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EDITOR'S NOTE

Welcome to Separation Science's March 2025 issue, 'Redefining Analytical Boundaries,' released to coincide with Pittcon 2025. This issue serves as your guide to some of the latest breakthroughs and important discussions in analytical science.

We begin by taking a bold look at how artificial intelligence can transform chromatographic peak picking, reducing analysis time while improving accuracy. We then aim for the stars by exploring NASA's mission to study Europa's chemistry using advanced mass spectrometry, unveiling new clues about potential life beyond Earth.

On page 14, Larry Tucker offers an insider's view on standardization in petroleum analysis, reminding us that consistent results underpin vital decisions in a changing industry. Later, Dr. Christopher D. Brown provides insights into portable FTIR in the forensic lab, revealing how this technique cuts investigative time and refines data quality in the field.

Sustainability takes center stage as Baljit Bains explains method development considerations to conserve energy and reduce waste without compromising results. We also introduce mass photometry, a label-free tool reshaping biomolecular analysis with unprecedented precision.

Finally, explore our eBook and webinar roundups for additional expert resources and insights. Thank you for joining us on this journey of innovation—we value your feedback, so please reach out to me at acichocki@sepscience.com with your thoughts or questions.

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Implementing AI to Streamline Chromatographic Peak Picking

Peak picking can see an efficiency boost with AI, but what is required to get up and running?

by Holden Galusha

Traditionally, scientists have manually reviewed chromatograms to identify and quantify compounds in a sample. The process involves establishing a baseline to represent the signal in the absence of analytes, setting a threshold to differentiate true peaks from noise, and inspecting the chromatogram for peaks that meet these criteria. Identified peaks are validated by comparing their retention times, shapes, and spectral characteristics against known standards or reference materials.

"Integrating AI solutions with existing lab infrastructure and workflows can be complex and time-consuming."

As chromatographs shifted to record chromatograms digitally instead of printing them onto long rolls of paper, algorithms were introduced in the chromatography software to help identify peaks and minimize noise. The software performs a preliminary peak identification, and the user confirms its validity.

While these algorithms are helpful, their utility is limited—after all, algorithms are static and cannot be tailored to an organization's unique data. This is where artificial intelligence (AI) can take the baton.

Comparing Manual vs AI Peak Picking

It's important to acknowledge that every chromatography lab is different, so some may benefit greatly from AI while others may be hindered by it. Here are two breakdowns illustrating the pros and cons of manual and AI-powered peak picking, respectively:

Manual peak picking

PROS	CONS
Quality assurance: Scientists personally ensure their data is accurate and precise.	**Time-consuming:** Peak picking is a meticulous task that demands time, focus, and experience.
Full context: Humans can examine data in full context, weighing factors that may not necessarily be quantified, in a way that AI cannot.	**Cognitive limits:** While humans are excellent at recognizing patterns, they may not be as good as AI. Some chromatography data may contain patterns that only AI can perceive.

AI peak picking

PROS	CONS
Automated: AI automates the peak picking process, slicing turnaround time and saving scientists time and energy to focus on work that requires a human touch.	**No contextual understanding:** AI models cannot know the inevitable nuances of a situation, which may result in output that seems appropriate on paper but does not necessarily reflect reality.
Accuracy: As mentioned, some data may contain patterns imperceptible to humans. In these cases, introducing AI can heighten accuracy as the AI will identify those patterns and account for them in the final output.	**Lack of transparency:** You cannot step through an AI model's "reasoning." You can only infer how it arrived at a particular output. While this is sufficient for many applications, it requires scientists to exercise caution with AI.

Let's say you've reviewed the pros and cons of both approaches, built a business case, and received approval to introduce AI in your peak picking process. What are the next steps?

What Do You Need to Implement AI?

To roll out an AI solution, you'll need more than just chromatograms. There are two key ingredients to implementing AI: annotated, high-quality data and a platform to access the solution.

High-Quality Data

Data is the lifeblood of any AI solution. Commercial AI solutions generally come pre-trained on the vendor's data set. While this is useful and sufficient for many use cases, labs should consider investing the time into collecting and annotating their own data, which will enable them to launch an AI solution tailored for them. Annotation is the process of defining and differentiating between elements of interest in a data set, which will enable the AI model to learn those patterns and draw the same distinctions in future analyses.

After annotation, you can then further train the AI model on your lab's data in a process known as fine-tuning. "Fine-tuning a model on a lab's own data is highly beneficial as it increases accuracy by tailoring the model to the specific characteristics and nuances of the lab's data," says Edison Cerda, product manager, informatics at Agilent Technologies. "It also improves relevance," Cerda continues, "ensuring the model's outputs are more actionable for your specific use cases." Annotating your lab's data and fine-tuning an AI model on it is essential to your AI strategy.

Data Platforms

Of course, all the data in the world means nothing if you can't use it. You need a centralized platform that can (1) receive input to process data and (2) make the output readily available to users. This is not a straightforward process. "Integrating AI solutions with existing lab infrastructure and workflows can be complex and time-consuming," Cerda says. Architecting the data pipelines that will enable the AI solution to receive data and then generate output requires technical expertise, deep collaboration with your organization's IT staff, and a clear vision of how you will integrate the solution with your lab's workflow.

Data Pipelines and Access

How are you hosting your AI model, and how will your chromatography data make it to the model? Some chromatograph vendors offer AI peak picking solutions that are cloud-based and operate as a software-as-a-service, easily scaling with your lab's usage. The downside is that subscribing to these services can be expensive, and they may only work with chromatographs made by that particular vendor, effectively locking you in to that vendor's walled garden.

In contrast, there are also on-premises solutions available, such as the open-source project PeakBot. On-premises solutions do away with recurring expenses and have enhanced flexibility. They can analyze data from any chromatograph as long as that data is scrubbed and standardized. The trade-offs, however, lie in cost and convenience.

According to Cerda, high-performance servers are required to handle the data processing and model training of on-premises solutions. These servers represent a significant capital investment, though their recurring operating costs may be lower than the cost of subscribing to a cloud AI platform.

The other factor to consider is convenience. A cloud solution makes access easy —it's either integrated with the chromatograph's software or available via a web browser. Meanwhile, an on-premises server demands network bandwidth, security, and a workstation to access the platform. All these factors must be weighed against each other when deciding if you should opt for a cloud or on-premises solution.

After deciding on a solution, you must then set up the data pipeline to move data from the chromatograph to the AI model. Cloud-based solutions will handle this out-of-the-box, piping all data into one model via the internet. If hosting on-premises, the ideal setup will hinge on the number of chromatographs you have, your internal network infrastructure, physical proximity, and other factors. One simple, but manual and time-consuming, solution is to export data from each chromatograph to a USB drive, walk it to the workstation hosting the AI model, and carry on from there. Ideally, you will be able to automatically send data to the model via your lab's internal network without exposing it to the internet. Consider hiring a lab informatics consultant to identify the best solution according to your needs and budget.

Holden Galusha *is the associate editor for Lab Manager. You can reach him at hgalusha@labmanager.com.*

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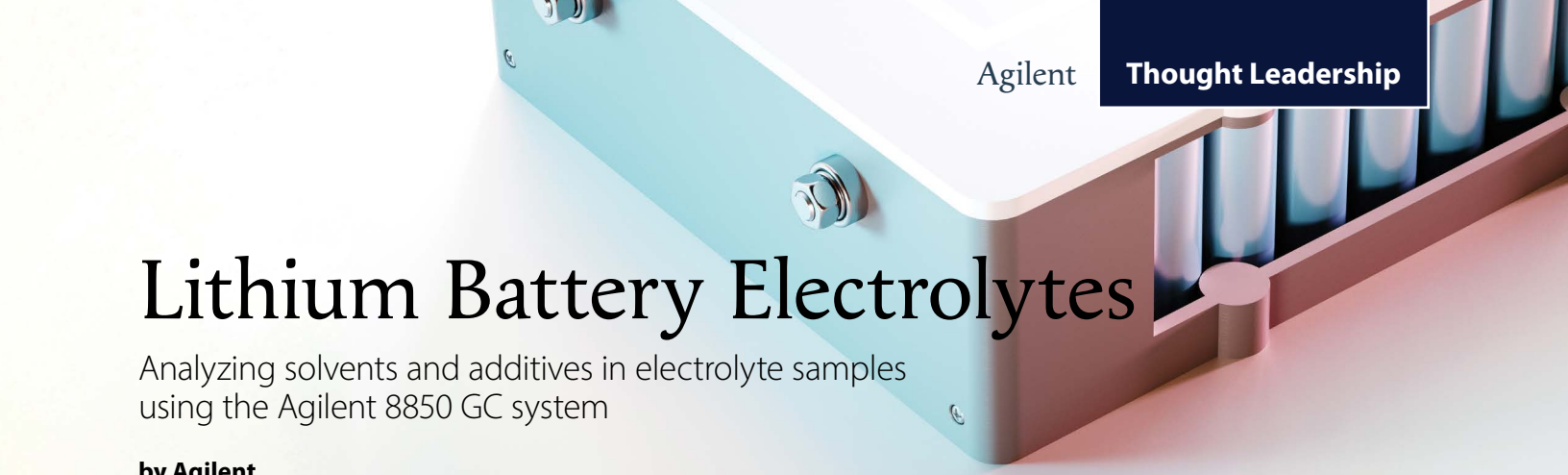


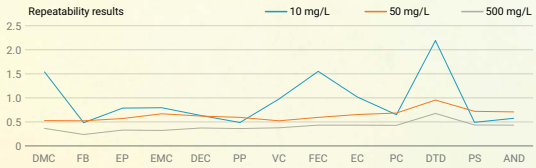
Lithium Battery Electrolytes

Analyzing solvents and additives in electrolyte samples using the Agilent 8850 GC system

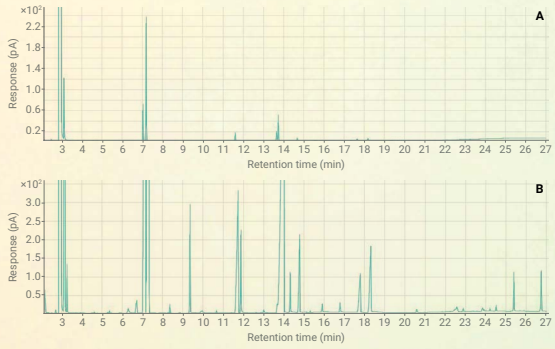
by Agilent

Electrolytes play a vital role in transferring and conducting current between the positive and negative electrodes in lithium-ion batteries. This application note introduces an analytical method for determining carbonate solvents and additives in lithium battery electrolytes.

In this study, commercially available standards were used for method evaluation in terms of linearity, reproducibility, and detection limits. Real samples were also run to investigate the impact of high acid and high salt samples on GC system performance. With an effective analytical method established, the impact of running large numbers of real samples on the overall GC system performance was also examined.



Repeatability results at low, middle, and high concentrations of calibration standards.



Chromatogram of sample after (A) 1,000-fold dilution with dichloromethane and (B) after 10-fold dilution with dichloromethane.

Performance results for linearity, repeatability, and detection limit of 13 target compounds confirm the outstanding sensitivity and reliability of the Agilent 8850 GC system. This study also demonstrates that even after more than 400 runs, the system can maintain excellent stability after the real samples have been diluted 100x.

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Mass Spectrometry Takes Flight to Unlock Europa's Chemistry

Cutting-edge technology aboard NASA's latest mission seeks to probe the building blocks of life on an icy moon.

by Adam Dickie, Kelly Miller

In October 2024, the Europa Clipper soared into space atop a SpaceX Falcon Heavy rocket, destined for a moon of Jupiter believed to harbor a vast ocean beneath its icy crust. Equipped with MASPEX (MAss Spectrometer for Planetary EXploration), the mission will analyze Europa's thin atmosphere and hidden waters, searching for chemical clues that could answer the existential question—does life exist beyond Earth?

"This is NASA's first mission dedicated to an ocean world," says Kelly Miller, a lead scientist at the Southwest Research Institute in San Antonio, Texas. "Where there is liquid water, the chance for habitability—and life—increases. MASPEX will be a critical tool for detecting and characterizing organic compounds and volatiles in Europa's exosphere."

To meet these ambitious goals, MASPEX's design features advanced elements to improve mass resolution and protective shielding to withstand one of the harshest environments imaginable. Separation Science spoke with Miller about the innovations that could set new benchmarks for analytical exploration.

Journey to Jupiter

The Europa Clipper mission emerged from decades of scientific intrigue surrounding Europa's icy shell and hidden ocean. Miller, who honed her expertise as a postdoc with the Cassini Ion Neutral Mass Spectrometer (INMS) team, joined the Clipper project as Calibration Lead in 2019. "While we call our pre-flight testing 'calibration,' it differs from typical laboratory calibration—it focuses more on evaluating and verifying instrument performance metrics," she explains.

The spacecraft faces a five-year journey to reach Jupiter. While much of this time involves transit, the team will conduct health checks, maintenance, calibration, and other preparations. Once at Jupiter, Europa Clipper must contend with intense radiation that can disrupt data and degrade sensitive components. For MASPEX, this requires operating with extensive shielding while capturing precise data during brief, high-speed flybys of Europa's exosphere.

Miller explains that MASPEX remains sealed behind a protective door early in the mission to avoid exposure to spacecraft outgassing. As time passes and conditions stabilize, calibration activities can begin. "We're planning to open the door around 2027 to start fully operating and characterizing the instrument," she says. "Our first flyby of Europa is scheduled for 2031, so we have a long journey ahead."

MASPEX: Advanced Instrumentation in Action

MASPEX uses multi-bounce time-of-flight (MBTOF) technology to achieve high mass resolution by reflecting ions between electrically charged mirrors, extending their path length to nearly a kilometer. This design enhances MASPEX's ability to separate ions with exceptional precision, distinguishing tiny differences between complex molecules—capabilities critical for analyzing Europa's volatile chemical environment.

"We'll conduct around 50 flybys, each with a different closest approach altitude," Miller says. "As we get closer to Europa, the density of the gas shell increases, giving us more opportunities to capture and analyze its composition."

To help perform precise measurements of Europa's exosphere—analyzing atoms and molecules such as water vapor, carbon dioxide, and potentially complex organic compounds—the team also incorporated a cryocooler into the probe. This system traps incoming gas by cooling it to extremely low temperatures, allowing MASPEX to concentrate and analyze volatile compounds with greater sensitivity and accuracy after each flyby.

During each flyby, MASPEX collects spatially resolved data in real time, with spatial resolution determined by the closest approach altitude, sometimes as low as 25 kilometers. "As we 'sniff' this gas, we'll detect differences in its composition that might correlate with varying surface features," explains Miller. During these passes, the cryocooler cools to about 70 Kelvin, measuring and ionizing some incoming gas while trapping another portion on its cold head.

Once the spatially resolved measurements are complete, a valve closes, and the cryocooler warms to ambient temperature, releasing the trapped gas sample into the instrument's housing. This process allows MASPEX to make longer, more stable measurements in lower-radiation regions farther from Europa, enhancing its ability to detect trace compounds with greater accuracy.

Another innovation of MASPEX is its 'ice grain mode,' designed to analyze tiny frozen particles striking a plate in its entry chamber. Traveling at about 5 kilometers per second, these grains produce a flash of gas upon impact, a phenomenon first observed with Cassini INMS. MASPEX's software monitors hydrogen levels, and when a spike indicates water, it adjusts to target heavier compounds in the ice grains rather than gas-phase molecules in the exosphere.

Habitability and the Hunt for Life

While atmospheric measurements of Europa are well planned, the search for habitability is enhanced by the potential presence of plumes—jets of water vapor and other materials possibly erupting from cracks in the icy surface. Observed by the Hubble Space Telescope and previous Galileo missions, these plumes offer rare access to Europa's subsurface waters, locked beneath 15 to 25 kilometers of ice.

MASPEX is designed to detect biosignatures in Europa's plumes, including organic molecules such as amino acids, lipids, and hydrocarbons, as well as volatile compounds such as methane, nitrogen species, and sulfur compounds. In Europa's dark subsurface, life would likely be chemotrophic, relying on chemical reactions rather than sunlight for energy. MASPEX will analyze chemical imbalances, such as hydrogen-to-methane and nitrogen oxide ratios, which may indicate either biological activity or abiotic reactions similar to hydrothermal processes on Earth.

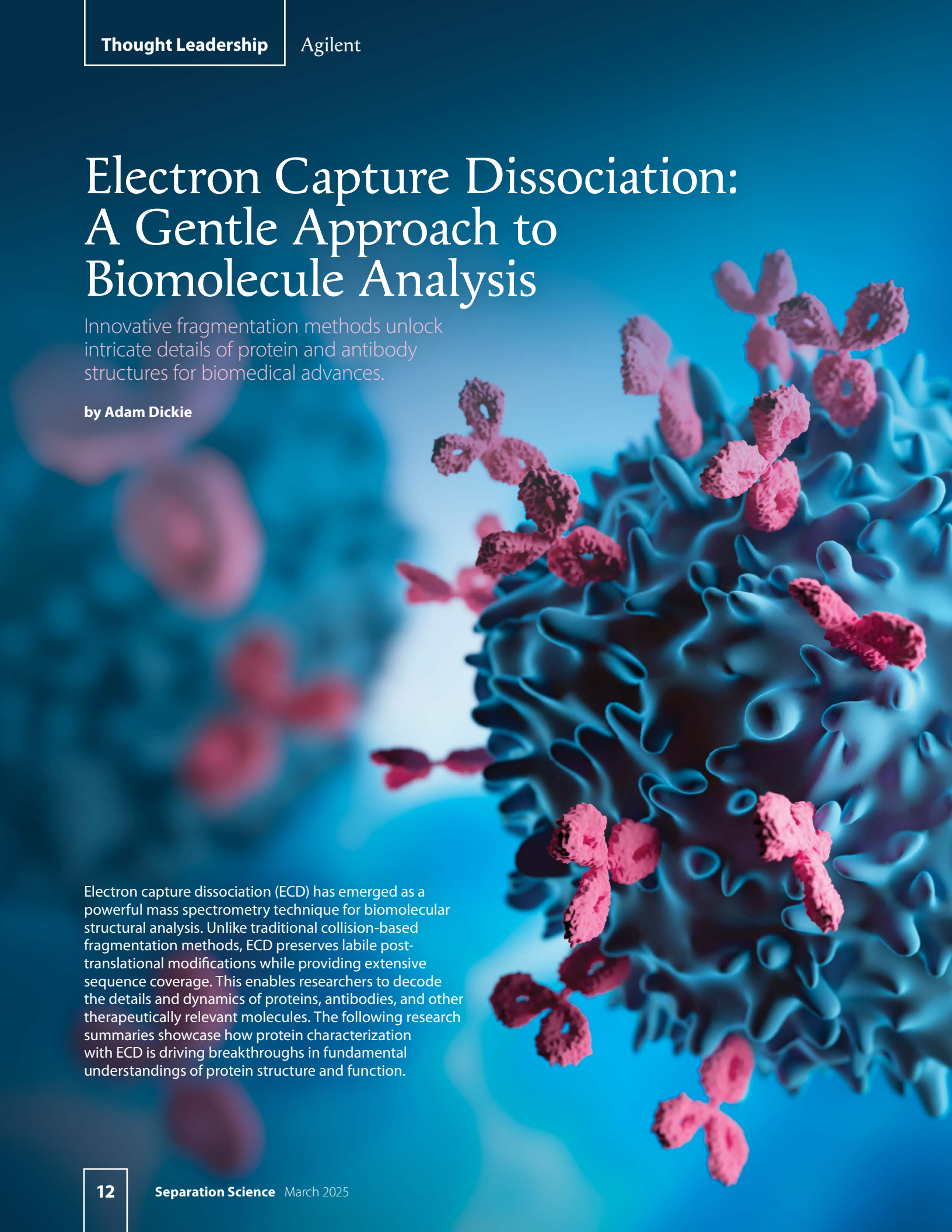
To address the fundamental question of extraterrestrial life, Miller explains that NASA has divided the process into smaller, manageable steps, beginning with habitability. "We know there is likely a subsurface ocean, but we need to evaluate whether it contains solutes and has the right pH, redox conditions, and temperature to support life," she says. "This mission offers a fantastic opportunity to learn more about our solar system and the habitability of ocean worlds."

Adam Dickie *is a science writer at Separation Science. He can be reached at adickie@sepscience.com.*

Electron Capture Dissociation: A Gentle Approach to Biomolecule Analysis

Innovative fragmentation methods unlock intricate details of protein and antibody structures for biomedical advances.

by Adam Dickie



Electron capture dissociation (ECD) has emerged as a powerful mass spectrometry technique for biomolecular structural analysis. Unlike traditional collision-based fragmentation methods, ECD preserves labile post-translational modifications while providing extensive sequence coverage. This enables researchers to decode the details and dynamics of proteins, antibodies, and other therapeutically relevant molecules. The following research summaries showcase how protein characterization with ECD is driving breakthroughs in fundamental understandings of protein structure and function.

TOP-DOWN MS: RAPID CHARACTERIZATION OF CELL DEATH PROTEINS

Researchers have developed a fast and precise method for analyzing modified Bcl-xL proteins, which are crucial in cell death processes. Rachel Franklin from Agilent Technologies and her team used genetic code expansion and top-down mass spectrometry to analyze modified Bcl-xL variants, including those with engineered phosphoserine and phosphoserine mimics. Unlike traditional procedures that require extensive sample preparation, this new approach uses ECD to break down the intact proteins and achieve 85–90% sequence coverage within minutes. Successful localization of phosphorylation modifications makes top-down analysis with ECD a powerful tool for characterizing phosphorylated proteins.

VIEW THE POSTER

DECODING FRAGMENTATION FROM INTACT ANTIBODIES WITH NEW SOFTWARE

ExDViewer software enables routine, parameter-free analysis of monoclonal antibody fragmentation data for effective top or middle-down sequencing. Prior work has shown that ECD can simultaneously fragment both heavy and light chains of an intact antibody, resulting in a mixture spectrum of ECD fragments. Stephanie Sturgeon at Agilent Technologies and co-workers have now enhanced ExDViewer to provide high-quality analysis and visualization of mixture spectra results within seconds. ExDViewer enables rapid processing of data to remove charge and isotope elements, producing clear fragments used for sequencing key antibody regions called CDR sequences. These improvements provide a user-friendly and powerful tool for the analysis of monoclonal antibodies using top-down ECD MS.

VIEW THE POSTER

PROTEIN THERAPEUTICS: ANTIBODY CHARACTERIZATION WITH ECD

Labile post-translational modifications are better preserved using ECD than conventional MS fragmentation techniques such as collision-induced dissociation (CID). Common modifications, such as glycosylation and phosphorylation, can impact the safety, efficacy, and binding activity of monoclonal antibodies but are challenging to identify.

Stephen Sciuto from Agilent Technologies and colleagues analyzed tryptic digests of NIST mAb and Infliximab using an 6545XT Q-TOF mass spectrometer in ExD or CID mode. ECD provided higher sequence coverage than CID, reaching 100% for glycosylated peptides in Infliximab. The ability to pinpoint glycosylation sites using fragment ions demonstrates the power of ECD for characterizing glycopeptides.

VIEW THE POSTER

MONOCLONAL ANTIBODIES: FASTER ANALYSIS WITH MICRODROPLETS

The first reported combination of microdroplet reactions with ECD fragmentation offers a quicker way to analyze monoclonal antibodies for disease treatments. Thomas Walker from Agilent Technologies and co-workers demonstrate the use of an Agilent Jet Stream electrospray ionization source to facilitate in-spray chemical reduction and protease digestion of monoclonal antibodies. Downstream fragmentation of the microdroplet reaction products with ECD provided rapid characterization of intact antibodies in minutes. Efficient ECD fragmentation yielded rich sequence information including evidence of disulfide bond connectivity and confirmation of key sequences called complementary determining regions. These results highlight this method's potential for fast and cost-effective antibody characterization with minimal sample preparation.

VIEW THE POSTER

Adam Dickie *is a science writer at Separation Science. He can be reached at adickie@sepscience.com.*

Petroleum Analysis: Ensuring Accuracy and Consistency in a Changing Industry

Hear from expert Larry Tucker on the importance and challenges of standardization in petroleum, along with emerging trends.

by Aimee Cichocki, Larry Tucker

As the energy sector shifts towards sustainable solutions, reliable analytical methods remain crucial. The role of standards within these methods is pivotal, ensuring accuracy, consistency, and reliability across various industries. In this Q&A session, we speak with Larry Tucker, the Director of Norms and Standards at Metrohm USA and the Second Secretary for Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants. Backed by extensive experience, Tucker shares his perspectives and insights on the current challenges, advancements, and future directions in the field of petroleum product analysis.

"When you look at the energy industry, all of our fuels—both conventional and renewable—are products that are blended to performance specifications."

Could you provide a brief overview of standardization in the petroleum industry?

Standardization is very important for commerce in general. When you look at the energy industry, all of our fuels—both conventional and renewable—are products that are blended to performance specifications. Having uniform products (by conforming to standards) means that every time you fill your car at a gas station, you're getting a product that will work in your vehicle, and you don't have to worry. That's only possible if you have consistent standardization and commercial enforcement of standards. We depend a lot on energy, and it's extremely important that everyone in society can rely on fuels, whether it's the natural gas in our house or the fuel that goes into the bus that takes our kids to school. You can only do this with some type of stamp—consistent standards that are accepted and adhered to. Because fuels are traded on a global basis, those standards must be globally recognized. That's where ASTM plays a large role in ensuring those global standards are in place for consistent quality.

What are some of the latest updates in this field?

This field is certainly moving. It's emerging quickly because of the shift to renewable, recyclable, cleaner, and greener initiatives. Of course, those core themes are being discussed across industries as organizations question how they can lower their carbon footprint. In the petroleum testing and marketing world, companies apply these topics in different ways that are unique to their situation, where they believe they can make a difference for their business.

For example, there's a push to produce renewable diesel, so there are large investments in renewable diesel plants. Significant investments have also been made in producing fuel from recycled plastics. Companies are making all sorts of efforts to take advantage of recycling and using renewable resources. There are also processes that can convert various feedstocks into fuel. I call this "trash to cash," which is waste to fuel. And there are many projects where people go to landfills, tap into the natural gas, and supply energy for a certain area. Those types of programs are really important.

Which analytical methods are most important within the industry?

There is a partnership in play when it comes to the analytical tools. Needs are constantly changing in response

to either regulations or changes in feedstocks. Many traditional analytical tools have a place in the industry, including gas and ion chromatography, spectroscopy, and wet chemistry (particularly titration), with needs changing depending on processes and regulations. For example, initiatives to reduce sulfur content in fuel caused a significant change in the industry. Fuels initially had high sulfur content, but in some cases, new regulations require a total sulfur level below five or 10 milligrams per kilogram of fuel. The industry had to adapt and find a way to process fuels that still work in vehicles yet have low sulfur content. Along with this came the need for analytical tools that could reliably measure sulfur at these low levels.

What are some key challenges faced by analytical scientists in this field?

New fuels bring process challenges, which require measurement by analytical techniques. Spectroscopy is used increasingly broadly within the industry, particularly in manufacturing processes, to assist with quality assurance and process control. One of the benefits of spectroscopy is its speed compared to chromatographic techniques. If you can measure multiple fuel parameters quickly, you can make faster decisions about process adjustments. Getting more data faster is an ever-present theme as economic pressure continuously encourages us to do more with the same or less. This forces productivity initiatives, and labs are becoming increasingly open to automation and other technologies that provide essential efficiency gains.

With labor shortages in the industry, it's becoming more difficult to find experienced, qualified personnel, so it's vital to leverage the existing workforce efficiently. This is where training plays an important role. From that standpoint, ASTM has launched a number of initiatives to help train laboratory technicians and personnel. The ASTM technician training program uses video tutorials to teach technicians how to run test methods and interpret the resulting data.

"Any time we're undergoing an evolutionary change, we have to consider if we have the capacity to implement that change and at what pace that can happen."

Are there any trends or emerging issues that you anticipate will drive significant changes in this field?

There is currently a lot of focus on synthetic aviation fuel (SAF). Airlines are committing to high volumes of SAF that aren't available in the market today. As a result, there's a push to build the production capacity of this cleaner, greener fuel. It's a similar situation to what we've seen with batteries. After the introduction of battery cars, many assumed we could quickly switch to these vehicles, but we are still lacking charging stations and other infrastructure. If everyone switches tomorrow, we could have potential problems, including long lines at charging stations or compatibility issues. Any time we're undergoing an evolutionary change, we have to consider if we have the capacity to implement that change and at what pace that can happen.

Aimee Cichocki *is the associate editorial director at Separation Science. She can be reached at acichocki@sepscience.com.*

From Lab to Field: The Impact of Portable FTIR in Forensics

Dr. Christopher Brown explains the game-changing role of mobile FTIR technology in speeding up and refining forensic investigations.

by Aimee Cichocki, Dr. Christopher D. Brown

In the high-stakes world of forensic science, speed and accuracy are paramount. For firefighters, hazmat teams, police groups, and government agencies, every second counts when identifying substances, analyzing evidence, and making critical decisions that impact public safety. The adoption of advanced Fourier-transform infrared (FTIR) spectroscopy is revolutionizing the field, offering rapid, on-site analysis capabilities that were previously confined to the laboratory.

Dr. Christopher D. Brown, co-founder and chief product officer of 908 Devices—a company specializing in advanced chemical detection and analysis tools—discusses how these innovations are reshaping forensic investigations, enabling teams to make quicker, more confident decisions. From developing portable FTIR units to advancing gas and vapor analysis, Dr. Brown provides insights into how these technologies address current challenges and set new standards for the future.

FTIR addresses key challenges in the field of forensics

FTIR technology has a long history in forensics applications. "It's regarded as one of the three pinnacle techniques for forensics identification," explains Dr. Brown. "Those three are mass spectrometry, FTIR/Raman, and NMR. Many regulating best practice guidelines for forensic entities require at least one of those to support the forensic identification of materials."

One key challenge in forensics applications is conducting accurate analyses in the field. *In situ* testing with rapid results provides obvious benefits, especially in an emergent situation, but this has been historically difficult to achieve. "In the early 2000s, several companies developed a fieldable FTIR, a small FTIR that could be taken out on scene," recalls Dr. Brown. "As you can imagine, having that capability in the field in real time changes the pace of what you can achieve in terms of rapid characterization and analysis, particularly when something scary is happening. This really started changing the concept of operations for a lot of field forensics teams and hazardous material response teams."

Dr. Brown notes that technological advancements have rapidly progressed to the point where portable FTIR devices are now standard equipment for many forensic teams. However, despite the significant benefits of field testing, further optimization in terms of accuracy and speed is still needed. Companies such as Red Wave Technology (now part of 908 Devices) are at the forefront of these efforts. Dr. Brown highlights one of 908 Devices' latest innovations—a product capable of identifying 20,000 materials in under a minute—demonstrating the strides being made in enhancing both the efficiency and precision of on-site forensic analysis.

While portable technology for solid and liquid analysis has improved significantly, analyzing gaseous samples still presents distinct challenges. Until recently, teams relied heavily on simple sensors to perform in-field detection of a single gas. But the latest product in this field can analyze more than 5,000 gasses and vapors. Dr. Brown illustrates the value of this capability in scenarios where an odor of concern is detected. "It may be absolutely nothing and teams can go out and calm everybody down. But in other circumstances, it could be of significant concern. Having the ability to perform a broad investigation within minutes, using lab-grade technology, has a huge impact on the timelines these teams can work on. It provides them with the confidence to make quick decisions in the field."

Portable FTIR advances involve more than miniaturization

An additional challenge in designing portable technology is reducing size without compromising functionality. "But making it small isn't good enough in its own right," advises Dr. Brown. "Once it's small and carried around by hand, it's prone to damage. It will be dropped and exposed to harsh temperatures, issues that don't apply to lab systems." He explains that careful engineering is required to improve temperature resilience and ensure shock and vibration isolation.

Usability is another critical aspect to consider. As Dr. Brown explains, traditional FTIR systems are set up for scientists, with an array of buttons (and accompanying choices to make). "But to enable on-scene, field applications of the technology, these systems essentially have to run themselves," says Dr. Brown. "So the tools are set up to be answer boxes rather than a typical laboratory analytical tool. Using the devices looks easy, but there's a lot happening under the hood to make them feel that simple."

Supporting usability also demands inventive approaches, especially when it comes to software components. "There's a lot of built-in automation and intelligence in the system, doing the job that a scientist would do in the lab—choosing settings, optimizing acquisition, and making a decision, all based on the data it's seeing," explains Dr. Brown. He elaborates that the data analysis component can be particularly tricky. "For example, for a gaseous sample, if you look at what's present in a room, there's nitrogen, oxygen, a range of trace normal gasses, VOCs coming from carpets and paints, and more. When you think about the part per million level in a typical room, there's a lot going on. It's very challenging to be able to cut through the complexity and determine the important components that are present."

Advances in FTIR are set to continue

As we look to the future, Dr. Brown sees a continuous push to lower detection limits. "That's something the segment as a whole is working toward," he advises. Dr. Brown notes that continued advancements in the automation of data interpretation are also important, particularly as it relates to quantitation and complex environments. He adds further miniaturization is also always of interest to the community.

Dr. Brown notes that scaling down systems can sometimes require trade-offs in sensitivity and performance, requiring significant ingenuity as miniaturization progresses. He also reminds us that the forensic landscape is constantly changing. "Some of the highest profile forensic problems of today are not really the forensic problems of 15 years ago," says Dr. Brown, citing the current fentanyl crisis as an example of a more recent challenge that wasn't a significant problem 10–15 years ago.

Conclusion

Advancements in FTIR technology are transforming the field of forensic science. The evolution from bulky, lab-based systems to portable, field-ready devices is giving forensic teams unprecedented speed, accuracy, and confidence. These innovations are not only enhancing on-site substance identification and analysis but also streamlining decision-making in critical moments.

Aimee Cichocki *is the associate editorial director at Separation Science. She can be reached at acichocki@sepscience.com.*

Faster, Smarter Gas Chromatography: The Role of Method Optimization

How method optimization and translation are transforming GC workflows across petrochemical, pharmaceutical, and flavor applications.

by Adam Dickie

Modern analytical labs face growing demands, from helium shortages to strict regulatory requirements, that push older gas chromatography (GC) methods and instruments to their limits. Staying competitive requires two key strategies: method optimization for faster, more precise analysis, and method translation to adapt workflows to advanced instruments.

Three recent application notes from Agilent showcase these strategies in action. By refining methods for faster analysis and adapting them for use across different setups, labs in industries such as petrochemicals, pharmaceuticals, and flavor testing are tackling their most pressing challenges. This article highlights insights from these application notes, illustrating how advancements in GC systems and software are helping labs improve throughput, enhance quality control, and stay adaptable for the future.

EFFICIENT HYDROCARBON ANALYSIS WITH DUAL FLOW GC

Monocyclic aromatic hydrocarbons (MAHs) such as benzene, toluene, and xylene are critical building blocks for industries including petrochemicals, solvents, and plastics. Labs tasked with analyzing these compounds encounter obstacles, particularly when handling large sample volumes. For instance, ASTM D7504, a widely used method for MAH analysis, often requires extended runtimes and relies on helium as a carrier gas.

An Agilent study, detailed in *The Analysis of Monocyclic Aromatic Hydrocarbons by ASTM D7504 on the Agilent 8850 GC System*, illustrates how innovative instrumentation and workflow design enhance MAH analysis.

Using the Agilent 8850 GC, a compact instrument with dual gas flow capabilities, researchers compared two workflows under ASTM D7504 standards. The conventional method relied on helium as the carrier gas and a 60-meter polyethylene glycol column, achieving precise separation of benzene, toluene, and xylene isomers over a 39-minute runtime.

Researchers optimized the method by using a shorter, narrower 10-meter column, which reduced elution time. Hydrogen, with its higher diffusivity compared to helium, further accelerated separation while maintaining baseline resolution for critical peaks such as ethylbenzene and xylene isomers.

Oven temperature programming was adjusted with a steeper ramp to speed up elution without compromising separation, and column flow rates were fine-tuned to align with hydrogen's properties. These adjustments were guided by Agilent's Method Translation Software, which ensured the optimized workflow adhered to ASTM D7504 requirements while maintaining precision.

The result was a faster, highly reproducible method, with RSD values below 1.0 percent for all major analytes—demonstrating how targeted changes to key parameters can significantly enhance throughput while meeting industry standards.

OPTIMIZED GC WORKFLOWS FOR RESIDUAL SOLVENT TESTING

Residual solvents are volatile chemicals used during the production of active pharmaceutical ingredients (APIs) and excipients. To ensure safety, these compounds must be monitored in accordance with USP <467>, which sets toxicity-based limits for solvent residues. In pharmaceutical labs, headspace gas chromatography (GC) is a preferred technique for this analysis, as it heats samples to release low boiling compounds, enabling precise detection and quantitation.

While effective, traditional headspace GC workflows for USP <467> compliance often rely on helium as the carrier gas, a resource facing rising costs and supply constraints. Additionally, the lengthy runtimes required to achieve precise separation can limit throughput, creating bottlenecks in high-demand labs. For facilities with limited bench space, the size of conventional GC systems adds another layer of complexity, making it difficult to scale operations efficiently.

In the application note *Residual Solvents Analysis for the Pharmaceutical Industry Using the Agilent 8697 Headspace Sampler and 8850 GC-FID System*, researchers from Agilent demonstrate how the integration of modern GC tools can reduce analysis time by up to 30% while maintaining precision in detecting residual solvent impurities required for regulatory compliance.

To ensure reproducibility in high-throughput testing, researchers used the Agilent 8697 Headspace Sampler's automated vial handling to minimize variability in sample introduction. Paired with the compact 8850 GC system, they first tested a helium-based workflow modeled on the traditional USP <467> method. While this approach delivered precise separations for residual solvents, it required runtimes of over 40 minutes per analysis.

To enhance efficiency, researchers switched from helium to hydrogen as the carrier gas and optimized method parameters using Agilent's Method Translation Software to account for hydrogen's properties. Challenging separations, such as methylene chloride and acetonitrile—compounds with high volatility and closely overlapping retention times—required precise adjustments. These modifications reduced analysis time significantly while preserving resolution.

With RSD values below 1.0 percent, the approach ensures reliable results even for challenging separations, making it ideal for high-throughput pharmaceutical labs.

FAST AND PRECISE FLAVOR ANALYSIS

In the food and beverage industry, flavor profiling is crucial for ensuring product quality and consumer satisfaction. For instance, the distinctive flavor of vanilla extract comes from a complex mix of volatile organic compounds (VOCs) that require precise GC separation to identify key components such as vanillin. Traditional GC methods, however, are often time-consuming, limiting efficiency in high-throughput production environments.

An Agilent study, *Method Translation for the Analysis of Vanilla Extracts Using an Agilent 8850 GC System with Helium Conservation Module for Carrier Gas Switching*, showcases an approach to balancing speed and precision in the analysis of challenging flavor profiles.

Researchers began by evaluating a traditional GC method for analyzing vanilla extract, which used helium as the carrier gas and required runtimes of up to 50 minutes to separate the complex mix of VOCs. Using the Agilent 8850 GC system, they transitioned to hydrogen as the carrier gas and employed shorter, narrower columns to achieve faster separations. Agilent's Method Translation Software guided adjustments to flow rates and oven temperature programming, ensuring the new workflow maintained accuracy while reducing runtimes to under 5 minutes.

This fast method addresses the high-throughput needs of QC labs in flavor manufacturing, where rapid raw ingredient purity analysis is essential. By utilizing shorter, smaller diameter columns and hydrogen as a carrier gas, the optimized approach achieved a 14-fold speed improvement over traditional helium-based workflows.

Researchers used the helium conservation module to enable seamless gas switching during high-throughput operations, transitioning between helium and hydrogen within a single sequence without disrupting workflows or requiring manual adjustments. This approach maintained less than 2.5% variability and delivered precise, reliable quantitation, making it ideal for flavor analysis in both R&D and QC environments.

CONCLUSION

Method optimization and translation connect legacy workflows with modern GC systems, retaining institutional knowledge while enhancing analytical capabilities. This strategy allows labs to modernize incrementally, balancing proven methods with cutting-edge performance to build future-ready systems.

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Sustainable Chromatography: Embracing Software for Greener Method Development

by Baljit Bains

Chromatography plays a vital role in separating and analyzing complex mixtures. Its broad applications provide crucial insights for quality control and research and development, making it an essential technique in industrial R&D, from pharmaceuticals to environmental science. However, several factors, including the use of resources (consumables and solvents), waste generation, disposal of solvents, and energy consumption, contribute to its significant environmental impact.

"Continual efforts are being made to reduce the environmental footprint of chromatographic processes."

Continual efforts are being made to reduce the environmental footprint of chromatographic processes. While some waste is inevitable and technical challenges, regulatory issues, economic constraints, scalability, and other difficulties emerge in creating greener methods, it is still possible to improve sustainability. The adaptation and application of the 12 Principles of Green Chemistry formulated by Paul Anastas and John Warner[1] to chromatographic processes and workflows help to minimize environmental impact without sacrificing efficiency and accuracy.

Approaching Sustainability in Analytical Labs: Adaptation of Green Chemistry Principles

Organizations are adopting green chemistry principles to transform existing chromatography practices and reduce their environmental impact. To make analytical labs more sustainable, it is necessary to implement strategies such as reducing and replacing solvents, designing workflows to improve energy efficiency, and conducting *in-silico* experiments to minimize waste.

Reduce Solvents and/or Replace with Safer Solvents and Auxiliaries

Solvents are extensively used in chromatographic processes, and their environmental impact can be attributed to their source/synthesis, properties, and disposal. Green chemistry principles dictate the importance of selecting the most suitable solvent to minimize environmental impact. To aid in selecting greener solvents, the pharmaceutical industry has developed solvent selection guides, such as the ACC GCI-PR guide.[2] However, it is important to note that a greener solvent does not always equate to a more sustainable process—multiple factors must be considered.

A key strategy for greener chromatography is reducing the volume of solvents used. While solvent-free methods would be ideal, they often lack the necessary selectivity and sensitivity. In such cases, replacing harmful solvents with greener alternatives such as supercritical fluids or ionic liquids, can significantly reduce environmental impact.

Design for Energy Efficiency

Energy is consumed through chemical and pharmaceutical processes, contributing significantly to their environmental footprint. The 12 Principles of Green Chemistry emphasize the importance of minimizing energy requirements.

Solvent removal is a major contributor to energy consumption, highlighting the need for careful solvent selection. Moreover, using energy-efficient instruments such as ultrahigh-performance liquid chromatography (UHPLC) enhances separation efficiency and shortens overall run time, reducing energy use significantly.

Maintaining the required temperatures and pressures for these processes also adds to their environmental impact. Conducting experiments at ambient temperatures and pressures and optimizing heating and cooling systems are essential to lower energy consumption.

Prevent Waste

According to green chemistry principles, preventing waste is preferable to treating/cleaning it once it has been created. Greener chromatography can be achieved by developing methods that require smaller sample sizes and generate less waste. The use of predictive software tools to develop and optimize these methods *in silico* helps minimize trial-and-error method development and unnecessary experimentation, further preventing waste generation.

Sustainable Chromatography using Software Tools

Waste is inevitable when conducting chemical experiments. When it comes to chromatography, the most eco-friendly experiments are those performed on a computer. The right software solutions can improve the sustainability of chromatographic experiments, significantly designing and optimizing methods that align with green chemistry principles. Software with predictive tools and method simulation enables optimization with fewer experiments—promoting greener practices and facilitating smarter decision-making.

"In silico modeling allows scientists to test conditions virtually, reducing both experiments and waste."

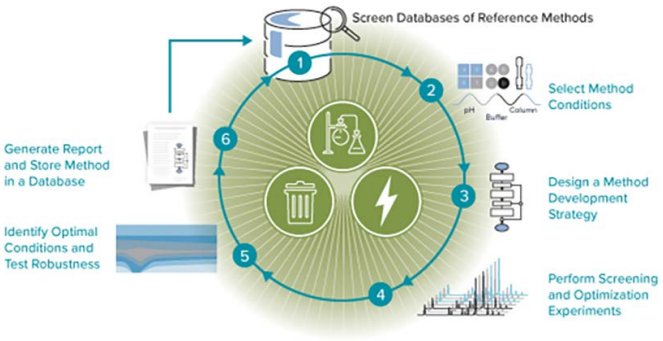

Figure 1: Workflow for method development using ACD/Labs' method development software, AutoChrom®.

Avoid Unnecessary Experiments with Predictive Technology

A deep understanding of the physicochemical properties and likely behavior of a molecule, along with the ability to rationally select chromatographic parameters, are required to develop, refine, and improve methods with minimal trial-and-error experimentation. A good foundation for this understanding comes from the expertise and

knowledge of scientists. However, there are limitations to this approach, such as cognitive capacity, potential biases, and manual analysis (often a slow process), which must be overcome. Building on this with a computational approach leads to more robust and insightful scientific outcomes.

Software prediction tools that use quantitative structure-property relationship (QSPR) calculations and complex algorithms to predict physicochemical properties such as logP, logD, pKa, and more are of immense value. Predictions generated with software tools offer high accuracy, consistency, speed, scalability, and the ability to manage substantial amounts of complex data.

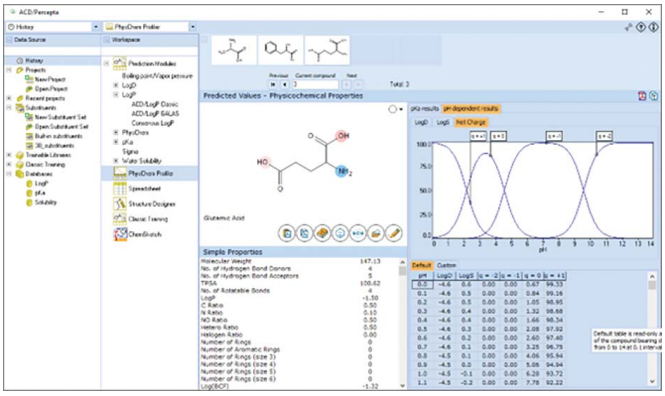

Figure 2: An example of logP, logD, and pKa property prediction calculated in PhysChem Suite prediction software.

Additionally, method development software tools such as column selection, column comparison, and pH selection can help predict a better starting point for method development. Combining these tools with a systematic and rational approach can help to quickly identify and select optimal chromatographic parameters while reducing the number of experiments required.

"Replacing harmful solvents with supercritical fluids or ionic liquids can significantly reduce environmental impact."

Combining scientists' expertise and leveraging intelligent software tools ensures reproducible and comprehensive scientific analysis while conserving resources by minimizing the number of experiments.

In Silico Modeling—Optimize Chromatographic Simulations, Reduce Waste, and Save Time

In silico modeling allows scientists to identify the most promising experimental conditions while minimizing unnecessary physical experiments. Using *in silico* modeling offers scientists increased flexibility in testing different scenarios and adaptability to easily adjust and re-run models to accommodate new data or changing experimental goals.

Early identification of optimal conditions and rapid simulations via *in silico* modeling accelerates the method development process. Complex algorithms and extensive datasets used by method development software help scientists quickly predict the most optimal chromatographic conditions (pH, gradient, etc.). They are also able to better separate peaks using 1D, 2D, or 3D models. Mathematical parameters in these software tools help scientists quickly select parameters that best meet their defined success criteria (k,' run time, resolution, and peak relevance). Software features such as multivariable analysis and visualization of data help scientists better understand and interpret complex datasets.

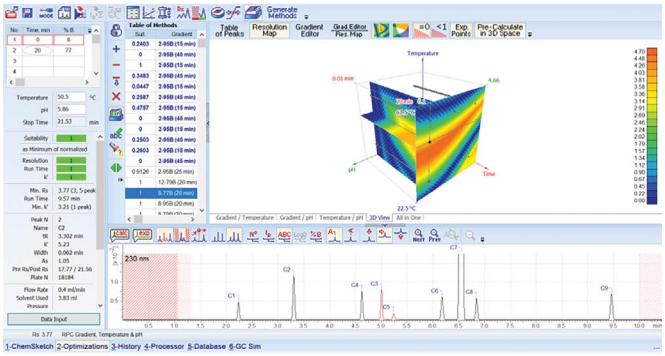

Figure 3: An example of method optimization using AutoChrom showing a resolution map and associated information in the Table of Methods.

Improve Sustainability with Enhanced Data Management

Labs usually operate with a variety of instruments from different vendors, leading to copious amounts of unstructured and isolated data. This can pose several challenges, such as higher susceptibility to errors and loss of data, which often means that experiments are duplicated. To achieve more sustainable research and development, it is essential to have efficient and effective data integration and management.

This can be achieved with vendor-neutral and platform-agnostic tools that provide a solution to capture, process, and analyze multiple file formats and data types into a single standardized data format within a single interface. Having standardized files and formats makes data easier to process and analyze, reducing the time scientists spend assembling and processing data.

The ultimate solution combines data standardization with data management systems to store and organize live analytical and chemical information (methods, structures, metadata, etc.) within centralized, searchable databases. These databases connect data to original experiments for simplified review and verification and give scientists easy access to all pertinent information to help them make informed data-driven decisions. Collaborative work environments are further facilitated, allowing scientists and organizations to work together seamlessly with software features that generate detailed customizable reports. Enhanced data management ensures that knowledge is preserved and leveraged for reproducible research.

Improving Sustainability with Artificial Intelligence (AI)

AI contributes to sustainability in analytical labs through the optimization of processes using real-time monitoring and adjustment, predictive analytics for sustainable experiment design, enhanced data management, and automation of routine tasks to reduce redundant work.

The quality of data is crucial for unlocking the full potential of AI. High-quality datasets must be standardized, comprehensive, and prepped for use with advanced analytical tools (such as data science, AI, or machine learning). As datasets increase in number, size, and diversity, the demand for efficient and effective data analysis increases. Having data that is ready for advanced analytical tools is necessary to facilitate data analysis, create predictive models, and accelerate the prediction and optimization of *in silico* experiments.

Advancing Sustainability in Analytical Labs

With the growing focus on sustainability, adopting green chemistry principles is becoming increasingly important. The environmental impact of chromatography, a vital analytical tool, can be significantly reduced by embracing green practices. Although challenging, sustainable methods can be implemented without compromising efficiency or accuracy. Enhanced software tools, including predictive technology, *in silico* modeling, and data standardization, not only align with green chromatography principles but enable scientists to perform fewer experiments, use resources responsibly, and manage data effectively. Incorporating these tools into laboratory workflows ensures that data is ready and accessible by scientists and AI and ML applications. With access to comprehensive and historical data, scientists can better manage their data and draw deeper insights, all while saving time and money. Embracing green chromatography enables scientists to maintain high-quality results and contribute to a more sustainable future.

"Enhanced data management ensures knowledge is preserved and leveraged for reproducible research."

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Unveiling the Power of Mass Photometry in Biomolecular Analysis

Precise mass analysis reshapes biomolecular research, offering label-free views of single molecules

by Aimee Cichocki, Stephen Maughan

Mass photometry is transforming biomolecular analysis by allowing scientists to observe and understand the composition of single molecules in solution. Developed at the University of Oxford and commercialized by Refeyn, this technology uses laser-induced signals to determine the mass of biological compounds, including protein complexes, nucleic acids, and viruses, without labels or modifications. With real-time insights into biomolecular mass and interactions, mass photometry is emerging as a powerful tool for studying complex formations, binding events, and aggregation behavior.

Stephen Maughan, Product Manager at Refeyn, provides insights into the core principles of this technology, its unique applications, and its potential impact on biomolecular research.

How Mass Photometry Works

Maughan explains that mass photometry (MP) relies on interferometric scattering (iSCAT), a microscopy technique that visualizes nanoscale objects by analyzing laser light scattered by these particles. In Refeyn's instrumentation, this involves shining a laser onto a microscopy coverslip, where samples of protein or other biomolecules or particles suspended in a buffer are introduced as droplets. "As the protein molecules land, they bind to the glass," he says. "We record the scattered light from the protein, examining how that light interferes with the reflected light from the coverslip."

The amount of light scattered by a molecule correlates with its polarizability, which, in proteins, depends on their mass because the refractive index and specific volume of each amino acid are sufficiently similar. As molecules in solution bind to a glass coverslip, incident light scatters, creating measurable patterns. These scattering events generate contrast signals, similar to ripples on a pond's surface, which mass photometry captures. The contrast signals correlate directly with the molecular mass.

"We record the scattered light from the protein, examining how that light interferes with the reflected light from the coverslip."

Bridging Gaps in Biomolecular Analysis

According to Maughan, this technique is particularly well-suited for protein analysis due to proteins' predictable interactions with laser light. "Proteins are all made up of amino acids, which respond in the same way to the laser illumination in terms of their refractive index. As a protein gets bigger, the contrast will increase linearly."

In contrast to bulk measurement methods, mass photometry excels at analyzing individual particles, offering advantages over techniques such as size exclusion chromatography with multi-angle static light scattering (SEC-MALS) or dynamic light scattering (DLS). "You're measuring the mass instead of the size, which differentiates the technique from DLS or nanoparticle tracking analysis (NTA)," explains Maughan. "Because it's single-particle, you're very sensitive to low abundance populations within your sample."

The simplicity and speed of mass photometry make it accessible and efficient. "The user interface is just a coverslip with a little well," Maughan says. "You pipette in 20µL sample and press go; in just over a minute, you have

your data." Most users become proficient within half a day, he adds. "The data analysis is very intuitive as there are no charge components like in mass spec or Native PAGE—it's just the mass distribution of your sample."

An additional advantage of mass photometry is its ability to perform measurements under native conditions. "Unlike an SDS-PAGE gel where you're separating out all the different components of your complex, mass photometry keeps that complex together," points out Maughan. "So you're measuring everything as it is in the buffer."

Unique Applications in Life Sciences

In protein analysis, mass photometry offers advantages that are challenging to achieve with other methods. Maughan notes that one area gaining traction is bi- and multispecific antibodies. Researchers aim to identify stoichiometries under different conditions, such as varying antigen-to-antibody ratios.

"Because we measure mass with good resolution, we're able to differentiate between what's bound to each arm of the antibody," says Maughan. "You can see the unbound antibody, one molecule bound, and then both molecules bound—something that is difficult to achieve with methods such as surface plasmon resonance (SPR)."

Another significant application is in the analysis of adeno-associated viruses (AAVs). "We focus on distinguishing between empty, full, and partially filled AAV populations," Maughan explains. "This works because we measure mass, not size—the viral capsid's size remains constant, but its mass changes with the payload." Mass photometry sets itself apart from SEC-MALS by detecting populations of partially filled AAVs, a capability typically only possible with complex methods such as mass spectrometry or analytical ultracentrifugation (AUC), which are more challenging and costly to use.

"The data analysis is very intuitive as there are no charge components like in mass spec or Native PAGE—it's just the mass distribution of your sample."

The Evolution of Mass Photometry

While this technology has demonstrated utility in various applications, ongoing work aims to further expand its capabilities. Maughan notes that recent developments are making mass photometry even easier and more efficient to use for specific research needs, such as measuring antibody aggregation. "We just introduced a new software module where rather than results appearing as a mass histogram (which is what a typical mass photometry method will yield), you instead see the ratios between your monomer, dimer, trimer, and larger populations," he explains.

A priority for Refeyn is to broaden the use of mass photometry in GMP-compliant environments and ensure compliance with 21 CFR Part 11 (a regulation for secure electronic records and signatures). "This capability would allow the technology to be used not just in the development of new therapies but also in their manufacture," asserts Maughan. Having already introduced software that enables AAV empty/full analysis in GMP-compliant environments, the company is looking

to bring this capability to other applications in the future. It is also looking at enhancing system throughput, improving automation, and refining specifications such as limit of detection (LOD) and resolution.

"Unlike an SDS-PAGE gel where you're separating out all the different components of your complex, mass photometry keeps that complex together."

Adopting Mass Photometry Methods

For researchers considering integrating mass photometry into their workflows, it's essential to evaluate a few key factors to ensure successful adoption. Maughan advises that a primary consideration is the sample's mass range—mass photometry works best for larger proteins and complexes, typically from 30–50 kilodaltons up to 5–6 megadaltons.

Another important consideration is sample concentration. Because the technique operates in the nanomolar range, you'll often need to dilute your samples more than you might with other methods, which can impact complexes with low affinities. That said, there is a product available that enables rapid dilution while maintaining measurement accuracy for low-affinity complexes.

Additionally, it's essential to be mindful of your buffers and sample cleanliness, as the sensitivity of mass photometry can reveal unexpected particulates that may interfere with results. Using clean buffers is crucial to avoid unwanted artifacts.

Maughan also notes that mass photometry offers some key advantages when used as an orthogonal technique, for example, in place of AUC alongside SEC-MALS. Because mass can provide valuable information in many contexts, mass photometry can be used in many ways. It's particularly suitable when there is a need for rapid, cost-effective assessments without the effort of labeling or other sample preparation.

Looking Ahead

By allowing researchers to study biomolecules in their native state without modification, mass photometry provides a powerful tool for understanding molecular composition, aggregation, and binding. This unique capability continues to pave the way for breakthroughs across fields such as structural biology, drug development, and beyond.

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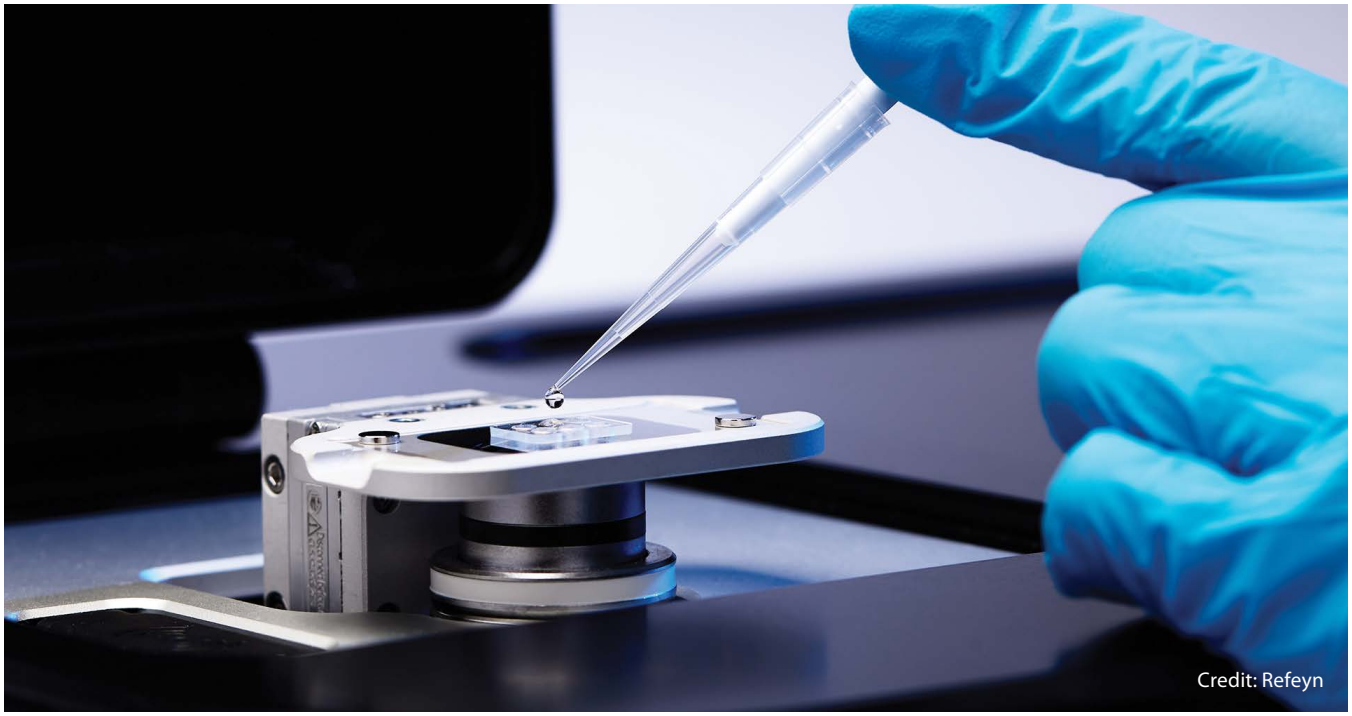

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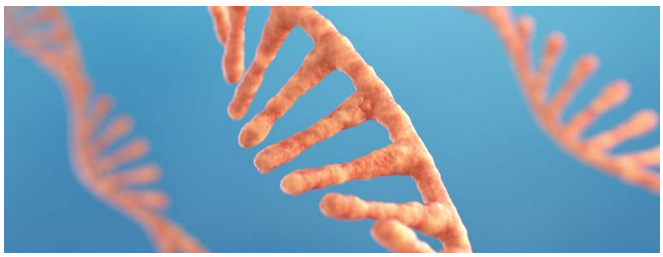
SUMMIT NANOTECH

Empowering Tomorrow's Therapeutics with LC-MS Capillary Chromatography

This presentation emphasizes the significance of capillary HPLC coupled with mass spectrometry. The first part discusses Merck's Lipidomics Analytical Platform for mRNA Lipid Nanoparticle (LNP) Innovation, aiming to study LNP metabolization and predict metabolites for regulatory approval of LNP-based therapeutics. The second part focuses on the use of liquid chromatography-mass spectrometry (LC-MS) as a powerful tool for studying organoids and organ-on-chip (OoC) models.



By watching the presentation, you will learn:

- How to develop sensitive and selective LC-MS analysis of organoids
- How to tailor sample preparation procedures to fit the uniqueness of such biosamples
- How to proceed with method validation

VIEW THE ON-DEMAND PRESENTATION

MERCK

The life science business of Merck KGaA, Darmstadt, Germany operates as MilliporeSigma in the U.S. and Canada.

For further information about our names in the US, Canada and internationally, please refer to our disclaimer at emdgroup.com.

Advanced GC–MS Techniques in Polymer Chemistry

Regulatory pressure and consumer awareness have increased the focus on reducing chemical emissions from materials, which has subsequently become a critical area of research and innovation for the polymer industry. With growing attention on environmental sustainability and public health, manufacturers are compelled to address the emissions of volatile organic compounds (VOCs) and other chemicals released during the production and lifecycle of polymer-based products. This presentation examines the latest trends and technologies in sampling and analysis of material emissions in the polymer industry.

By viewing this presentation, you will:

- Discover the challenges involved in the analysis of VOCs from polymers
- Learn how TD–GC–MS can improve the detection of trace compounds, including odorants
- Explore real-world examples of emissions considerations applied to polymers

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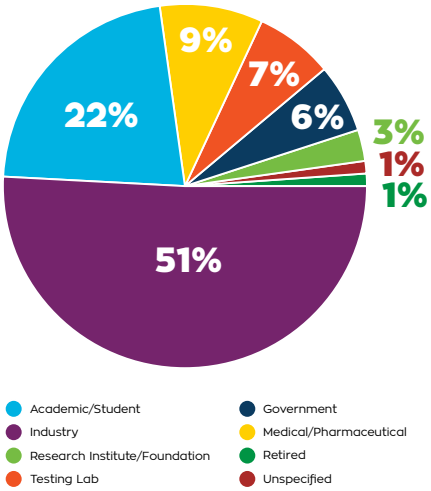
Field of Employment



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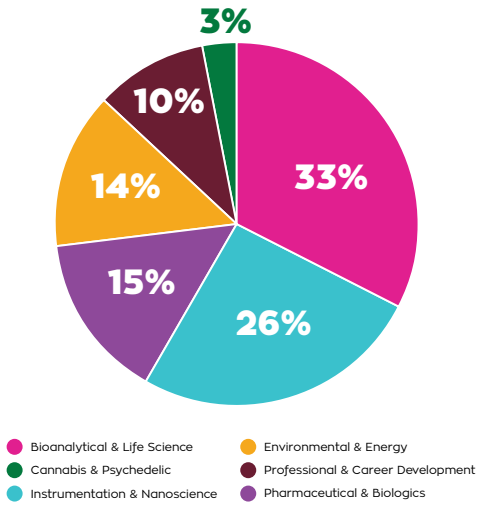
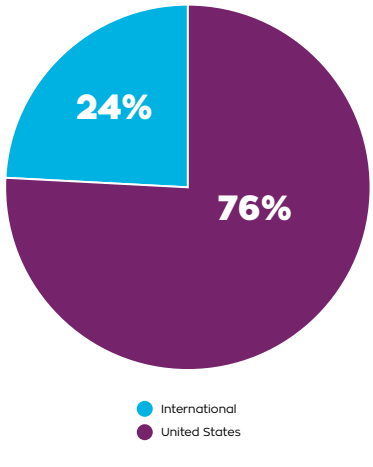


U.S. vs International



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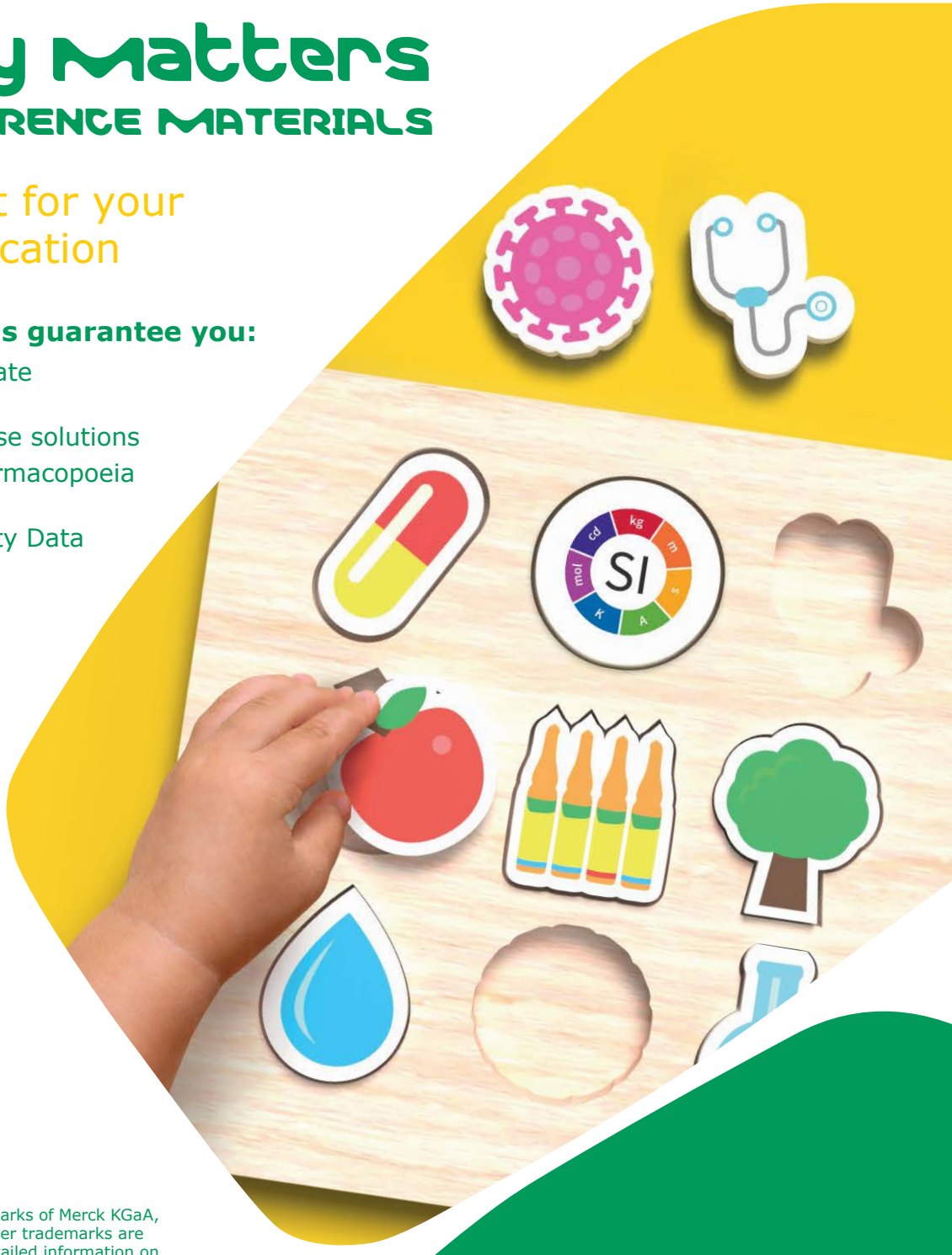

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