Analytical Chemistry Seminar

Tuesday, August 27, 2024
3:30 p.m. ~ WTHR 172

"Positron Emission Tomography Imaging: Instrumentationand Potential Clinical Applications in Neurological Disorders"

Behnaz Akbari
Graduate Student, Purdue Univesity

Bio:
Behnaz Akbari received her BS in chemistry and MSc in analytical chemistry in Iran, where she developed a chromatography method for detecting a biomarker of oxidative stress in human serum samples. Before joining the University of Nebraska-Lincoln (US) to obtain her second MSc in chemistry (2021), she worked at Newcastle University (UK) in fluorescence probes to establish a photochemical platform within ROS-mediated DNA lesions (e.g., 8-oxodG) in 2017. To advance her career in medicine, Behnaz pursued her interests at Boston University School of Medicine and obtained her third MSc in bioimaging in 2022. In 2023, she received two travel awards; one from the National Organization for Rare Disorders (NORD) and another one from Stanford University School of Medicine; one Educational Grant award from Mass Spectrometry & Advances in the Clinical Lab, and later, the FeMS Empowerment Award from the Females in Mass Spectrometry (FeMS) community. She was recognized as among the Top 10 Most-Cited Papers from WILEY in 2024. Behnaz joined Dr. Chopra's lab (Fall 2023), where she focuses on Expansion Microscopy-Based Mass Spectrometry Imaging for Single-cell Spatial Lipidomics. She also serves as the Purdue University Chapter of NORD students for rare.

Abstract:

PET (positron emission tomography) is a type of nuclear medicine imaging that measures critical body functions such as blood flow, oxygen utilization, and glucose metabolism. This helps doctors assess the functioning of organs and tissues. The core components of PET instrumentation include the detector system, typically composed of scintillation crystals coupled with photomultiplier tubes or silicon photomultipliers (SiPMs), which convert gamma photons into electrical signals. These signals are then processed by the data acquisition system, which reconstructs them into high-resolution images. Advances in PET instrumentation (e.g., Time-of-Flight (TOF) technology and improved detector materials) have significantly enhanced image quality, spatial resolution, and sensitivity.

As a powerful diagnostic tool, PET plays a crucial role in the diagnosis and treatment of various diseases (e.g., Long COVID). By tracking the biochemical activity of cells and analyzing how they process compounds like glucose, PET scans can detect microscopic cancerous tumors and subtle changes in the brain and kidney and provide doctors with vital early insights into conditions such as heart diseases and neurological disorders like Alzheimer's. PET scan uses radioactive ligands to detect and quantify biomarkers in vivo. The imaging results provide detailed insights into the distribution of radioactivity and pharmacokinetics, which are influenced by the radiotracer's chemical properties and the living subject's physiological state. Therefore, designing a specific radiotracer (e.g., Fluorodeoxyglucose or 18 FDG, where one of the hydroxyl groups in the glucose molecule is replaced by the radioactive isotope fluorine-18 (^{18}F)) is crucial to ensure the target selectivity and accurate distribution within the desired region. While PET provides valuable functional information, its spatial resolution is generally lower than other imaging modalities like MRI or CT. This limitation can make it challenging to localize small lesions or differentiate closely situated structures precisely. PET is primarily a functional imaging modality, meaning it excels at showing metabolic and biochemical activity but provides limited anatomical detail. This often necessitates using PET/CT or PET/MRI hybrid systems to obtain functional and anatomical information. Despite these limitations, PET continues to be a powerful tool in medical imaging, especially when integrated with other modalities to offer a comprehensive view of metabolic changes in the body.

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"SHERLOC and WATSON Search for Signs of Ancient Aqueous Environments on Mars Using Deep-UV Raman and Fluorescence"

Azaria Wagner
Graduate Student, Purdue Univesity

Abstract:

In February 2021, the Perseverance rover landed on Jezero crater, Mars, to investigate the chemical composition of this theoretical ancient aqueous environment.1,2 Among the arsenal of instruments aboard the Perseverance, SHERLOC (Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals) and WATSON (Wide Angle Topographic Sensor for Operations and 'Ngineering) worked in conjunction—utilizing deep-ultraviolet Raman and fluorescence spectroscopy alongside a maneuverable, topographical camera to probe abraded surfaces for aqueously-influenced minerals and organics in-situ.1–10 One set of such abraded surfaces is known as the Garde target in the Séítah formation—a ~3.7 billion year old layer of Jezero crater.4–6,10 Here, evidence for a distinct ancient aqueous environment was potentially uncovered. Deep-ultraviolet Raman revealed carbonates coexisting in an olivine-rich igneous rock.6 NASA claimed fluorescence signatures were consistent with either aromatic organic compounds or cerium(III), though this claim could not be fully substantiated with coordinating Raman peaks.6,10 Upon Perseverance's return to Earth, these in-situ results will need to be further evaluated and compared to extracted mineral samples stored within the rover.4,5

References:

1. Bhartia, R. et al. Perseverance's Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals (SHERLOC) Investigation. Space Sci Rev 217, (2021).
2. Farley, K. A. et al. Mars 2020 Mission Overview. Space Sci Rev 216, (2020).
3. Razzell Hollis, J. et al. A Deep Ultraviolet Raman and Fluorescence Spectral Library of 51 Organic Compounds for the SHERLOC Instrument Onboard Mars 2020. Astrobiology 23, 1–23 (2023).
4. Simon, J. I. et al. Samples Collected from the Floor of Jezero Crater with the Mars 2020 Perseverance Rover. J Geophys Res Planets 128, (2023).
5. Wiens, R. C. et al. Compositionally and density stratified igneous terrain in Jezero crater, Mars. Sci. Adv 8, 3399 (2022).
6. Scheller, E. L. et al. Aqueous alteration processes in Jezero crater, Mars-implications for organic geochemistry. Science (1979) 378, 1105–1110 (2022).
7. Fries, M. D. et al. The SHERLOC Calibration Target on the Mars 2020 Perseverance Rover: Design, Operations, Outreach, and Future Human Exploration Functions. Space Sci Rev 218, (2022).
8. Razzell Hollis, J. et al. A deep-ultraviolet Raman and Fluorescence spectral library of 62 minerals for the SHERLOC instrument onboard Mars 2020. Planet Space Sci 209, (2021).
9. Jakubek, R. S. et al. Calibration of Raman Bandwidths on the Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals (SHERLOC) Deep Ultraviolet Raman and Fluorescence Instrument Aboard the Perseverance Rover. Appl Spectrosc (2023) doi:10.1177/00037028231210885.
10. Sharma, S. et al. Diverse organic-mineral associations in Jezero crater, Mars. Nature 619, 724–732 (2023).

Bio:

Azaria Wagner is a second-year student conducting research in Dr. Jeffrey Dick's lab. Azaria is originally from a small town called Farmland, Indiana (yes, that is the actual name) and pursued his Bachelor's in Biochemistry from Rose-Hulman Institute of Technology. His research journey began with his undergraduate advisor, Dr. Daniel Morris, when he helped investigate if epicatechin would assist in preventing oxidative DNA damage. In Dr. Dick's lab, he has worked with the Jonathan Amy Facility for Chemical Instrumentation to develop a method for taking electrochemical measurements at microsecond-scale sample intervals and is now a basement-dweller analyzing surface interactions of sub-diffraction limited nanodroplets in real-time using fast sample rate experiments coupled with COMSOL. Besides research, Azaria enjoys cooking, reading, biking, swing dancing, making memes, and playing board games.

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"Coulomb Explosion Imaging"

Tuono Van Nguyen

Bio:

Van graduated with a bachelor's degree in pharmacy and then earned a master's degree in Analytical Chemistry. She joined the Kenttämaa group at Purdue University in Fall 2023. Her research focuses on the organic aspects of polystyrene pyrolysis and the reactivity paradigms of aromatic radicals using ion-molecule reactions.

Abstract:

Coulomb explosion imaging (CEI) is a powerful technique that provides detailed information about both light and heavy atoms by capturing data in momentum space, typically within a molecular reference frame. Current studies in laser-induced CEI are generally categorized into two main approaches based on the initiation method: strong field ionization (SFI) and soft X-ray ionization. In both methodologies, the resulting multiply charged cations undergo Coulombic repulsion, leading to an explosion of the molecular structure. The three-dimensional momenta of the ionized fragments are measured in coincidence. By analyzing the velocities and momenta of these charged products, CEI enables a direct reconstruction of the positions of the charged nuclei in coordinate space.