check out the great achievements of graduate, undergraduate students, and alumni of CES!

Mitun Chandra Bhoumick, a final-year doctoral candidate in Environmental Science under the guidance of Dr. Somenath Mitra, has been honored with the CSLA Outstanding Graduate Student Award for the year 2023. Mitun holds a Bachelor's degree in Chemical Engineering and Polymer Science from Shahjalal University of Science and Technology. Mitun's Ph.D. research is focused on the development of novel membranes for desalinating high salinity water while mitigating membrane scaling. His approach focuses on synthesizing nanocarbon-immobilized membranes. Notably, Mitun recently collaborated with the US Navy and the Lawrence Berkeley National Laboratory on a project involving the enrichment of biofuel precursors from fermentation broth. Besides experimental research, his work also includes predictive model development. His research has led to five first-author and two co-authored papers. He has also presented papers at conferences such as the ACS, NJWEA, NSF Grantees conference, and MARM. He was also awarded a NJWRRI graduate student award in 2022 for his proposal aimed at removing microparticles from aqueous systems.

Dr. Indrani Gupta, a member of Dr. Somenath Mitra's group, has recently accepted a Postdoctoral Research Associate position at Oak Ridge National Lab, a highly esteemed National Laboratory in the United States. Her research at Oak Ridge will focus on membrane-based separations, which is in perfect alignment with her doctoral work at NJIT and research expertise. Her project will specifically study fundamental issues related to gas separations using nanostructured membranes and unconventional media that selectively bind and/or transport targeted molecular species through tailored interactions. This opportunity will enable her to further advance her knowledge and skills in the field of membrane technology.

During her doctoral research, Indrani focused on using nanomaterials and membrane processes to eliminate or deactivate microbial contaminants from aqueous media and produce clean water. Her work has led to the development of novel membranes based on carbon nanotubes, graphene oxide, and metal organic frameworks. Her research is highly innovative, involving the use of various nanocarbon-immobilized membranes for the same application. Through filtration and membrane distillation, she successfully removed bacteria and viruses from contaminated water. Indrani has published five first-author papers in high-impact factor journals and presented five papers at national conferences. She also has some unpublished work that is expected to result in further publications in the coming year. Indrani is a co-inventor of a patent application titled "Nanocarbon immobilized membranes for generating bacteria and endotoxin-free water via membrane distillation".

During her stay at NJIT Indrani also received prestigious awards, including the John J. LaGrosa Award from the New Jersey Water Environment Association and the Student Research Grant Award from the New Jersey Water Resource Research Institute. Most recently, she received the "Best Visuals" Presentation Award at the NJIT GSA Research Day Event and the "Outstanding Graduate Student Award in Research" from the Chemistry and Environmental Science department at NJIT. We wish her success!!

Sumbel Yaqoob, a second-year doctoral student in Dr. Mengyan Li's lab in the Department of Chemistry and Environmental Science, was awarded the 2023 National Science Foundation Graduate Research Fellowship Program (NSF GRFP). The highly competative award sees about 12,000 applicants each year and only 16% of proposals are accepted. Awardees receive 3 years worth of funding for their research endeavors.

Ms. Yaqoob began her research as an undergraduate studying intragenomic evolution patterns of Plum pox virus where she learned a suite of bioinformatic tools and was named a Paul Robeson Scholar in 2019. She received her undergraduate degree from Rutgers University - New Brunswick.

Currently, she is exploring the biotransformation of per- and polyfluoroalkyl substances (PFAS) to determine how microbial interactions can influence, and possibly degrade, these "forever chemicals." Yaqoob is utilizing pure cultures, aerobic enrichments, and anaerobic microcosms to observe PFAS metabolite formation and liquid chromatography-tandem mass spectrometry for analysis.

Ms. Yaqoob has plans to continue studying PFAS in her graduate program with possible applications to bioremediation and attenuation processes, and aspires for a research career in industry or government. She is also the founder of Graduates for Inclusion, Diversity, and Equity (GIDE) and aims to increase diversity within the NJIT graduate student body and support traditionally marginalized communities in STEM-related disciplines.

Undergraduate Students Recognized for Research Excellence

Undergraduate research in CES has had an outstanding year highlighted by several awards. Biochemistry major Dhruvi Prajapati, performing research with Professor Jay Meegoda through the URI Provost Fellowship, received honorable mention for the Dr. James F. Stevenson Innovation award for her work entitled "The Use of NMR to Quantify the Degradation Efficiency of PFAs Using High Frequency Ultrasound".

Student Success Stories in Evironmental Sciences

Tolani Taylor: recent alumna of EVSC program at NJIT now works for Clean Water Action in Environmental Justice, has given a talk this month (April) at NJIT about her work and how students can get involved in advocating for environmental justice .

Emma Bitar: senior EVSC enrolled in our BS/MS program, has been working as an intern at Panasonic HQ in Newark, in environmental regulatory and compliance. She has also received an offer from Langan Environmental Engineers, where several of our alum work in groundwater remediation.

Grace Bambilla : graduating senior. CSLA student award winner last year received an internship award at Middlesex County Utilities Authority working on testing wastewater parameters. Lauren is applying for her MS in environmental engineering at Stevens.

Pasqualina Rivetti: completing her EVSC requirements while working part-time at NJDEP in an ecological group. She will be interning within the Clean Energy Division of NJEDA this summer. She has recently received a scholarship to support in part her senior year tuition at NJIT.

Cami Augustine: finishing her third year, has landed a summer internship with the NGRREC (National Great Rivers Research and Education Center) in St Louis studying urban impacts on field ecology.

Avery Lange: sophomore EVSC major, has landed an interesting summer internship at Global Treks and Adventures and will be carrying out a summer research program on one of their global adventures to Iceland.

Kaitlyn Pinto: is completing her EVSC requirements in S24 and has landed a post as a summer intern at the ecologically sensitive areas of New Jersey's Chesequake State Park

BioSMART REU Student receives an NSF Graduate Research Fellowship

Renallan Neckles, a 2022 REU student, has been awarded an NSF Graduate Research Fellowship (GRF). Renallan came to our BioSMART Research Experience for the Undergraduate program from the Indiana University of Pennsylvania. With little research experience, Renallan was determined to apply for this prestigious and highly competitive fellowship. Working with BioSMART mentors, he developed and fine-tuned his ideas, and after only 10-weeks of research experience here at NJIT, Renallan was awarded an NSF research fellowship. Renallan said, "I am grateful for the opportunity given to me by the BioSMART REU to be exposed to undergraduate research. Securing the GRF would probably not have been possible without my participation in the program. The Greek mathematician Archimedes is quoted to have said, "Give me a lever long enough and a fulcrum on which to place it, and I shall move the world." There is a sense in which I can say the BioSMART REU provided me with such a metaphorical lever and fulcrum pertinent to a research career. The program gave me a 10-week research experience I could leverage to secure the GRF (which, although I think is a relatively short experience to stand on for the GFRP application, it was long enough for me)"—Renallan plans to enroll in the environmental engineering masters of science program at Rice University for Fall 2023.

Chemistry Nobel Laurette Professor Stan Whittingham at NJIT

Professor Stan Whittingham, the 2019 Nobel Prize Laureate, visited NJIT on May 4, 2023, to deliver this year's keynote lecture at the CSLA awards ceremony. Professor Whittingham is the Distinguished Chemistry and Material Science & Engineering Professor at the State University of New York-Binghamton (SUNY-Binghamton). Professor Whittingham discovered the concept of intercalation electrodes leading to the development of Li batteries commonly used in portable electronics such as laptops, mobile phones, and electric cars. Professor Whittingham poses with Dean Belfield, Drs—Sadik, and Mitra at the awards ceremony.

More information can be found here: https://news.njit.edu/2023-csla-awards-honors-star-achievers-welcomes-nobel-laureate-m-stanley-whittingham

THE 35TH IN-PERSON NEW JERSEY CHEMISTRY OLYMPICS (NJCO)

After three years of virtual competition, the New Jersey Chemistry Olympics returned to being in-person on May 12 much to the delight of students, coaches, judges, and directors. Twenty-one teams from fourteen high schools across New Jersey came to NJIT to compete. In round numbers over 200 high school students and their coaches came to NJIT from as far south as Ocean County.

Teams could compete in up to six of the eleven events offered. With the return to an in-person competition large size teams and prizes for overall top scoring teams returned. Once again, the Platinum Crucible was up for grabs.

There was a lot of diversity in the teams that came to compete. Long term competitors Hunterdon Central Regional High School (HCRHS), James Caldwell High School (JCHS), John Paul Stevens High School (JPSHS), The Marine Academy of Technology and Environmental Science (MATES), Pascack Hills High School (PHHS), Pascack Valley High School (PVHS), South Brunswick High School (SBHS), Watchung Hills Regional High School (WHRHS), and Tenafly High School (THS) were joined by the Woodbridge Academy Magnate School (WA) who had only competed virtually in 2022. Bergen County Technical High School (BTHS) returned after a long absence. The Academy of Law and Public Safety (ALPS), Glen Ridge High School (GRHS), and Summit High School (SHS) all came to their first NJCO of any kind.

The judging was also done by a mixture of veteran judges and newcomers. For NJIT faculty, Dr. Farnaz Shakib, Dr. Hao Chen, Dr. Chris DeSantis, Dr. Mieke Peels and Dr. Xianyang Meng as well as graduate students Sumona Paul, Dan Khorazian, and Egor Demidov who are all part of the Department of Chemistry and Environmental Science at NJIT participated for the first time at the NJCO. North Jersey American Chemical Society (NJACS) member Mary C. Okorie's participated in her first competition this year. Sumeet Agarwal, a scientist in Texas contacted us and helped with pre-event day judging. Mario T. Da Costa (BASF) came as a first-time judge but previous competitor. Experienced judge Mike Bonchonsky, also from the Department of Chemistry and Environmental Science at NJIT, altered the timing of the debate event he developed for the virtual NJCOs to run on in-person timescales. Dr. Sandra Keyser (NJACS Chair elect) came back as both a seasoned judge and to show the ropes to newcomer Mary Okorie. Dr. Alexei Khalizov (Department of Chemistry and Environmental Science at NJIT) came to judge the environmental science research event which he also developed. Emeritus chemistry professor, Dr. Joe Bozzelli, also part of the event steering committee, returned to judge multiple events. Long time judging pair Dr. Chaudhery Mustansar Hussain (Department of Chemistry and Environmental Science at NJIT) was joined by Dr. Ara Kahyaoglu (former coach, current Bergen County College Chemistry Department chair) in administering the nomenclature test. Another long term judging pair, Dr. Bhavani Balasubramanian (Department of Chemistry and Environmental Science at NJIT) and Ms. Diane Krone (NJACS) returned to judge the microscale lab event. Founding NJCO father, Dr. Reginald Tomkins (Professor emeritus Otto H. York Department of Chemical and Materials Engineering) judged virtually from his home in England. He joined his long time judging partner, Dr. Mirko Schoenitz (Department of Chemical and Materials) and newcomer Dr. Xianyang Meng to judge the Chemical Engineering Research event.

The events:

The three Research Events (1-3) ask students to investigate a topic through primary sources and to synthesize or create something central to the topic using protocols adapted from the literature. Designing experiments from primary sources is never part of high school science classes and only occurs in upper-level undergraduate classes if at all.

•Event 1, Chemistry Research was on the Polymorphism of Chocolate. Competitors had to create the three types of chocolate (only one is usually eaten), characterize their similarities and differences and present the judges samples of each. First place (team A) and third place (team B) went to MATES while second place went to WHRHS (team A)

(continued on page 14)

(continued from page 13)

•Event 2, Environmental Science Research, asked students to investigate nuclear reactors and the use of ceramics to embed radioactive materials as a way of minimizing the toxicity of used nuclear waste. Students had to try to embed a metal oxide (nonlethal and nontoxic) into a ceramic and present their product to the judges on event day. WHRHS captured both first place (team A) and second place (team B) while THS (team B) took home third place.

•Event 3, Chemical Engineering Research had competitors build a working fuel cell. Videos showing its use were turned in a few weeks before the event. On event day, teams had to bring their fuel cells for inspection and demonstrate that they worked. WHRHS (team A) took home first place, their third medal. THS (team A) took the bronze (the second medal for the school) and PHHS (team A) picked up the second place medal

•Event 4, Webpage Design was one of the most subscribed events (13 teams participated) in part because the event ran in all three virtual NJCOs. In this event students build their own websites. They are judged on design, informativeness as well as usability. This year's topic: Alternative Energy Sources. ALPS captured the first place medal, their first medal in their first NJCO. HCRHS (team A) took second and SBHS (team A) earned the third place medal.

•Event 5, Demonstration Show returned after a 3-year hiatus. Students in this event had to demonstrate a working polymerization reaction. The two teams that signed up for this event submitted very different protocols but Dr. Bozzelli was able to clearly award ALPS its second first place medal and MATES (team A) took second place, the team's second metal (the school's third).

•Event 6, Nomenclature Test: teams of 3 students battle with our computer generated nomenclature test which we developed for the vNJCOs. The scores of the three are combined and winners chosen by the combined score. Woodbridge Academy (WA) took first place, their first medal; THS (team A) was awarded second place and HCRHS (team A) took third.

•Event 7, Information Search on flavors. Students had to build an accurate model of a flavor molecule using Styrofoam balls and wooden dowels. Models are graded on everything from appropriate relative size of the atoms, bond angles, and bond lengths. In addition, each team of 3 is handed a set of questions and a computer. They need to research the answers and present their findings to the judges before the clock runs out. The judges gave PVHS (team A) first place and their first medal, WA was awarded second place (their second medal) and THS (team A) took third place (their third medal).

•Events 8 – 10 are the lab events. Prior to event day students find a protocol for experimentally determining the objective of the event. On event day each team has 75 minutes to run their analysis, analyze their data, and turn in their results to the judges who rate them on result accuracy, lab technique, and safety.

•Event 8, Analytical Chemistry Lab – determination of the amount of copper in a penny. JPSHS brought home the first place medal, JCHS was awarded second place (the first medals for both of these schools). PHHS (team B) earned the third place medal; the first team medal but the school's second medal.

•Event 9, Instrumentation Lab – determination of the amount of food dye in a sports drink. First place went to PVHS (team B). It was the team's first medal, but the 2nd medal for the school. SHS took second place; the team's first medal. WHRHA (team B) took home the third place medal (team's 2nd medal, school's 5th).

•Event 10, Microscale Lab - determination of the amount of iron in iron pills. The judges awarded PVHS both first place (team A) and second place (team B). SBHS (team B) took the bronze.

•Event 11, Debate - Should CRISPR-edited agriculture be banned? Teams from different schools debated the issue for 20 minutes on event day but they had to present reasonable arguments for both sides to the judges a few weeks ahead of time. The side they argue is determined by the judges on event day. The judges awarded SBHS (team A) their first medal, first place (medal #2 for the school), HCRHS (team A) received second place (medal #2 for both the team and the school), and PVHS (team A) took third place (the second medal for the team and the school).

After the judges submit their scores, team totals are computed and the teams with the highest total point score win the overall competition. While ties are not allowed for event rankings, it is impossible to avoid ties in overall point score. Two teams tied for third place, SBHS (team A) and PVHS (team A). Second place also had a tie between two teams: WHRHS (team A) and HCRHS (team A). Fortunately, one team came out on top overall. PHHS (team A) had the highest point score, took home a first place plaque and the Platinum Crucible. (continued on page 15)

The NJCO would like to also thank the chair of the Department of Chemistry and Environmental Science at NJIT, Dr. Omowunmi Sadik for opening and closing the awards ceremony and for postponing the monthly faculty meeting freeing up faculty members for judging. Dr. Kevin Belfield who could not attend but who supports us by soliciting donors and helps to make sure we have everything we need. Dr. Jingjun (JJ) Yin, Executive Director of Process Research and Development at Merck for speaking at the awards ceremony and representing our biggest corporate donor. Ms. Diane Krone who took on the roll as master of ceremonies as well as judged the microscale lab. Mr. Tom Krone, our photographer. Of course, many thanks to Mr. John Krane the department's administrative coordinator, Ms. Genti Price who is central to a large number of things – too many to innumerate, our IT staff who made it possible for Dr. Tomkins to be here and ran the awards ceremony, and for the behind-the-scenes advisor Mrs. Carrie Jacobus (retired coach), as well as stealth director and webmaster Dr. Kathleen Gilbert. Thanks also to the students who donated their time to help make event day a success and to Rohan, who was critical to keeping the lab events running on event day.

Respectfully submitted,
Dr. Miriam Gulotta (Department of Chemistry and Environmental Science at NJIT) and director of the NJCO.

And the winners are.....

Event Winners

Event	1st	2nd	3rd
1	MATES A	WHRHS A	MATES B
2	WHRHS A	WHRHS B	THS B
3	WHRHS A	PHHS A	THS A
4	ALPS	HCRHS A	SBHS A
5	ALPS	MATES A	
6	WA	THS A	HCRHS A
7	PVHS A	WA	THS A
8	JPSHS	JCHS	PHHS B
9	PVHS B	SHS	WHRHS B
10	PVHS A	PVHS B	SBHS B
11	SBHS A	HCRHS A	PVHS A

Overall Winners

1st Place & Platinum Crucible winner
Pascack Hills HS, Team A

2nd Place	
Hunterdon County Regional HS, Team A	Watchung Hills Regional HS, Team A

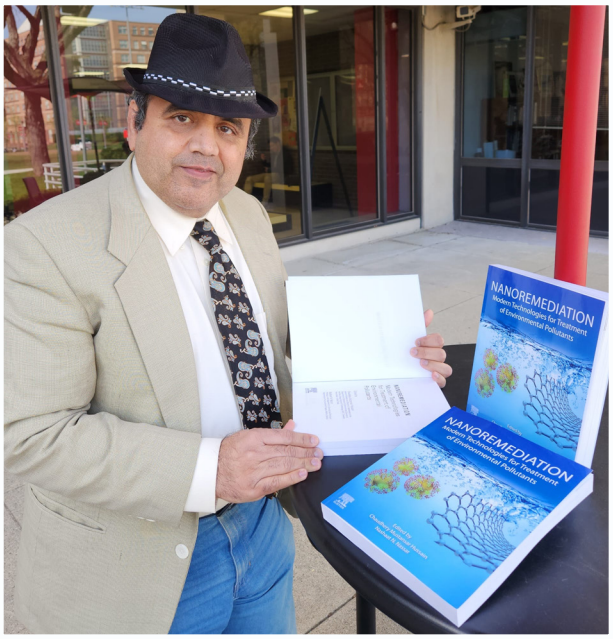
3rd Place	
South Brunswick HS, Team A	Pascack Valley HS, Team A

Team Abbreviations & School Names

ALPS	*Academy of Law and Public Safety	MATES A	Marine Academy of Technology and Environmental Science, Team A	SBHS B	Team B
BT	Bergen County Technical High School	MATES B	Team B	SHS	*Summit High School
GRHS	*Glen Ridge High School	PHHS A	Pascack Hills High School, Team A	THS A	Tenafly High School, Team A
HCRHS A	Hunterdon County Regional High School, Team A	PHHS B	Team B	THS B	Team B
HCRHS B	Team B	PVHS A	Pascack Valley High School, Team A	WHRHS A	Watchung Hills Regional High School, Team A
JCHS	James Caldwell High School	PVHS B	Team B	WHRHS B	Team B
JPSHS	John Paul Stevens High School	SBHS A	South Brunswick High School, Team A	WA	**Woodbridge Academy Magnet School

*ALPS, GRHS, AND SHS joined us for the first time
**WA started competing in 2022 vNJCO so this is their first in-person NJCO

Nanoremediation: Modern Technologies for Treatment of Environmental Pollutants



Edited by: Chaudhery Mustansar Hussain & Nashaat N. Nassar

Use of nanomaterials can transform existing remediation technologies in pollution abatement and show their potential to improve human and environmental health. Nanoremediation: Modern Technologies for Treatment of Environmental Pollutants (Publisher: Elsevier; Publication date: February 7, 2023) is a comprehensive reference that highlights established nanoremediation practices, discusses their rapidly emerging applications in industry, and points out future research directions. The book provides researchers and scientists in academia and industry with a high-tech start-up that will revolutionize modern remediation practices. It condenses all relevant information on nano-remediation and provides an amalgamation of the latest trends in the field. In addition, the book handles the design and modeling of nano-remediation processes and the trends and challenges that nano-remediation is facing in various sectors. Special attention is given to approaches that lead to green and sustainable industrial developments, as well as to the legal, economical and toxicity aspects of nano-remediation.

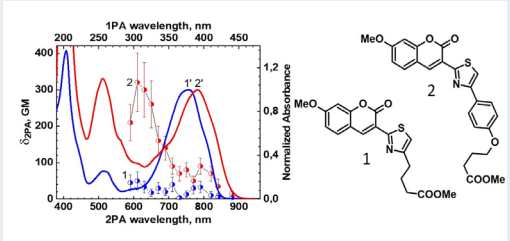
To capture comprehensive impression of nanoremediation and to provide the reader a coherent and communicative representation, the book is divided into four parts, where each part comprises on different chapters. Part 1, is about nano-perception in remediation arena. Second part explores various nanoremediations with processes. Third part is all about nanobioremediation. Then the last part discusses green nanotechnology.

Advanced undergraduate and graduate students can find this book a source of knowledge and a guideline for their studies as it is highly up to date, easy to use and understandable. Moreover, this book will be of significant interest to scientists and researchers working on the issues surrounding real time applications of nanomaterials for environmental remediation, as well as those working in industry on commercial scale exploration.

This book can be used in specialized courses (postgraduate) in environmental Science and Engineering.
More information can be found here: https://www.sciencedirect.com/book/9780128238745/nanoremediation

Great work from the Lab of Dean Belfield

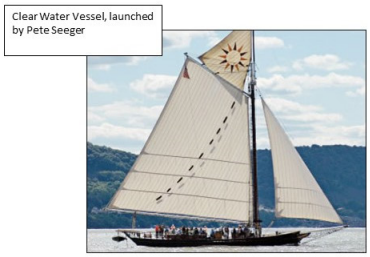
The Belfield lab had a productive year in the research lab. Here are some of their works published this last year:



1. "The Nature of Linear Spectral Properties, Fast Relaxations in the Excited States and Two-photon Absorption Efficiency of 3-Thiazolyl and 3-Phenyltiazolyl Coumarin Derivatives" in ACS Omega provided a comprehensive investigations of the steady-state photophysical and photochemical properties, fast electronic relaxations in the excited states, possibility of light amplification, and high two-photon absorption efficiency revealed the potential of two new hetaryl coumarins for a number of photonic and biophotonic applications(pictured).
2. "Hemolytic Iron Regulation in Traumatic Brain Injury and Alcohol Use" in the journal Alcohol. We have demonstrated that alcohol consumption acts as a secondary stressor to increase bleeding and consequent iron deposition in the central nervous system following traumatic brain injury fluid. We propose that microglia may also play a role in iron management through red blood cell clearance.

Recollections: 50 years since the passage of the Clean Water Act

Written by Michael P Bonchonsky.


Clear Water Vessel, launched by Pete Seeger


Impacted waterway before the CWA of 1972


Untreated discharge prior to 1972


Coast guard vessel on patrol


EPA Sampling Vessel


NYC secondary treatment plant today today

An important environmental milestone has recently passed us by. We are only a few months since the 50th anniversary of the Clean Water Act, signed off by Congress on Oct 18, 1972. These few months have given me some time to reflect on the progress made and the improvements yet to be achieved. My first assignment at the USEPA, fresh out of grad school and raring to go, was to man a coast guard vessel patrolling NY Harbor looking for aberrant discharges into the murky waters and taking a few samples. We spotted a massive pipe from the industrial lined docks in Brooklyn spewing effluent of changing hues from red to blue to green. Nearby was a printing operation for a notable newspaper, the discharge colors curiously matched the main print colors of the Sunday magazine section! A bit further, up the Brooklyn coast lay the Newtown Creek, an East River backwater into which one of NYC's largest discharges of sewage deposited its grim solids visibly floating into the NY waterways. Our boat drifted close, we held our noses, and tried to fill jars with samples later finding DO near zero, with equally shocking TSS levels, and hardly any sign of aquatic life. All were discharging filth consistent with the law at the time, which allowed industrial waste to freely flow without much treatment. We met with industrial and commercial dischargers trying to jawbone them into treatment plans, largely without success. This was 1971, prior to the modern Clean Water Act (referred to at the time as the Federal Water Pollution Control Act of 1972).

Then like a bolt from above the rules changed dramatically. Discharge permits were required for every single pipe bearing wastewater. Secondary Treatment (about 85% removal) became the law of the land. At EPA, I began to work on the first of these permits demanding the installation of treatment for all. I met with NYC's soon to be Commissioner of Sanitation and renowned water pollution expert Martin Lang, demanding the start of construction for advanced treatment works. He told me in no uncertain terms: "over my dead body will we spend that kind of money considering the vast dilutive capacity of the Harbor waters." We threatened to sue NYC, he ate his words and with the help of federal and state funding the nation's largest system of secondary treatment works began upgrades, and especially the treatment of any raw discharges. He later championed this important investment in environmental upgrades.

Fast forward a decade or so, I was invited to speak on Pete Seeger's sloop the "Clearwater" (an activist famed for his battle to fight water pollution) about treatment progress. We threw in a drag net to see if aquatic life (in the past largely absent or seriously impaired) could be identified. Lo and behold, we found crabs, flounder, clams, mussels! A eureka moment for me, improvements were taking hold. By then I headed EPA's enforcement operations, working under Dr. Richard T. Dewling, a great environmental leader, and really felt a rush to see these great changes taking place beneath the surface of NY harbor. Today, the City's 14 treatment plants, now upgraded, treat about 1.3 billion gallons of wastewater each day.

Surprisingly, too, there is a nature walk now along the rehabilitated Newtown Creek! All discharges are treated, permitted, and monitored after treatment. Penalties are in the order of $50,000/day; jawboning no longer necessary. We go to class every day in Tiernan Hall, after Dr. Martin Tiernan, founder of Wallace and Tiernan, Inc., whose famed wastewater equipment products went into these early treatment works.

There are many frontiers yet to cross. Runoffs from streets and old industrial sites are not adequately remediated, for example. Contaminated sediment still lies untended. New toxicological understandings emerge and new parameters measured and limited: PFAS, for example. EPA identifies impaired waterways every day. Recent reports still show about 50% of US waters do not meet ambient standards. Glass half-full or half empty? You be the judge. I am pleased to have contributed to the part that is half-full and I celebrate with you, the engineers and scientists of tomorrow, the passage of fifty years from when we began in 1972 to implement the modern version of the Clean Water Act.