ANALYTICAL SEMINAR

Maggie Milligan

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"Benchtop NMR for Micromolar Range Quantitation of Mixtures Using Cosubstrate SABRE Hyperpolarization"

Nuclear Magnetic Resonance spectroscopy (NMR) has been an invaluable, non-destructive spectroscopic method for analyte characterization and quantification since its discovery in the 1940's, but modern high-field NMR instrumentation is expensive and sizable. Benchtop NMR systems are relatively inexpensive and more compact, and therefore present a more practical alternative to high-field NMR, but suffer from decreased sensitivity due to limited magnetic field strength. Many sensitivity enhancement techniques have been employed to combat this difficulty and increase the sensitivity of benchtop NMR instrumentation to be comparable to that of high-field instruments. One such technique, Signal Amplification By Reversible Exchange (SABRE), is a hyperpolarization technique that increases NMR sensitivity by transferring spin order from parahydrogen to a substrate through an organometallic complex. The SABRE method has previously been applied to benchtop systems to quantitate concentrations in the millimolar range, but has been impractical for micromolar range quantitation due to decreased efficiency of substrate binding at low concentrations. The use of a cosubstrate to facilitate substrate binding with the SABRE catalyst allows for increased efficiency of SABRE hyperpolarization, making it a practical and more affordable tool for increasing NMR sensitivity for mixtures in the micromolar range. The use of a cosubstrate can also enhance selectivity for particular analytes in complex mixtures, allowing for cosubstrate SABRE to be used as a technique for trace detection of low concentration analytes such as pyrazines in edible oils. The addition of effective substrates to SABRE mixtures can increase SABRE efficiency such that benchtop instruments can achieve quantification of components in dilute mixtures, and allow for sensitivity enhancements comparable to high-field NMR.

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ANALYTICAL SEMINAR

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"Volumetric Imaging via Photochemical Sectioning: Mapping Neural Structure in Mesoscale"

Electron microscopy (EM) has been extensively utilized for the analysis of biological tissues due to its nanoscale resolution. However, EM typically necessitates mechanical sectioning as a sample preparation step, commonly accomplished through microtoming. This mechanical sectioning can introduce distortions such as tearing, stretching, and tissue loss, resulting in incomplete structural information. Consequently, there is a pressing need for an analytical technique capable of mapping biological tissues, such as the brain, at nanoscale resolution without the artifacts associated with physical sectioning. To address this gap, volumetric imaging via photochemical sectioning (VIPS) has recently been introduced. VIPS enables imaging of biological samples without the requirement for mechanical sectioning by employing two-photon illumination for the photodegradation of thin tissue layers in situ. Furthermore, the method preserves nanoscale resolution of millimeter-sized tissue volumes by utilizing lattice light sheet microscopy (LLSM). Overall, the approach facilitates large-volume brain mapping with high spatial resolution for the individual tracing of axons across extensive tissue regions.

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ANALYTICAL SEMINAR

Mackenzie Stockwell

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"Inductively Coupled Plasma-Mass Spectrometry for Heavy Metal Analysis in Cannabis Products"

As cannabis legalization expands, products are increasingly regulated to ensure consumer safety, particularly with respect to heavy metal contamination. Toxic elements such as arsenic, cadmium, lead, and mercury pose significant health risks, yet their detection in complex cannabis-derived matrices presents substantial analytical challenges. Cannabis products such as viscous vape oils and the aerosolized droplets they generate represent highly nonpolar matrices that can induce significant matrix effects, complicating accurate trace-level metal analysis. Inductively coupled plasma–mass spectrometry (ICP-MS) provides sensitive, multi-element detection with parts-per-billion limits, broad dynamic range, and reliable quantification across diverse sample types. However, achieving accurate results in hydrophobic, nontraditional matrices requires careful method development and tailored sample handling strategies. Recent advances, including modified aerosol collection and digestion approaches, have improved metal recovery and enabled reliable quantification at inhalation-relevant concentrations. By adapting established ICP-MS methodologies to emerging regulatory matrices, these innovations enhance analytical figures of merit such as sensitivity, recovery efficiency, and reproducibility. Together, these developments demonstrate how method refinement within established instrumentation expands measurement capabilities and supports regulatory confidence in a rapidly evolving industry.

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