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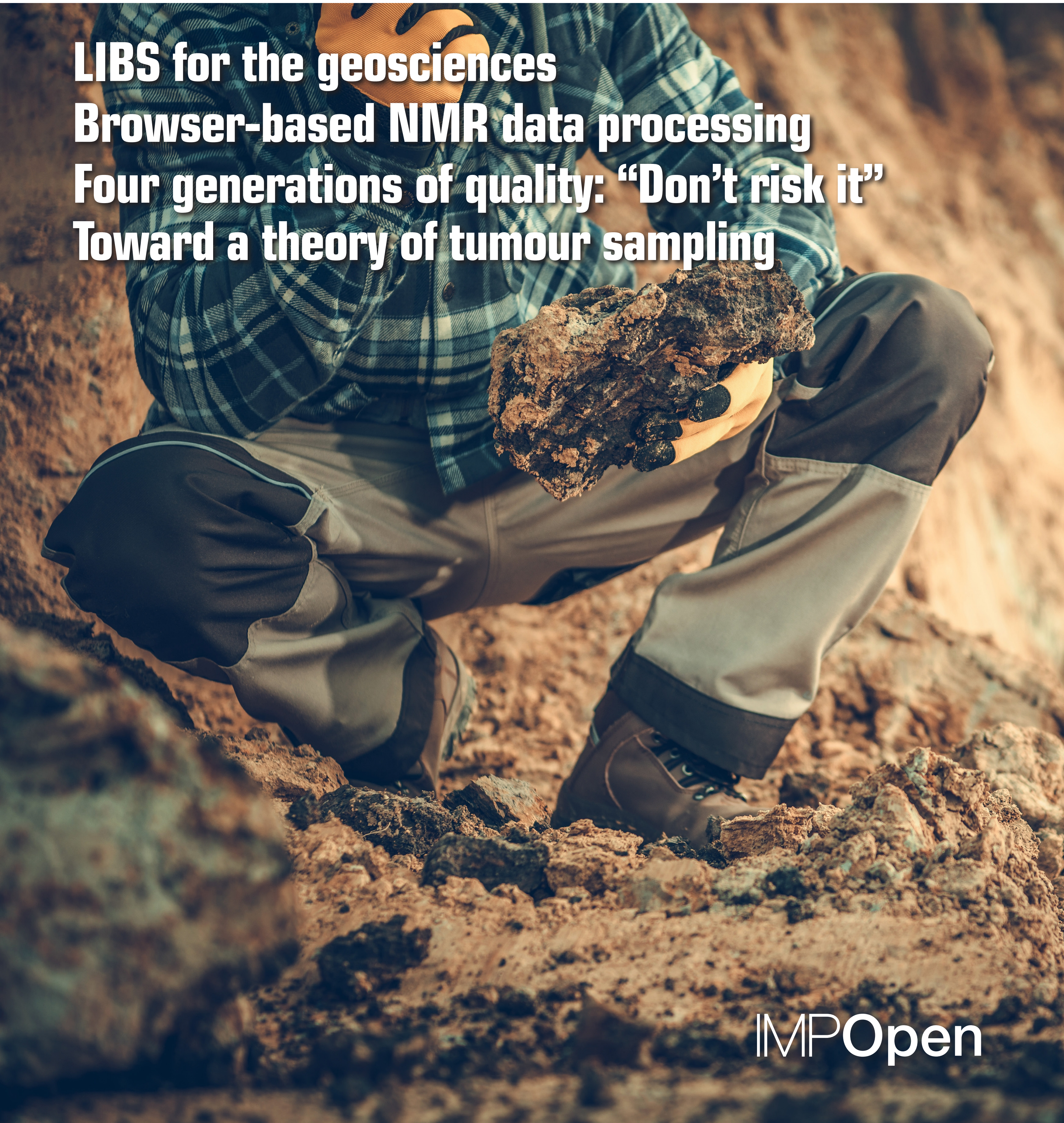
SPECTROSCOPY europe

Spectroscopy since 1975



LIBS for the geosciences

Browser-based NMR data processing

Four generations of quality: "Don't risk it"

Toward a theory of tumour sampling

IMPOpen

Laser-induced breakdown spectroscopy (LIBS) has proved to be a unique analytical tool for use in the geosciences. Find out why in the article starting on page 15.

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CONTENTS

Spectroscopy Europe is a digital magazine, published eight times a year and available free-of-charge to qualifying individuals in Europe and the Middle East.

IMPOpen

EDITORIAL

I normally start my overview of each issue with the first article and work to the last column. This time I am starting at the end, with the Sampling Column. Column Editor, Kim Esbensen, is very excited about this contribution and I hope you will quickly see why when you read it.

Many of you will be working in the cancer field, whether in diagnosis or research, in which case you will be very interested in this issue's Sampling Column. Even if this is not your field of work, you will be interested from a personal point of view! "Theory of Sampling application: toward a theory of tumour sampling" by Nelson Alexander of Roche Diagnostic Solutions presents a fascinating idea and solution to improving the identification of different parts of a tumour and, thus, to provide better personalised treatment. "*… in solid tumour oncology, representative sampling is truly a matter of life or death…*"

Returning to the first article, in which Giorgio Senesi and Russell Harmon tell us about "Laser-induced breakdown spectroscopy: a unique analytical tool for the geosciences". Whether it is looking at geological samples to exploit potential mineral deposits, identifying the provenance of gemstones or exploring the surface of Mars, LIBS has proven to be a valuable technique. The ability to take the instrument into the field with the development of handheld spectrometers has only enhanced its utility.

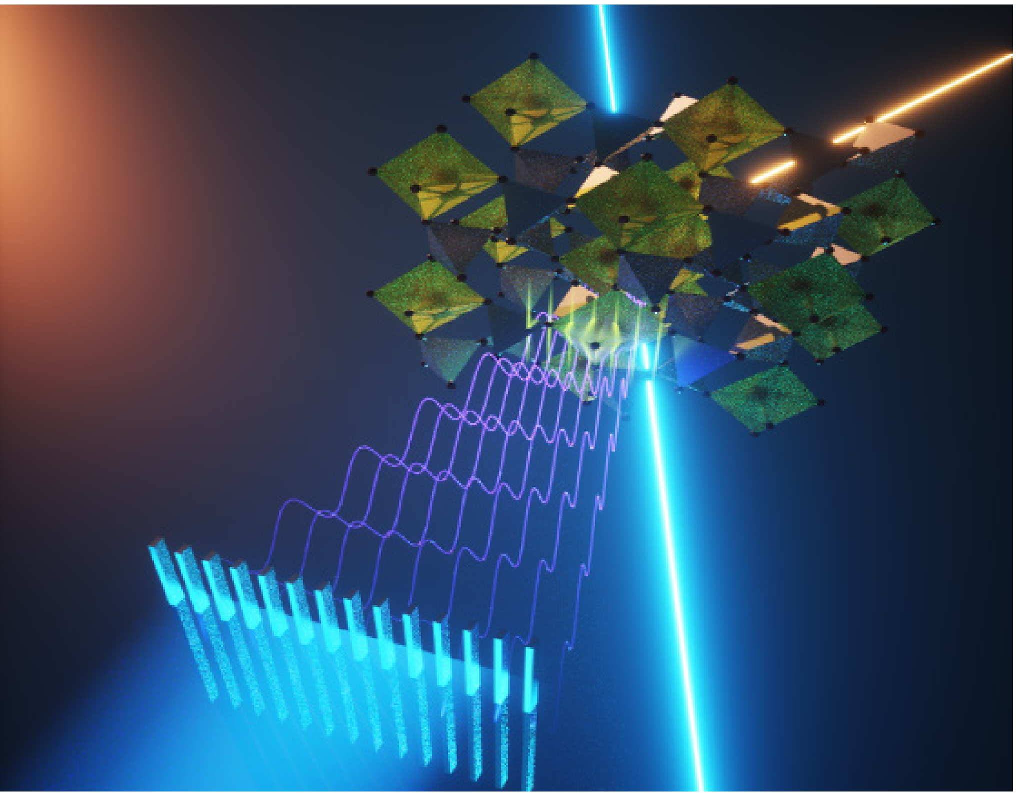
In his Column, Tony Davies, with the help of Luc Patiny, introduces us to a free online NMR data processing tool in "NMRium browser-based nuclear magnetic resonance data processing". They run through the background to the project, how it works and how you can try it yourself. There is a video introduction and an online demo page where you can play with different scenarios.

John Hammond continues his journey through four generations of quality with "'Don't risk it'. Accreditation standards and their role in quality assurance". John reviews the two main ISO 17000 series accreditation standards—ISO/IEC 170251 and ISO 17034—their impact on quality assurance, testing or calibration laboratories, and how these standards have evolved and continue to be implemented.

As usual we start with a selection of News stories on significant new research in and fascinating applications of spectroscopy. There is also news of three important anniversaries for UK companies involved in the spectroscopy market: Applied Photophysics and Specac are both celebrating 50th anniversaries and Starna Scientific have achieved 20 years of accreditation to ISO/IEC 17025.

Ian Michael

NEWS



A pulsed beam of X-rays is incident on a diamond mask (blue), creating a grating of excitation on the sample. A laser beam (thin blue line on the right) is diffracted by the transient grating in the sample, and the diffracted beam (yellow line) is recorded as a function of time, with respect to the initial X-ray beam pulse. Credit: Ella Maru Studio (https://scientific-illustrations.com)

Transport grating spectroscopy at the nanoscale

Transient grating spectroscopy is an elegant method that uses two laser pulses to activate a medium by creating an interference pattern made of parallel stripes of excitations that can be thermal, electronic, magnetic or even structural. The modulation depth of the pattern and its evolution can be measured by diffracting a third, time-delayed probe beam on the transient grating.

The modulation depth decays as the initial excitation propagates through the material. The distance between the stripes is determined by the wavelength of the pulses used to create the grating, which in the visible-ultraviolet part of the spectrum, is in the order of hundreds of nanometres.

Transient grating spectroscopy is a powerful tool for monitoring the transport properties of a material, be it heat, electric or magnetic flux, or structure. At a time of miniaturisation of devices, the need to reach the regime of nanoscale transport is ever more pressing. Transport properties at the nanometre scale are completely unknown, and are expected to greatly differ from those at the micrometre or larger scales. This calls for the use of short wavelength radiation, and in particular X-rays. The main challenge is to cross two X-ray beams in order to generate a grating with nanometre step size.

Now, an international team of scientists have exploited the so-called Talbot effect to create the interference pattern with hard X-ray beams at a sub-nanometre wavelength (0.17 nm). The collaboration includes the LSU and LACUS (Majed Chergui) at EPFL, the PSI (Cris Svetina), the MIT (Keith Nelson), the FERMI free electron laser in Trieste (Claudio Masciovecchio), the Université Jean-Monnet-Saint-Étienne (Jérémy Rouxel) and the European Laboratory for Non-Linear Spectroscopy in Florence (Renato Torre), among others. The scientists used the Swiss X-ray Free Electron Laser (SwissFEL) at PSI.

The results have been published in *Nature Photonics* (doi.org/gc94), showing that the transient excitation grating decays in tens of femtoseconds to picoseconds, revealing the material's phonon response. The researchers probed the grating using an optical pulse at 400 nm. This is the first demonstration of hard X-ray transient grating spectroscopy, which opens the way to exciting and novel developments.

"Hard X-ray transient grating is uniquely suited for investigating nanoscale transport phenomena in bulk and nanostructured materials, disordered materials, and even in liquids", said Majed Chergui. "Future experiments can open the field to applications in the characterisation of materials, especially for nano-electronics, nano-optics and nano-magnetism."

Spectroscopy "saves" Picasso paintings

In the summer of 1917 in Barcelona, Picasso worked on four paintings inspired by Ballets Russes, using a similar set of material for all of them, including seven pigments, drying oils, animal glue and canvas. The four paintings remained in Picasso's family home until 1970 when they were donated to the Museu Picasso in Barcelona.

A century after it was created, the painting *Hombre sentado* (Seated man) seemed to be in precarious conservation conditions which were worse than the other three paintings in the series. Experts observed numerous superficial cracks and the museum decided to restore the painting, but it wanted to understand why such similar paintings, which had been stored in similar conditions for a century, were so different.

The work was undertaken by an international, multidisciplinary team of conservation scientists, which included Francesca Izzo, a researcher in Sciences and Technologies for the Conservation of Cultural Heritage at Ca' Foscari University of Venice. The project ProMeSA (Study of the mechanical and

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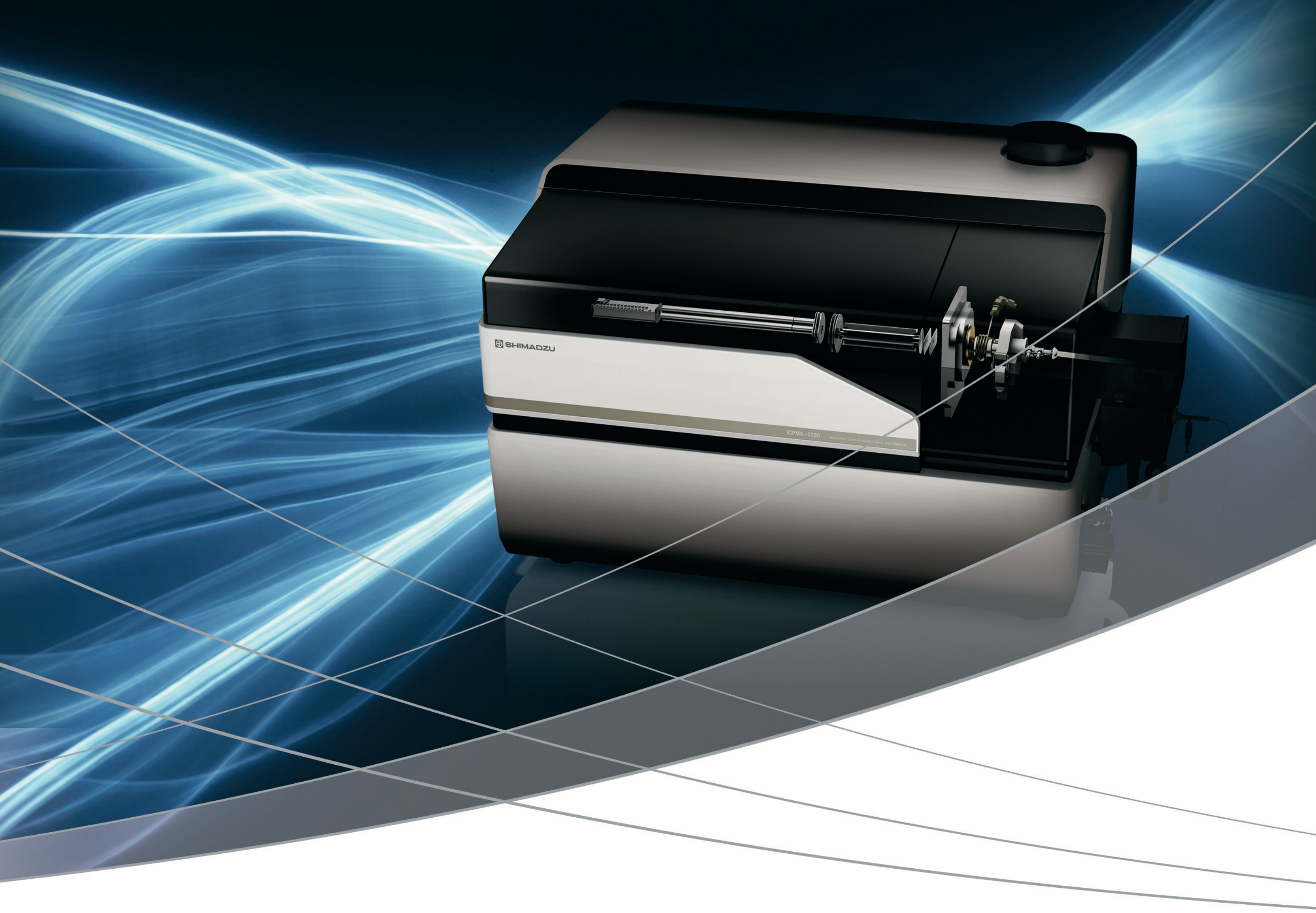

Outstanding sensitivity meets high efficiency

The ICPMS-2030 Inductively Coupled Plasma Mass Spectrometer supports an extensive range of analysis from trace levels to high concentrations. It is ideal for the elemental analysis of sample solutions, in particular where the lowest detection limits are demanded.

Two assistant functions simplify analysis
by providing results with exceptionally high reliability

Designed for high stability, high sensitivity and low interference
based on an optimized internal structure

Unique Mini-Torch plasma unit results in low running costs
through reduced gas consumption

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dimensional properties of commercial paint films), coordinated by Laura Fuster-López, professor of Conservation at the Universitat Politècnica de València, has recently been completed and the results published in *SN Applied Sciences* (doi.org/gdcv).

"The project focused on the combined study of chemical composition and of the physical–mechanical degradation processes that characterise modern and contemporary artwork", says Laura Fuster-López. "Because not all problems share a common cause, and given that artwork silently and constantly degrades, even in controlled environmental conditions, researchers need to understand which inherent properties in the materials used by artists can be at the root of their instability over time, in order to adopt preventive measures for the conservation of our collections."

The four 1917 Picasso paintings became the testing ground for researchers to explore the correlation between the material used by the artist and their conditions. The adoption of a multi-analytical approach using XRF, fibre optic reflectance spectroscopy in the 350–2200 nm range, GC-MS and FT-IR spectroscopy enabled the scientists to study every layer of the painting and to obtain information that was invisible to the naked eye. The outcome of this research is the first study that analyses the issues of mechanical degradation of Picasso's paintings with a scientific, analytical and diagnostic approach.

Francesca Izzo, who is an expert on artistic painting of the 20th and 21st centuries, focused on the exploration of the paint layers and the ground layer. "The analyses we conducted show that Picasso used oil paints, which contained both traditional linseed oil and less drying oils, such as safflower and sunflower oils", says Izzo. "Furthermore, in one case we believe that the artist experimented with the use of semi-synthetic paint that was not yet common in 1917. Picasso painted on cotton canvas and applied two ground layers: the first was obtained with animal glue and the second with drying oil. In both cases, various pigments were mixed in (such as white lead, barite, zinc). Moreover, it is interesting to note the presence of so-called 'metal soaps'—compounds that originate when the binder interacts with some ions released by the pigments. Metal soaps can cause clearly visible damage, both on an aesthetic level and in terms of chemical and mechanical stability."


Pablo Picasso, *Seated Man*, Barcelona, June–November 1917. Oil on canvas 104 × 54 cm, Museu Picasso, Barcelona. Gift of Pablo Picasso, 1970, MPB 110.005, Museu Picasso, Barcelona. Photo: Gasull Fotografia

The results obtained have been combined with the visual examination of cracks and mechanical problems, in order to develop hypotheses on the differences in degradation among the four paintings. This is one of the first situations in which researchers have adopted a non-invasive documentation approach and observations of mechanical damage to gain insight into the possible contribution of each layer to the degradation observed.

The interaction of pigments and binders may have made paint films more or less subject to degradation. The same has been observed in the layers beneath the paint film: differences in paint thickness, varying pigment–binder interactions and other minor differences may have caused different reactions to similar environmental conditions. The study of this case has given rise to new questions and ideas for further research. Scientists are trying to understand the impact of the possible "migration" of material between the paint layers and the ground layer.

Thanks to these new results, Reyes Jiménez de Garnica, Head of the Department of Preventive Conservation and Restoration of the Museu Picasso in Barcelona, will be able to refine the strategies for preventive conservation and assessment of the conservation conditions (in particular of humidity) and exposure of the artwork.

MS of rare earth elements used to learn about prehistoric human activity

The research group led by Gianni Gallello, from the Department of Prehistory, Archaeology and Ancient History of the University of Valencia, has used the analysis of rare earth elements by mass spectrometry for the first time to find human activity in a prehistoric cave. Through the analysis of the archaeological strata, with chemical methods, it has been possible to interpret the occupation and uses of the Cocina Cave (Dos Aguas). Previously, the Department of Analytical Chemistry (ArchaeChemis) group tested it in deposits in Ethiopia and Tanzania.

Rare earth elements are common chemical elements in the Earth's crust whose importance as a strategic resource has been growing in recent years, since they are essential for the development of new technologies. Gianni Gallello specialises in the analysis of the use of rare soils as an indicator of human activity. A multidisciplinary team led by Gallello, made up of researchers from the Department of Prehistory, Archaeology and Ancient History and ArchaeChemis, together with specialists from the British Geological Survey and the University of California (Santa Barbara), has used for the first time the analysis of these elements to study human activity in a prehistoric site.

Gathering samples

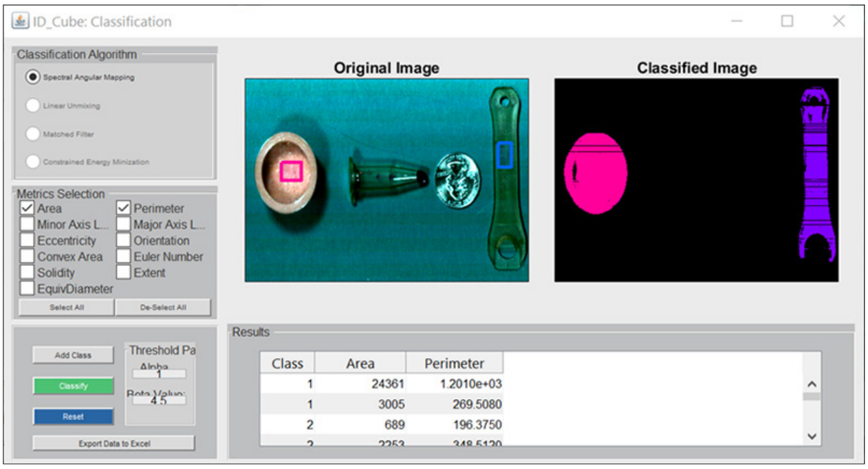
"To determine these elements, mass spectrometry has been used from samples taken from archaeological sediments, digested with an acid solution, to later be able to study their proportions and concentrations," explains Gallello. This analysis in archaeological deposits has been developed by the ArchaeChemis multidisciplinary unit over the last 10 years and has been tested in Ethiopia, Tanzania or the Vall del Serpis (Alicante).

The new study, reported in *Boreas* (doi.org/gdc2), addresses information from a prehistoric site, Cocina Cave (Dos Aguas), recently excavated by the University of Valencia and the SIP (Museum of Prehistory of València) under the direction of Oreto García Puchol, Sarah McClure and Joaquim Juan Cabanilles. The long sequence of human presence (8500–4000 BC) includes mainly evidence of activities related to hunting, gathering and ranching.

"In this study, rare soil elements and stratigraphic information were used together with other archaeological markers. Thus, the concentrations and proportions of these elements are very consistent with the archaeological interpretation. Our studies show that lands can be very useful in identifying whether the formation of soils or archaeological strata is related to natural processes or anthropic activities," said Gianni Gallello.

Free hyperspectral software

Multi- and hyperspectral imaging modalities encompass a growing number of spectral techniques that find many applications in geospatial, biomedical, machine vision and other fields. The rapidly increasing number of applications requires convenient easy-to-navigate software that can be used by new and experienced users to analyse data, and develop, apply and deploy novel algorithms. In a paper in *Journal of Spectral Imaging* (doi.org/gdcw), the authors present their software platform, IDCube Lite, an Interactive Discovery Cube that performs essential operations in hyperspectral data analysis to realise the full potential of spectral imaging. The strength of the software lies in its interactive features that enable the users to optimise parameters and obtain visual input for the user in a way not previously accessible with other software packages. The software can be operated without any prior programming skills allowing interactive sessions of raw and processed data. IDCube Lite, a free version of the software described in the paper, has many benefits compared to existing packages and offers structural flexibility to discover new, hidden features that allow users to integrate novel computational methods.



ID_Cube: Classification

Classification Algorithm

● Spectral Angular Mapping

○ Linear Unmixing

○ Matched Filter

○ Constrained Energy Minization

Metrics Selection

☑ Area
☐ Minor Axis L...
☐ Eccentricity
☐ Convex Area
☐ Solidity
☐ EquivDiameter
☑ Perimeter
☐ Major Axis L...
☐ Orientation
☐ Euler Number
☐ Extent

Threshold Pa

Alpha 1

Beta Value: 4.5

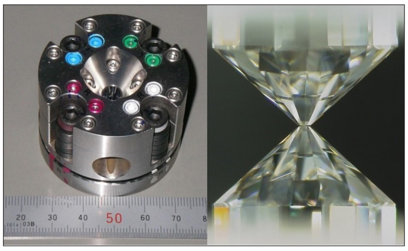
Results

Class	Area	Perimeter
1	24361	1.2010e+03
1	3005	269.5080
2	689	196.3750
2	2253	348.5120

SIMS imaging provides information about the Earth's core

High-temperature and high-pressure experiments involving secondary ion mass spectrometry (SIMS) imaging, a diamond anvil and chemicals to simulate the core of the young Earth demonstrate for the first time that hydrogen can bond strongly with iron in extreme conditions. This explains the presence of significant amounts of hydrogen in the Earth's core that arrived as water from bombardments billions of years ago.

Given the extreme depths, temperatures and pressures involved, we are not physically able to probe very far into the Earth directly. So, in order to peer deep inside the Earth, researchers



Diamond anvil. The outer metal casing and inner diamond teeth of the high-pressure anvil. © 2021 Hirose *et al.*

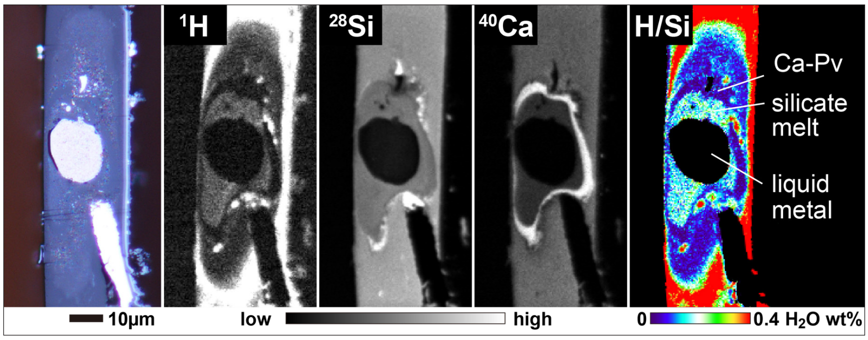
use techniques involving seismic data to ascertain things like composition and density of subterranean material. Something that has stood out for as long as these kinds of measurements have been taking place is that the core is primarily made of iron, but its density, in particular that of the liquid part, is lower than expected.

This led researchers to believe there must be an abundance of light elements alongside the iron. For the first time, researchers have examined the behaviour of water in laboratory experiments involving metallic iron and silicate compounds that accurately simulate the metal–silicate (core–mantle) reactions during Earth's formation. They found that when water meets iron, the majority of the hydrogen dissolves into the metal while the oxygen reacts with iron and goes into the silicate materials.

"At the temperatures and pressures we are used to on the surface, hydrogen does not bond with iron, but we wondered if it were possible under more extreme conditions", said Shoh Tagawa, a PhD student at the Department of Earth and Planetary Science at the University of Tokyo during the study. "Such extreme temperatures and pressures are not easy to reproduce, and the best way to achieve them in the lab was to use an anvil made of diamond. This can impart pressures of 30–60 GPa in temperatures of 3100–4600 K. This is a good simulation of the Earth's core formation."

The team, under Professor Kei Hirose, used metal and water-bearing silicate analogous to those found in the Earth's core and mantle, respectively, and compressed them in the diamond anvil whilst simultaneously heating the sample with a laser. To see what was going on in the sample, they used high-resolution SIMS imaging. This allowed them to confirm their hypothesis that hydrogen bonds with iron, which explains the apparent lack of ocean water. Hydrogen is said to be iron-loving, or siderophile. They reported their work in *Nature Communications* (doi.org/gdcx).

"This finding allows us to explore something that affects us in quite a profound way", said Hirose. "That hydrogen is siderophile under high pressure tells us that much of the water that came to Earth in mass bombardments during its formation might be in the core as hydrogen today. We estimate there might be as much as 70 oceans' worth of hydrogen locked away down there. Had this remained on the surface as water, the Earth may never have known land, and life as we know it would never have evolved."



Sample from high-pressure experiment. High-resolution chemical analyses with secondary ion mass spectrometry showed the abundance of water left in silicate melt after compressing with liquid iron metal. © 2021 Tagawa *et al.*

Company News

Sensirion acquires IR spectrometer company IRsweep

Sensirion Holding AG has completed the acquisition of IRsweep AG, based in Stäfa, Switzerland, which develops, manufactures and supplies optical spectroscopy solutions based on semiconductor quantum cascade laser (QCL) frequency comb technology in the mid-infrared. Sensirion has been a minority investor of IRsweep with 33 % of the shares since 2017. With this acquisition, Sensirion expands its optical sensing technology portfolio from components and modules to stand-alone infrared spectrometers for industrial and research applications. Many spectroscopic applications in industry and research simultaneously require high spectral resolution and speed. IRsweep's infrared spectrometers based on its QCL frequency comb technology allow the study of fast processes very accurately, such as protein dynamics or industrial reaction monitoring, without the need for moving parts.

Shimadzu has received two design awards

Shimadzu has received two design awards: a "Red Dot: Best of the Best Award 2021" in the product design category for the MALDImini-1 and a Red Dot Design Award 2021 in the product design category for the iMScope QT, which will soon be available on the European market.

The Red Dot Design Award has a history of more than 60 years and appraises the best products created every year. Alongside the German iF Award and the US IDEA Award, it is one of the three major design awards in the world.

New China production facility for Hitachi High-Tech

Hitachi High-Tech Analytical Science has opened a new high-tech manufacturing

THz spectroscopy diagnosis of thyroid tumours

Researchers from 10 research centres in Russia have developed a new approach to diagnosing thyroid tumours, based on terahertz (THz) spectroscopy of a blood sample. "The methods currently used to diagnose thyroid tumours are either complicated or not accurate enough", explains Yuri Kistenev, head of the Tomsk State University (TSU) Laboratory of Biophotonics and executive director of the TSU Institute of Biomedicine. "Our approach involves the analysis of molecular markers of blood by THz spectroscopy and machine learning."

Diagnostic markers in blood and analysis of the spectral data were carried out by several research teams in Moscow. "We, in turn, focused on creating methods of analysis using artificial intelligence", says Yuri Kistenev. "We analysed the data obtained by our colleagues and used this information for machine learning. We have developed a variant of ensemble learning, its essence is in a combination of several algorithms that simultaneously learn and correct each other's mistakes. This approach gives significantly better results than each algorithm separately. In this case, this made it possible not only to teach artificial intelligence to establish the presence or absence of a tumour but also to determine whether it is malignant or not."

According to Yuri Kistenev, histology remains the "gold standard" for diagnosing neoplasms, but the new method can be used as an auxiliary tool that helps to quickly establish the nature of the problem and determine the further strategy for examining the patient. The work was published in *Biomedical Optics Express* (doi.org/gdc3).

Discovery of huge Raman scattering at atomic point contact

Nanofabrication of electronic devices has reached the scale of a single nanometre. The rapid advancement of nanoscience and nanotechnology now requires atomic-scale optical spectroscopy in order to characterise atomic-level structures that will affect the properties and functions of electronic devices. An international team, headed by Takashi Kumagai at the Institute for Molecular Science, have discovered a huge enhancement of Raman scattering mediated by the formation of an atomic point contact between a plasmonic silver tip and a Si(111)-7 × 7 reconstructed surface. This was achieved by means of state-of-the-art low-temperature tip-enhanced Raman spectroscopy, which allows atomic-scale vibrational spectroscopy to be conducted. They published their results in *Nano Letters* (doi.org/gdc4).

The research team applied state-of-the-art low-temperature tip-enhanced Raman spectroscopy, developed in collaboration with the Fritz-Haber Institute, to obtain the vibrational spectra

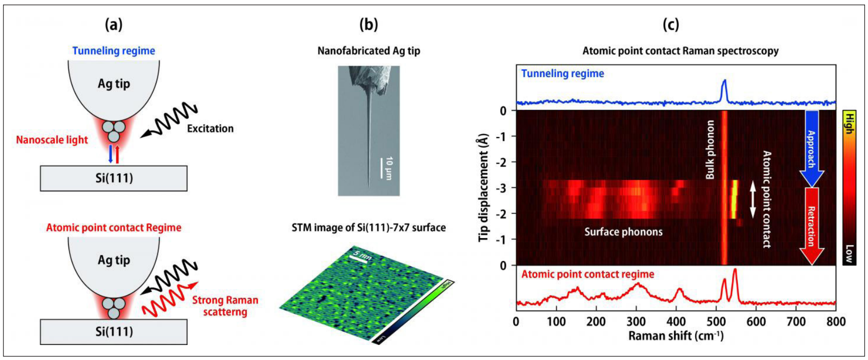


Figure 1. (a) Illustration of the experiment. (b) Scanning electron micrograph of a Ag tip (top) and scanning tunnelling microscopy image of the Si(111)-7 × 7 surface. (c) Atomic point contact Raman spectra. Credit: NINS/IMS

facility in Shanghai, China. The state-of-the-art 4118 m^2 facility in Laigangxin Bay Technology Innovation Park, Minhang District, has been designed to support a rapid upscaling in the development and production of high-tech analysis equipment, to meet increased demand worldwide. The new site combines the company's two existing Shanghai locations into a single facility. As the company's China headquarters, it will support robust demand for analytical equipment from the booming Chinese industrial sector, as well as supplying companies worldwide.

MKS Instruments acquires Photon Control

MKS Instruments, Inc. has entered into a definitive agreement to acquire Photon Control Inc. for CAD$3.60 per share, in an all-cash transaction valued at approximately CAD$387 million.

The transaction has been approved by the MKS and Photon Control boards of directors and is subject to customary closing conditions, including approval by Photon Control's securityholders and court approval in the Province of British Columbia, Canada, and is expected to close in the third quarter of 2021.

Hyperspectral imaging company Impact Vision acquired by Apeel

Hyperspectral imaging company Impact Vision has been acquired by Apeel Sciences. Apeel produce a range of plant-based coatings that are used to extend the shelf life of fruit and vegetables. The acquisition will enable Apeel to integrate hyperspectral imaging technology into their supply chains, providing new insights to customers, ranging from ripeness prediction to nutritional characteristics.

SCIEX and Waters collaboration

SCIEX are to work with Waters Corporation to offer their customers fully configured and interoperable Waters™ Ultra-Performance Liquid Chromatography (UPLC™) instruments as part of their purchase and deployment of SCIEX mass spectrometry systems. The collaboration makes it easier for customers to choose the most suitable tools for both large and small molecules.

SCIEX and Waters developed instrument control drivers that have been tested to ensure compatibility and compliance. These allow SCIEX OS software to directly control Waters ACQUITY™ UPLC I-Class PLUS Systems, as well as the H-Class PLUS, H-Class PLUS Bio and M-Class instruments. SCIEX will support the full customer relationship while Waters will provide direct UPLC service and support.

Agilent LC/MS instruments earn sustainability recognition

Agilent Technologies has announced that both their InfinityLab LC/MSD iQ and the Ultivo Triple Quadrupole LC/MS systems have earned the Accountability, Consistency and Transparency (ACT) label from My Green Lab (a non-profit organisation dedicated to improving the sustainability of scientific research). Agilent say that they are committed to helping labs meet their sustainability goals. In a recent global survey, 87 % of lab managers indicated that sustainability goals are important in running their labs. Additionally, 68 % reported that further work is required to achieve their sustainability goals.

Applied Photophysics celebrates 50 years

Applied Photophysics started in Mayfair, London, in April 1971. An unusual place perhaps for a start-up scientific instrument company, was although explained by the fact that the origins of the company lie within the Royal Institution. The Royal Institution has been at 21 Albemarle Street, Mayfair, since 1799 and conducting scientific research since from a silicon surface. Tip-enhanced Raman spectroscopy employs a strong light–matter interaction between a material and nanoscale light (localised surface plasmon resonance) generated at an atomically sharp metallic tip. The research team discovered that an atomic point contact formation of a silver tip and a reconstructed Si(111)-7 × 7 surface leads to a huge enhancement of Raman scattering. Figure 1a illustrates the experiment. A sharp silver tip fabricated by focused ion beam (Figure 1b, top) is moved toward the silicon surface (Figure 1b, bottom), while monitoring the Raman spectra from the junction. Figure 1c displays the waterfall plot of the obtained Raman spectra, where the horizontal axis is the Raman shift and the colour scale the Raman intensity. When the tip is in the tunnelling regime, only the optical phonon mode of the bulk silicon is observed at 520 cm^{-1}. However, when the atomic point contact between the tip and the surface, the strong Raman scattering from the surface phonon modes suddenly appears. These modes disappear again when the tip is moved away from the surface and the atomic point contact is broken.

The research team further demonstrated that this atomic point contact Raman spectroscopy (APCRS) can resolve the atomic-scale structures of the silicon surface. The Raman spectrum is different when it is recorded at an atomic step of the surface. Furthermore, the characteristic vibrational modes can be observed selectively at the locally oxidised site (Figure 2), indicating the atomic-scale chemical sensitivity of atomic-point-contact Raman spectroscopy.

It was previously thought that a plasmonic nanogap is necessary to obtain ultrahigh sensitivity in tip-enhanced Raman spectroscopy, which typically requires a metal substrate. This imposed a severe limitation on measurable samples. The discovery of the huge Raman enhancement upon the atomic point contact formation will expand the potential of atomic-scale vibrational spectroscopy, which is applicable to non-plasmonic samples, and the exceptional chemical sensitivity will be obtained for many other materials. In addition, the results also suggest that atomic scale structures may play an indispensable role in metal–semiconductor hybrid nanosystems to affect their optoelectronic properties.

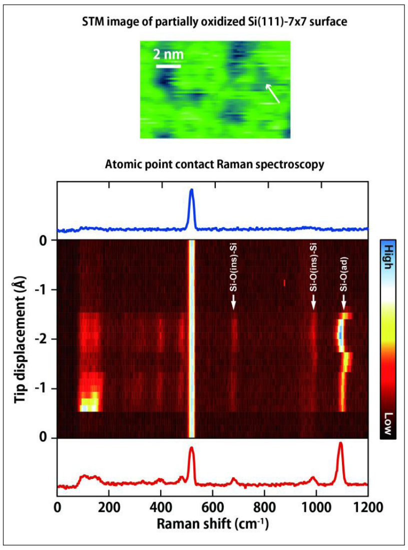


Figure 2. Atomic point contact Raman spectra obtained at a partially oxidised area over the Si(111)-7 × 7 surface (indicated by the arrow in the STM image). Credit: NINS/IMS

ICP-MS to count and identify viruses

A new methodology, which has been adapted from the use of ICP-MS to identify metallic nanoparticles, is able to detect the presence of viruses within just 20 s. The proposed technique, called "Single virus inductively coupled plasma mass spectroscopy" (SV ICP-MS), can be used to quickly determine families of viruses. However, although the concept can identify that someone has a coronavirus, for example, it would not be able to determine the type of coronavirus, or variants. Additional tests would still be required to find out the specific virus someone was infected with.

The idea, developed by Professor Claude Degueldre from Lancaster University's Department of Engineering and published in *Talanta* (doi.org/gdc5), uses diluted samples of fluids, such as nasal mucus or saliva, from patients. Measurements of intensities for selected masses of the elements from the viruses provide rapid results to show the presence of a virus or not. This process works on DNA and RNA virus types within seconds. Another key benefit is the ability to test a large number of samples quickly.

Professor Degueldre said: "What we are proposing here is not a new Covid test but is a new concept to rapidly find out if there are viruses present. This would be useful if people are ill but it is not known if they have a virus or another health condition that is making them sick. This concept would inform the clinical team whether or not there is a virus to inform early treatment actions and other measures such as the need for isolation. More detailed tests would still be required to discover the exact viral infection, but results from these take longer. Another application for the concept is to test water samples from sewage systems or down flow in rivers. The results would enable public health experts to identify areas of cities that have viral outbreaks."

The concept is still at an early stage and further research and experiments are needed to further develop the process.

LIBS of skid marks may identify cars in accidents

Skid marks left by cars are often analysed for their impression patterns, but they often do not provide enough information to identify a specific vehicle. Matthieu Baudelet and his forensics team at the National Center for Forensic Science, University of Central Florida are proposing the use of laser-induced breakdown spectroscopy (LIBS) to collect evidence from those skid marks.

"Tyre evidence is often overlooked in forensics", says Baudelet. "In cases of hit and runs or accidents involving multiple cars the chemical signature of the tires have the potential to be integral information to the investigation."

Baudelet and his graduate student, John Lucchi, started testing their idea by recreating skid marks in the laboratory using road materials like concrete and asphalt. By pressing a tyre into the surface at the same velocity as a moving vehicle, a braking impression is made on the laboratory-controlled "road" from the tyre. This in turn gives the team a chance to analyse the chemical composition of the tyre and the road material and make chemical comparisons.

Every tyre is expected to have its own chemical signature and, as such, a unique, corresponding skid mark. One current challenge is identifying how elements on the road like oil, rainwater

The University of Central Florida team used LIBS on tyre samples. Credit: University of Central Florida/Karen Norum

Humphrey Davy became director in 1801. Many eminent scientists have been involved in the Royal Institution ever since then, most famously Michael Faraday who, with Davy, gave his name to the Davy Faraday Research Laboratory (DFRL) established in the building next door (20 Albemarle Street).

In 1966 George Porter (George, Baron Porter of Luddenham) moved from Sheffield University to the Royal Institution and moved his research into early uses of lasers for laser flash photolysis analysis of fast reactions to the DFRL. A year later he was awarded a Nobel Prize in chemistry for his work. There was a demand in the scientific community for instruments based on Porter's research. With most of the research equipment in Porter's lab being made in the DFRL workshops, a small cottage industry began selling this equipment to other research labs. This became formalised into the Applied Photophysics Limited company in 1971.

Applied Photophysics stayed in the Royal Institution throughout the seventies, looking at several different commercial applications of laser spectroscopy, not just laser flash photolysis. This included some of the earliest commercial laser Raman spectrometers. The company moved out in the 1980s to the east end of London and then eventually to their current home in Leatherhead, Surrey, south-west of London. Throughout our history, there has been a common thread of fast chemical kinetics and spectroscopy. In the early 1990s they branched out from laser flash photolysis into stopped-flow spectroscopy, and in the late 1990s they started developing circular dichroism stopped-flow instruments.

Specac's 50th anniversary

Specac celebrate their 50th anniversary on 21 April 2021. Congratulations to them on their half-century, and the range of spectroscopic accessories and sample preparation equipment they have designed and manufactured over those 50 years.

and other cars interfere and change that signature. Baudelet says the National Center for Forensic Science has been working on overcoming these interference challenges with other evidence for years.

Now that the process shows promise, the team will focus on establishing statistical reliability. Currently, using principal component analysis combined with linear discriminant analysis, a classification accuracy close to 99 % has been found. Standards for police evidence are justifiably high, so next steps involve reproducible, dependable protocols, Baudelet says. Ultimately, he would like to know his team's work provided justice and closure to cases of hit-and-run and vehicle violence.

"We're still working but so far we've made a lot of progress", Baudelet says. "I feel that this can be a great supplementation to the methods currently being used in forensics and law enforcement."

They published their work in *Applied Spectroscopy* (doi.org/gdc6).

WITec Paper Award 2021 recognises three outstanding publications

Three scientific publications have been recognised by the WITec Paper Award, an annual competition among peer-reviewed articles from the previous year that feature results acquired with a WITec microscope. The exceptional quality of the 115 submitted publications made it particularly challenging to select only three winners. The Paper Awards for 2021 go to researchers from the UK, Turkey and the USA who performed Raman imaging measurements on zebrafish embryos, meteorites and jet engine thermal barrier coatings, respectively. WITec congratulated the winners and thanked all the participants.

Full details of the winners and their papers can be found at https://bit.ly/344opvW.

Enter the WITec Paper Award 2022

WITec invites scientists from all fields of application to participate in the 2022 Paper Award competition (www.witec.de/paper-award). Articles are eligible if they were published in 2021 in a peer-reviewed journal and feature results (at least partially) obtained with a WITec instrument. Submit your work as a PDF to papers@witec.de before 31 January 2022.

New ISO committee for reference materials

The need for accurate measurement results that are comparable between laboratories anywhere in the world has never been greater. To achieve this, one needs metrologically traceable reference materials for use in the calibration and validation of measurement methods—certified reference materials (CRMs). Reference materials in general also play an important part in other aspects of quality assurance in testing, and a new ISO technical committee in this field has just been formed.

ISO/TC 334, Reference materials, will develop standards related to the competent production and use of reference materials, including the concepts, performance characteristics, terms and definitions related to reference materials. It replaces a former ISO committee known as ISO/REMCO, building on its existing work and developing new ISO deliverables for the future.

These include, as examples, ISO Guide 30:2015 (under revision), *Reference materials – Selected terms and definitions*, ISO Guide 33:2015, *Reference materials – Good practice in using reference materials* and ISO Guide 35:2017, *Reference materials – Guidance for characterization and assessment of homogeneity and stability*.

New documents in development are ISO Guide 86.2, *Guidance for pure reference materials for small organic molecules*, and ISO Guide 87, *Guidance for "pure" reference materials for metals and metalloids*.

The committee consists of experts in a range of diverse fields from nearly 40 countries. Anyone interested in getting involved should contact their national ISO member. The secretariat of ISO/TC 334 is held by SABS, the ISO member for South Africa.

Quality Matters Column Editor comments: "Whilst essentially the structure of TC 334 will 'mirror' that of ISO/REMCO, the significant change is that TC 334 (as a Technical Committee of ISO) will have the capability and be tasked with producing appropriate ISO standards relating to the production, certification and use of reference materials."

You may also be interested in John's recent column article on ISO, Four generations of quality: International Standards Organization (ISO) (https://bit.ly/3vasjz7).

NMR helps understand COVID-19 mutations

When the SARS-CoV-2 virus mutates, this initially only means that there is a change in its genetic blueprint. The mutation may lead, for example, to an amino acid being exchanged at a particular site in a viral protein. In order to quickly assess the effect of this change, a three-dimensional image of the viral protein is extremely helpful. This is because it shows whether the switch in amino acid has consequences for the function of the protein—or for the interaction with a potential drug or antibody.

Researchers at Goethe University Frankfurt and TU Darmstadt began networking internationally from the very start of the pandemic. Their goal was to describe the three-dimensional structures of SARS-CoV-2 molecules using nuclear magnetic resonance (NMR) spectroscopy. NMR can be used to look in detail and with high throughput at how potentially active compounds bind to viral proteins. This is done at the Centre for Biomolecular Magnetic Resonance (BMRZ) at Goethe University and other locations. However, the basic prerequisite is to produce large quantities of the proteins in high purity and stability, and with their correct folding, for the large amount of tests.

The network, coordinated by Professor Harald Schwalbe from the Institute of Organic Chemistry and Chemical Biology at Goethe University, spans the globe. The elaboration of laboratory protocols for the production of proteins is already the second milestone. In addition to proteins, the virus consists of RNA, and the consortium already made all


Scientists Martin Hengesbach (left) and Andreas Schlundt at the NMR spectrometer at Goethe-University Frankfurt, Germany. Photo: Uwe Dettmar for Goethe-University Frankfurt, Germany

important RNA fragments of SARS-CoV-2 accessible last year. With the expertise of 129 colleagues, it has now been possible to produce and purify 23 of the total of almost 30 proteins of SARS-CoV-2 completely or as relevant fragments *in vitro*, and in large amounts.

For this purpose, the genetic information for these proteins was incorporated into small, ring-shaped pieces of DNA (plasmids). These plasmids were then introduced into bacteria for protein production. Some special proteins were also produced in cell-free systems. Whether these proteins were still correctly folded after their isolation and enrichment was confirmed, among other things, by NMR spectroscopy.

Dr Martin Hengesbach from the Institute of Organic Chemistry and Chemical Biology at Goethe University explained: "We have isolated functional units of the SARS-CoV-2 proteins in such a way that their structure, function and interactions can now be characterised by ourselves and others. In doing so, our large consortium provides working protocols that will allow laboratories around the world to work quickly and reproducibly on SARS-CoV-2 proteins and also the mutants to come. Distributing this work from the beginning was one of our most important priorities. In addition to the protocols, we are also making the plasmids freely available."

Dr Andreas Schlundt from the Institute for Molecular Biosciences at Goethe University said: "With our work, we are speeding up the global search for active agents: scientific laboratories equipped for this work do not have to first spend several months establishing and optimising systems for the production and investigation of SARS-CoV-2 proteins, but can now start their research work within two weeks thanks to our elaborated protocols. Given the numerous mutations of SARS-CoV-2 to come, it is particularly important to have access to reliable, rapid and well-established methods for studying the virus in the laboratory. This will, for example, also facilitate research on the so-called helper proteins of SARS-CoV-2, which have remained under-investigated, but which also play a role in the occurrence of mutations."

The work was carried out by members of the COVID-19 NMR Consortium and published in *Frontiers in Molecular Biosciences* (doi.org/gdc7).

Raman spectroscopy could allow early detection of aortic aneurysms

Ascending thoracic aortic aneurisms (aTAAs) occur when the walls of the aorta, the largest blood vessel in the body, weaken and begin to bulge. This can result in rupture or dissection (a tear in the aortic wall), leading to life-threatening bleeding and death. Sometimes these complications can occur before any symptoms of the aneurysm appear. However, an international team led by Hiromi Yanagisawa at the University of Tsukuba and Katja Schenke-Layland at Eberhard Karls University, Tübingen have used Raman microspectroscopy and Raman imaging to identify signatures in the fibres of the aortic wall that indicate the presence of an aneurysm. They published their work in *Cell Reports Medicine* (doi.org/gdc8).

The risk of aTAA is usually assessed by monitoring enlargement of the lumen, the interior space of the aorta. There are no known cardiovascular biomarkers for aortic aneurysms, and changes to the components surrounding the cells (known as the extracellular matrix, or ECM) are not routinely monitored. Changes to the ECM are thought to be involved in the development of aortic aneurysms, because these are commonly seen when there are genetic mutations affecting the ECM. It seems likely that cellular and extracellular (taking place outside of cells) changes to the vessel wall are involved as aneurysms develop.

The research team used both a mouse model of aTAA and human samples to examine the structural and molecular signatures in the aorta. Raman imaging allowed the team to detect changes to the aortic wall that are characteristic of aneurysms. "Specific elastic fibre-derived components and collagen fibre-derived components were significantly increased in aTAA lesions in both mice and humans", say co-lead authors Kaori Sugiyama and Julia Marzi. "These human aneurysm-specific marker signatures in the elastic and collagen fibres can be used as biomarkers for aTAA diagnosis."

These techniques enabled the identification of minor alterations in the ECM structure. This means that this imaging may be used as a diagnostic tool to identify early changes on the aortic wall, known as pre-aneurysmal lesions. Given that, currently, aneurysms can sometimes develop undetected until they cause significant complications, the ability to detect them sooner could save a great many lives.

Starna Scientific celebrates 20 years of accreditation

According to ISO, a fully accredited certified reference material (CRM) supplier should be accredited to both ISO 17034:2016 and ISO/IEC 17025:2017 Standards. Accreditation to ISO/IEC 17025 is a complex and detailed process: Starna achieved this in 2001 and in doing so became the first commercial supplier accredited to calibrate liquid and glass RMs for UV-visible spectrophotometry. In 2006, they became the first and only supplier of spectrophotometry references accredited to both standards.

A particularly important aspect of these accreditations is their Scope, which defines the range of materials that can be produced as CRMs and the measurements that the calibration laboratory is entitled to perform. A laboratory could claim to be "accredited to ISO/IEC 17025" on the strength of just one measurement, so users should satisfy themselves that a proposed supplier's Schedule of Accreditation includes the references they intend to purchase.

Furthermore, it is now recommended that instrument qualification measurements are conducted over the operational range required for the analysis. A laboratory performing measurements over a wide wavelength or photometric range will likely require several different CRMs to cover each instrument parameter.

A CRM is defined by ISO as a "Reference Material, characterised by a metrologically valid procedure for one or more specified properties, accompanied by a certificate that provides the value of the specified property, its associated uncertainty, and a statement of metrological traceability". So, it is important that all CRMs are supplied with a certificate showing the traceability of the certified value to NIST Standard Reference Materials (SRMs) and a statement of the measurement uncertainty, as required by the ISO definition of a CRM.

Nathan Hulme of Starna said "We are committed to the process of continuous improvement demanded by those standards and look forward to another 20 years as the preferred supplier to many of the leading pharmaceutical companies, instrument manufacturers and accredited laboratories worldwide".

You can learn a lot more about ISO 17034:2016 and ISO/IEC 17025:2017 in John Hammond's contribution to the Quality Matters column on "Four generations of quality—'Don't risk it' Accreditation standards and their role in quality assurance" that starts on page 25.

Laser-induced breakdown spectroscopy: a unique analytical tool for the geosciences

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Introduction

Knowledge about the chemical composition of minerals, rocks and soils is of fundamental importance in the earth and environmental sciences (i.e. geosciences). Historically, during the late-19th and mid-20th centuries classical wet chemical analytical methods were the means of determining the elemental composition of such geological materials. Since then, intensive research in analytical inorganic chemistry has led to the development of a multiplicity of rapid and accurate instrumental analytical techniques for use in the laboratory that can be applied to elemental analysis across the periodic table. This has been of particular benefit to research in the geosciences, where the need for chemical data has continuously expanded with regard not only to the type of elements and their concentration levels, but also application to a wide variety of geological materials across the solid–liquid–gas spectrum.

One of the enduring needs within the geoscience community has been the availability of analytical instrumentation capable of routine use outside the laboratory setting. Laser-induced breakdown spectroscopy (LIBS) is one of the very few current analytical technologies suitable for routine use outside the laboratory and has a persuasive set of advantages that makes it ideally suited for chemical analysis in the field. These include rapid analysis with a compact and lightweight instrument by a single individual of most types of natural materials under ambient environmental conditions in real time, and with little to no sample preparation. Although such a field analytical technique does not provide the level of elemental detection and analytical precision possible with laboratory instruments, it nevertheless provides an efficient and invaluable capability to the field investigator.

To date, LIBS has been applied widely across the geosciences in sub-fields as diverse as mineralogy and petrology, volcanology, sedimentology, natural resources exploration and exploitation, pedology, and geoarchaeology.[1,2] The most common applications of LIBS in the analysis of geological materials include: (i) elemental detection and identification; (ii) quantitative elemental analysis; (iii) microscale geochemical mapping; (iv) discrimination and classification of minerals and rocks of similar character via spectral matching against an assembled spectral library; and (v) determination of sample geographical origin and provenance. Although LIBS is not able to address all questions arising in geochemical research and practice due to some inherent limitations in sensitivity, it can excel for specific geoscience applications.

The LIBS technique

The four essential components of a LIBS instrument are (i) a laser, the most commonly utilised of which is the short-pulsed, Q-switched laser that releases the large amount of energy over a short interval of time needed to ablate the sample; (ii) a time control system, which allows precise control of the analytical sequence—the beginning of laser pulse, the number of pulses, the interval between pulses, the beginning of emission capture and the signal acquisition interval; (iii) a set of optics comprised of mirrors and lenses that focuses the laser light onto the sample and then collects the light emitted from the plasma; and (iv) a spectrometer/detector system for the collection and spectral discrimination of the plasma light emission that

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contains information on the sample composition and physical conditions of the plasma.

The high-energy laser pulses are focused on the sample surface, which may be in air or in an inert gas at ambient or controlled pressure. This laser–material interaction results in the ablation of picograms to nanograms of the sample and its vaporisation to produce a high-temperature plasma containing the thermally excited analyte. As the plasma cools down, the excited ions, atoms and molecules decay to lower energy levels and, in doing so, emit electromagnetic radiation that is typical of each species present. Collection of this light by a detector/spectrometer produces an emission spectrum for the sample in which the intensity of each spectral line is proportional to its concentration in the sample analysed. The acquired signals are then processed, visualised and analysed using spectral analysis and chemometric software. An optically thin plasma in the condition of Local Thermodynamic Equilibrium (LTE) is expected to yield a LIBS spectrum (Figure 1) that directly reflects the elemental composition of the sample.[3]

Quantitative elemental analysis by LIBS is based on the proportionality between the spectral emission line intensity of the element and its concentration in the sample analysed, which can be ascertained by constructing a classical calibration curve that relates the measured elemental line intensity to the elemental concentration of standards of known composition measured under the same analytical conditions. A conceptually different approach is the calibration free LIBS method that avoids the use of calibration standards and was developed to address sample matrix issues. This procedure is based on the assumption that the LTE condition is fulfilled within a LIBS plasma, thus allowing calculation of certain plasma characteristics (i.e. excitation temperature and electron density) from which the elemental composition of the sample can then be estimated.[4] Furthermore, multivariate statistical methods have opened a new path for LIBS analysis beyond traditional univariate calibration. In particular, these methods use all the information contained in a LIBS spectrum, rather than just that for one or more emission lines in a limited portion of it. Such an approach allows for both quantitative analysis as well as the identification/discrimination of different geomaterials.[5]

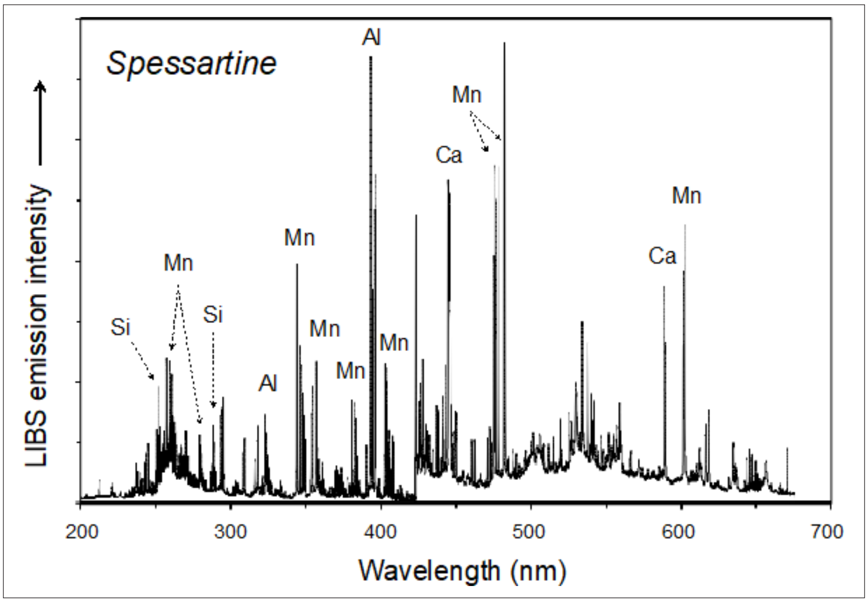

Figure 1. Broadband LIBS spectrum for the spessartine variety of the aluminosilicate garnet ($Mn_3Al_2Si_3O_{12}$).

Unique attributes of LIBS for geomaterial analysis

LIBS was introduced as a laboratory analytical technique in 1963, but commercial instruments only became available in the 1970s and 1980s.[6] These were subsequently refined, closely tracking technological progress in the development and miniaturisation of lasers, detectors and spectrometers.

Compared to many other common analytical techniques, which are mostly laboratory based and often require complex and time-consuming procedures, LIBS features several attributes that make it an attractive and unique tool for the analysis of geological and environmental materials. These include:

- Instrumentation requiring only a small number of relatively simple components (i.e., a laser, optics, a detector/spectograph and a computer);
- Rapid real-time (<1 s) analysis;
- Simultaneous capture of the full elemental composition of a sample with a single laser pulse based on one or more emission lines in the spectral region between 200 nm and 900 nm;
- Particular sensitivity to light elements such as H, Li, Be, B and C, which cannot be readily analysed by many other analytical techniques;
- Requirement of only picograms to nanograms of material for the analysis;
- Capacity to clean the sample surface by removal of particulates and biofilms;
- Capability to analyse mineral and rock surfaces with sub-millimetre spatial resolution;
- Ability for stratigraphic compositional profiling within a sample down to >100 µm depth;
- *In situ* analysis of individual particles and mineral grains plus liquid and solid inclusions;
- Megapixel compositional mapping at kHz rates of compositionally complex samples at tens of µm spatial scale with ppm-level sensitivity;
- Capacity to perform stand-off analysis with the sample located at some distance from the instrument;
- Availability of portable and handheld instruments allowing on-site, in-field analysis.

The relativity recent development and introduction of handheld LIBS (*h*LIBS) instruments represents a promising milestone, particularly because LIBS instrumentation is generally more robust, less expensive and has lower day-to-day operating costs than many other analytical techniques. Although further technological refinement will undoubtedly continue, *h*LIBS analysers have already been utilised for a wide variety of geoscience applications and this trend will undoubtedly continue as its use becomes more widespread across the earth and environmental sciences community.

Over the last two decades, hyphenated approaches that couple LIBS with Raman or laser-induced fluorescence (LIF) or inductively coupled plasma have expanded widely the capabilities of the technique as an invaluable geochemical tool.[2] These techniques can be combined conveniently with LIBS as they also make use of handheld instrumentation, thus permitting simultaneous, complementary and multi-elemental analysis. For example, the *SuperCam* suite installed onboard the NASA Mars 2020 *Perseverance* rover comprises co-aligned LIBS, visible-near infrared and Raman analysers and colour imaging, which allows simultaneously analysis for (i) the identification of minerals at the sub-mm spatial scale; (ii) the characterisation of rock textures and coatings; (iii) the determination of sediment stratigraphy; (iv) the search for organics and bio-signatures; and (v) the measurement of the degree of aqueous alteration of rocks by quantifying their volatiles content.[7]

Applications of LIBS across the geosciences

As described in the review paper by Harmon and Senesi,[2] LIBS has been shown to be very well suited for the rapid identification, classification and discrimination of minerals in compositionally complex rocks. For example, LIBS analysis can be used to readily identify aluminosilicate minerals containing light elements, such as spodumene by Li, beryl by Be and tourmaline by B. Bulk analysis of coarse-grained rocks is often difficult, but LIBS has shown to be straightforward and effective for the quantitative analysis of fine-grained sedimentary rocks and their metamorphic equivalents, e.g. limestones/marbles and shales/slates, metamorphic hornfels and igneous rocks (e.g. basalt, andesite and rhyolite), and for discrimination of tholeitic, sub-alkaline and transitional alkaline volcanic series.

LIBS coupled with chemometric data processing methods has shown a great potential for a broad spectrum of practical geoscience applications including environmental monitoring and remediation,[8] paleoclimate reconstruction,[9] stratigraphic correlation,[10] geoarchaeology,[11] the determination of material properties,[12] mineral provenance determination[13] and mineral exploration, prospect evaluation and quality control in deposit exploitation.[14–16] The application of chemometric methods to LIBS data in a geological context is continuously increasing as spectral databases grow ever larger and are applied to an increasing variety of geomaterials for new purposes.[5] For example, a correlation of rock units was attempted on 16 limestone beds collected from three quarries in Kansas (USA) by processing their LIBS chemical fingerprint data using various chemometric methods such as principal component analysis, soft independent modelling by class analogy and partial least squares regression analyses to obtain a stratigraphic interpretation.[10]

The determination of gemstone provenance is an important issue for the gemmological community and diamond industry for both financial and security reasons. Multivariate LIBS analysis has shown a high potential to identify gem provenance.[17] LIBS is also a unique tool for the accurate and rapid control of the origin of minerals extracted in areas of civil conflict and sold to sustain fighting, such as columbite-tantalite.[18]

Natural resources exploration is one of the fundamental activities of geology. The discovery and exploitation of new deposits is required to supply minerals and other resources to an ever-expanding global population. Another unique feature of LIBS is its capability of performing elemental identification and multi-elemental compositional mapping at high spatial resolution of a geological specimen,[15] for which quantification can be subsequently performed using a calibration curve approach. In particular, LIBS can be used efficiently as a mapping tool for light elements, and to complement other mapping methods. For examples, LIBS-based maps of Li distribution in hydrothermally altered spodumenes from the Li pegmatite deposit at Neoarchaean Mt Cattlin in Western Australia facilitated efficient discrimination between spodumene, its altered compounds and matrix silicate minerals.[19] The use of 2-D mapping LIBS combined with two other techniques not able to detect Li provided additional unique information that allowed discrimination of Li-bearing and Li-free feldspar (a Na-K-Ca aluminosilicate). LIBS data combined with other types of data were used by Nikonow *et al.*[20] to map mineral alteration and differentiate different types of chlorite (a Mg, Fe, Ni and Mn phyllosilicate). LIBS in combination with LIF was used to map even the elemental distributions of rare earth elements in minerals at different locations in a sample by monitoring the plasma formed from a single laser shot.[21] More recently, Rifai *et al.*[22] performed the ultrafast composite mapping of elemental distributions by acquiring nearly half-million LIBS spectra of Na, Mg, Al, Si, S, K, Ca, Fe, Ni, Cu, Pd and Pt over multiple 30 × 40-mm areas of drill cores collected from a Pt-Pd mine in the Stillwater layered mafic complex in Montana (USA) (Figure 2). That same year, Nardecchia *et al.*[23] developed a new LIBS spectral analysis strategy, called embedded k-means clustering, which allowed a deeper and more sensitive examination and mapping of both major and minor elements in a complex mineral sample originated from the Tighza polymetallic W-Au-Pb-Zn-Ag (Sb-Ba) deposit in central Morocco.

The mining industry worldwide makes use of well-established, but time-consuming and expensive, laboratory techniques for ore chemical analysis, so that the availability of rapid and precise techniques for on-site analysis of ore materials would be helpful to both exploration and exploitation. The recent development of commercial field-portable and *h*LIBS analysers has facilitated the

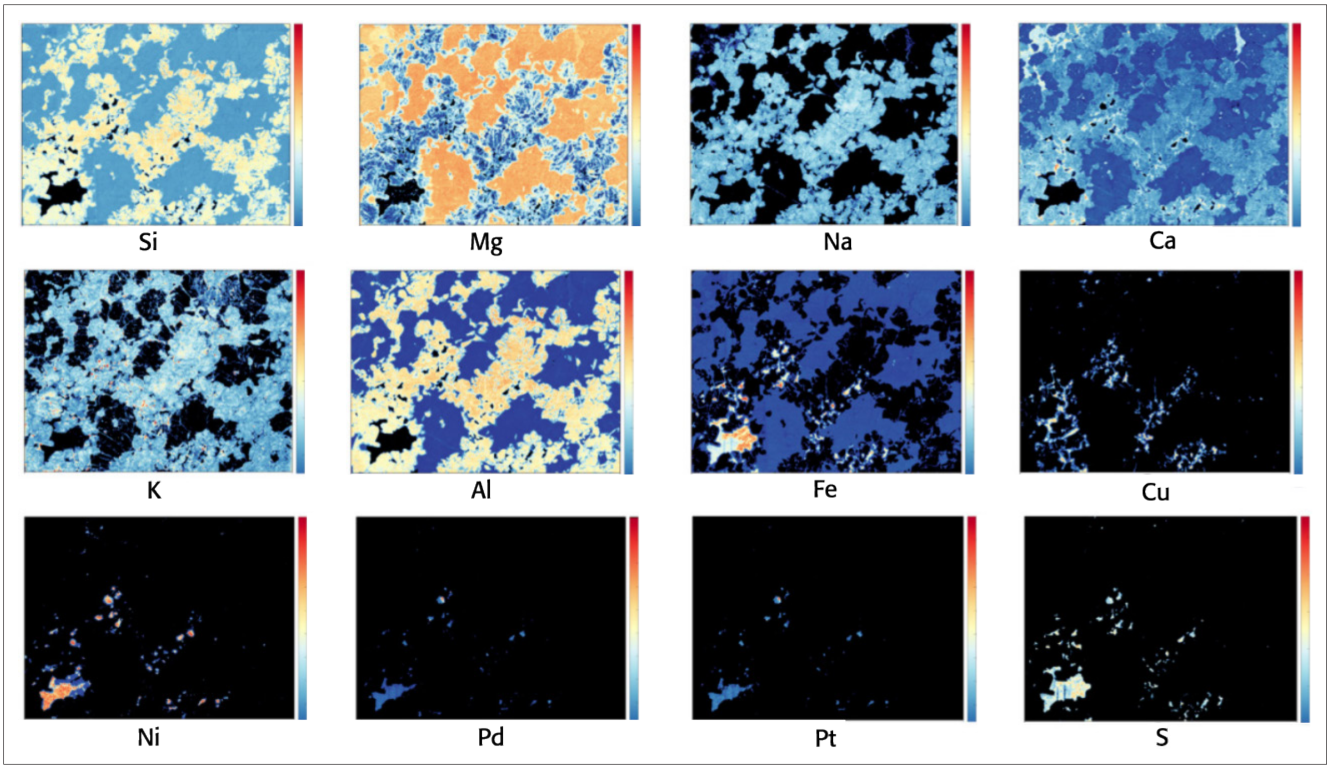

Figure 2. Single element microscale LIBS mapping for Si, Mg, Na, Ca, K, Al, Fe, Cu, Ni, Pd, Pt and S on a 40 × 30 mm section of drill core containing platinum and palladium from the JM Reef at the base of the banded zone in the Stillwater Igneous Complex, a layered mafic intrusion in southwestern Montana (USA). The JM Reef consists of pegmatitic peridotite and troctolite containing the sulfide minerals pyrrhotite [$Fe(1-x)S$], pentlandite [$(Fe,Ni)_9S_8$], and chalcopyrite [$CuFeS_2$], with overall assayed concentrations of 110 ppm Pd and 21 ppm Pt. As shown on the scale bar beside each of the 12 plots, elemental emission line intensities are scaled between 0 (dark blue) and 1 (red). Modified from Reference 22 under a CC BY licence.

rapid, on-site qualitative and quantitative elemental analysis, classification, discrimination and imaging of a wide variety of geological samples. This has permitted the rapid acquisition of compositional data and their rapid interpretation in a mineralogical context, which highlights the unmatched potential of LIBS for field applications.[24] For example, both conventional laboratory LIBS and *h*LIBS have been used to identify the relative amounts of Ag in placer deposit Au specimens, whereas PLS-discriminant analysis of LIBS broadband spectral analysis was able to determine sample provenance.[25] An *h*LIBS analyser was used for the rapid detection and analysis of Au in the MacLellan deposit at Lynn Lake, Manitoba (Canada) and to detect minor and trace element signatures of sulfide phases, whose relative abundance assisted in mineral identification.[26] Furthermore, LIBS raster mapping allowed for the rapid discrimination of arsenian pyrite and arsenopyrite, the two main As-bearing phases at MacLellan, from other Fe-bearing minerals in the sample matrix. More recently, Lawley *et al.*[16] demonstrated that the resolution of *h*LIBS-based geochemical imaging was sufficient to map a suite of kimberlite-hosted mantle xenoliths in Nunavut (Canada). In particular, LIBS was particularly sensitive for mapping the microscale distribution of elements with low atomic number, e.g. Li and Na, which represent important geochemical tracers of hydrothermal and magmatic processes but are difficult to detect at low concentrations with other field-portable analytical technologies.

Final considerations and perspectives

A variety of different laboratory, stand-off, field-portable and handheld LIBS instruments have been used for geoscience applications during the last two decades. These applications include elemental identification and quantification, mineral recognition and discrimination, provenance determination, the stratigraphic correlation of rocks, and material property determination. Such LIBS studies application provided unique insights into geological environments and their formation and subsequent history. The very successful use of LIBS on Mars, which had been used to analyse >4000 rocks, minerals and soils up to December 2020, has greatly boosted interest in using *h*LIBS and for applications here on Earth.

The analysis of complex materials like rocks and soils by LIBS is strongly affected by sample inhomogeneity and matrix effects that might be overcome by processing a massive number of spectra to “homogenise” the data. Supervised machine learning and chemometric methods have advanced the LIBS applications to rock analysis and classification, also allowing the matrix effects to be used beneficially as a fingerprint for that specific LIBS spectrum.

The brightest prospects for LIBS in geosciences will probably occur along three promising directions: micro-LIBS imaging, fast remote diagnosis of geological and environmental processes, and event prediction. Advances in the use of LIBS in the geosciences are also expected in the areas of geochemical prospecting, material property determination, volcanic gas studies for the prediction of volcanic eruptions, in support of broadband seismology and satellite observations of ground deformations.

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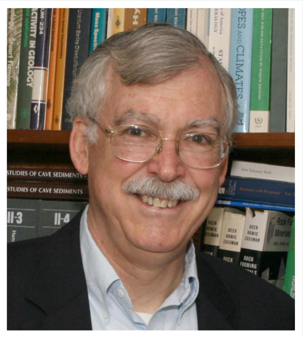

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NMRium browser-based nuclear magnetic resonance data processing

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As you will have seen in recent columns there has been much discussion about what spectroscopic data format is most appropriate in different scenarios. Depending on your workflows. an image might be the best format even if it hurts the "standardisation at all costs" side of my brain to admit it (for example see Figure 2 in Reference 1). During part of the quite animated discussions on this topic. especially around making repositories future-safe by ensuring data processing, Damien Jeannerat asked me if I had seen the release of a free nuclear magnetic resonance (NMR) web-based data processing tool which could handle both raw data files as well as JCAMP-DX NMR standardised files. This tool is NMRium, produced by Luc Patiny and colleagues at a Swiss scientific data management company called Zakodium. I had not heard of it and so I looked at their webpage and was impressed, so asked Luc directly if he was happy to be the subject of a column in SE to discuss the interesting innovative solution they are now providing users for free. (Just a quick reminder that the "F" in FAIR does **not** standard for Free or even open access!)

Luc was very forthcoming about the NMRium system from its beginnings and the ethos behind the open source development work that their company had done. I hope you enjoy his comments and try out their system. I am certain they will welcome any feedback you may have or suggestions for functionality!

Background to the NMRium project—why would a company want to produce an advanced data processing application and make it available for free?

The owners of Zakodium are all scientists and we maintain and participate in over 150 open source projects (several of them can be found in areas such as machine learning, image and data processing at https://www.zakodium.com/open-source). An early driver was that, as scientists, we found out that far too much data are lost because they are not stored and shared correctly. When carrying out research for our 2016 paper[2] we found out that it was difficult to find open access NMR spectra. However, the results showed that we could clearly produce a self-learning algorithm that would be extremely powerful IF more data were available.

One of the reasons why data are not available is that software to reprocess spectra are expensive and (as published in this column in recent editions—Ed!) some people only make available PDFs or static images of their spectra. There is also no straightforward workflow that allows the storage and sharing of data and share it (and Damien's NMReData format is one solution).[3]

We were also looking to NMRshiftDB, and in their database there are nearly no JCAMP-DX files, only the chemical shifts.

A grant from the German government[4] enabled the NMRshiftDB team to develop a new way to process NMR data in the browser. We took the lead to develop such a solution as an open source React component.

The overall NMRium project is a collaboration developed between Zakodium Sàrl, Switzerland, the University of Cologne, Germany, Johannes Gutenberg University Mainz, Germany, and Universidad del Valle, Colombia. The project was funded by the IDNMR DFG grant, as well as Zakodium Sàrl and the Universidad del Valle, Cali, Colombia.

Zakodium Sàrl is I assume a commercial company—is it the intention to start getting people to pay for this service?

Zakodium is a company that specialises in the storage and processing of scientific data with the goal to convert data to knowledge. The service of processing NMR spectra will stay free (anyway it is an open source project, you could just take a copy of the component). Our paid services are consulting, custom development and data management.

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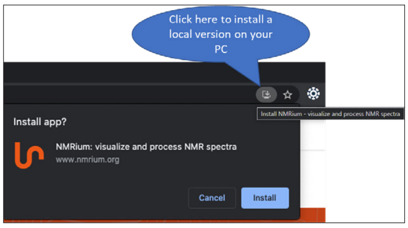
When you say that there is no backend processing on a server, so it is "Safe" is there any data stored on the web server or is all processing carried out in local memory—so effectively only on the local PC?

We took care that ALL the processing is done in your PC and nothing is sent to the server. As an experimental feature you can even install it locally on your PC (as a PWA, progressive web app) and you will be able to process NMR spectra offline. There is a small icon on the website that allows to do this (Figure 1).



Install app?

NMRium: visualize and process NMR spectra
www.nmrium.org

Figure 1. This is a screenshot taken using an up-to-date Chrome browser under Windows 10.

Even if you access the spectra using this kind of URL, https://www.nmrium.org/nmrium#?jcamp=https://cheminfo.github.io/nmr-dataset-demo/ethylbenzene/1h.jdx, we take care to add this "#" so that your browser does not send the URL of the JCAMP-DX file to our server. *(Ed.: I had to look this up! In JavaScript, the query after the # character is only handled by the client side of the service running locally on your machine and not parsed back to the server.)*

How would you describe the state-of-the-art environment which you have now improved on by the release of NMRium?

We are convinced that in the future the only application you will need on your computer is a web browser. In fact, your computer, after 40 years, is again becoming a "terminal" (you process data that are not locally saved from a browser). While today it is easy to have spreadsheets, word processors or email in the browser, the processing of spectra is barely possible. This means that up to now you had to install an application on all the computers that are required to process spectra. Installing software is expensive not only for licenses but also the cost of IT to install the software (in some companies it is really complex).

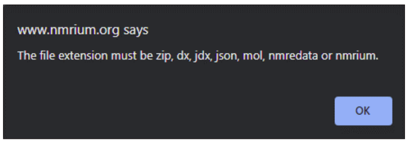
By using web applications, you avoid all the problems of installation and updates (simply reload the page and you get the latest version).

NMRium in action

OK thanks Luc, so let us see NMRium in action. When you open the program, you are faced with a large area of whiteness with some clear instructions on how to proceed (Figure 2).

For those of us who do not read instructions and just try to dump the NMR files into the program they nicely remind you with some more details of what you really need to do (Figure 3).

Suitably embarrassed by my over-confidence (who does ever read QuickStart guides by the way?), I decided to test the system out with Peter Lampen's original JCAMP-DX encoding test files, which are 1D ethylbenzene NMR spectra and an FID encoded using the various allowed JCAMP-DX XY-DATA encoding standard algorithms AFFN, PAC, SQZ, DIFF and NTUPLES formats. As you can see from Figure 4, NMRium passed with flying colours showing that NMR data which was originally saved in 1992 using the JCAMP-DX NMR 5.01 standard format can still be read almost 30 years later.



www.nmrium.org says

The file extension must be zip, dx, jdx, json, mol, nmredata or nmrium.

Figure 3.

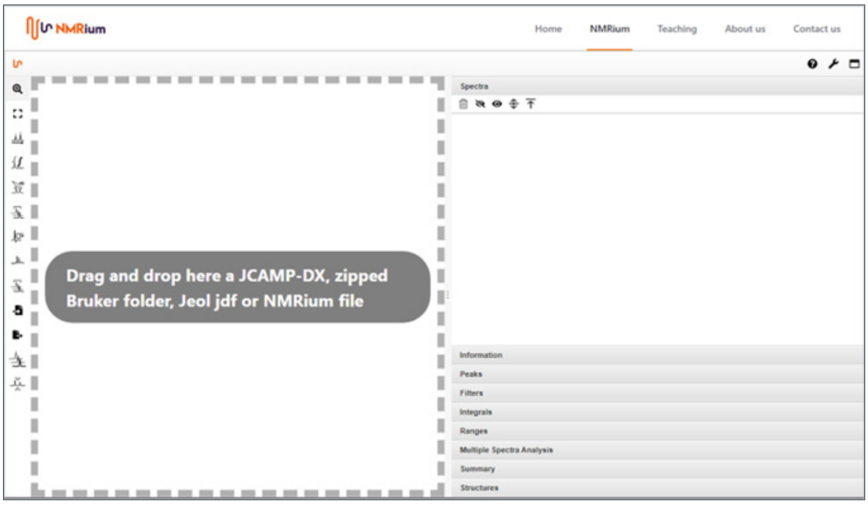
There are all the usual NMR data processing tools you would expect including ^{1}H-NMR prediction which I carried out for Robert Lancashire's favourite acetophenone but I have run out of space for more figures.

Conclusions

I am very pleased that new Open applications are becoming available against which we can test the FAIR principles and data longevity strategies that have been developed over the years.

Tools like NMRium will greatly help in moving to a FAIR world as it means organisations that cannot afford to pay acquisition and maintenance contracts on expensive specialist spectroscopic software will still be able to get quite detailed access and analysis of spectra stored in Open spectroscopic data repositories.

Damien's vision for this capability goes further, "anybody" can make a set of spectra available on a mini web server, a GitHub page in fact. He published an



Drag and drop here a JCAMP-DX, zipped Bruker folder, Jeol jdf or NMRium file

Figure 2.

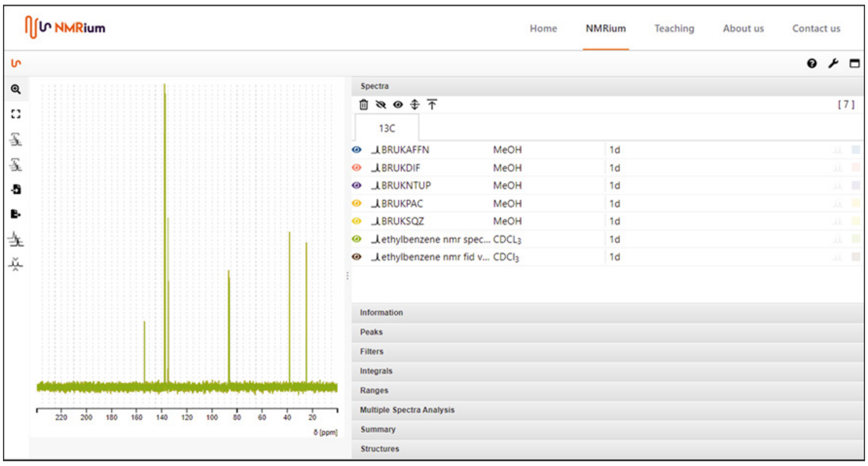


Figure 4.

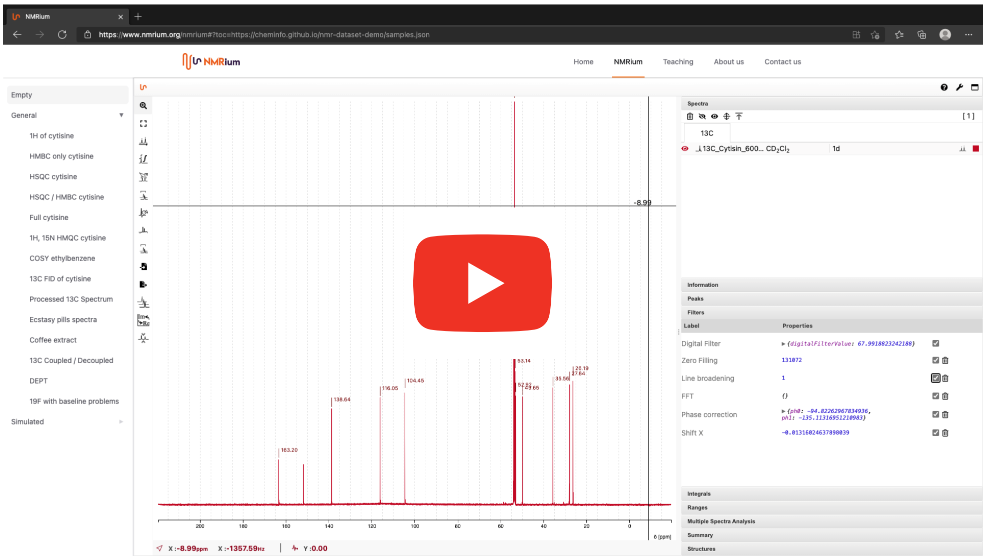
example in his most recent paper with Carlos Corba from Mestrelab Research.[5] It is easy to imagine having a mini site for Zenodo, Dataverse etc. repository including NMR. If these repositories then had an agreed, open and uniform structure, this could be fully automated (eliminating some of the manual steps we had in the EuroSpec spectroscopic repository).

Creating such a dataset involved dropping a spectrum into NMRium, then using a Save As… cycle to create the JCAMP-DX file (something that could be easily automated using an archive forge of a simple front-end page—yeah, I keep talking about this!). Then a script automatically generates a table of content file that ends up as the anchor of the URL. Pretty elegant stuff!

The NMRium format allows spectra to include embedded links. Nice to avoid duplicating data. Ideally, if the link could extract an individual file from a zip file sitting in a repository, it would be a dream come true for NMR archaeology!

In fact if you want to see more there is a short explanatory video below and at https://www.nmrium.org/videos/presentation. Better examples than I have created for the column including 2-DNMR are available at https://www.nmrium.org/nmrium#?toc=https://cheminfo.github.io/nmr-dataset-demo/samples.json. You can also download the demo data from https://github.com/cheminfo/nmr-dataset-demo to try out the entire process. By the way note that the example URL launches NMRium but loads the data set it is showing from GitHub. Damien, your dream is close to being reality!

Everyone please, stay safe!



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Luc Patiny has a background in organic chemistry and structural analysis and has been interested in making chemical information available for computers for over 20 years. He is strongly involved in the development of open-source tools, freely accessible and that run directly from a web browser.

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Four generations of quality—“Don’t risk it” Accreditation standards and their role in quality assurance

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Introduction

This article reviews the two principal ISO 17000 series accreditation standards, namely ISO/IEC 17025[1] and ISO 17034,[2] their impact on the associated Quality Assurance, Testing or Calibration Laboratory and historically how these standards have evolved and continue to be implemented. In addition, this article discusses the role(s) of the ISO 9000 series and ISO 17000 series support standards within this controlled environment. It introduces the ISO Technical Committee, ISO/REMCO, which has supported this evolution/development. This Reference Material committee, now formally reorganised by ISO as TC 334, will be reviewed and discussed in the next article in the series. As we shall see, the “Don’t risk it” message is a common theme through this review and is explicitly addressed in the latest revision of ISO/IEC 17025.

Background

The ISO Technical Committee responsible for the 17000 series standards, in all aspects of production and maintenance is ISO/CASCO – Conformity assessment, which is defined by its term of reference as follows.

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ISO/CASCO—Terms of reference

- To study means of assessing the conformity of products, processes, services and management systems to appropriate standards or other technical specifications.
- To prepare international guides and International Standards relating to the practice of testing, inspection and certification of products, processes and services, and to the assessment of management systems, testing laboratories, inspection bodies, certification bodies, accreditation bodies and their operation and acceptance.
- To promote mutual recognition and acceptance of national and regional conformity assessment systems, and the appropriate use of International Standards for testing, inspection, certification, assessment and related purposes.

ISO 9000

As detailed in the previous article ISO 9000 can essentially provide the quality management principles, required by the 17000 series standards. This is clearly demonstrated in the initial publication of ISO 17034, by the fact that an existing ISO 9000 quality management (QM) system can be used as an alternative to meet the QM chapter requirements of ISO 17034.

ISO 17000 series

Developed under the responsibility of ISO/CASCO, this series currently consists of 41 standards related to conformity assessment.

The three key standards in our area of interest are:

ISO/IEC 17025: General requirements for the competence of testing and calibration laboratories is the main ISO standard used by testing and calibration laboratories. In common with other ISO quality standards, ISO/IEC 17025 requires continual improvement. Additionally, the laboratory will be expected to keep abreast of scientific and technological advances in relevant areas.

ISO 17034: General requirements for the competence of Reference Material producers.

ISO 17043: Conformity assessment—general requirements for proficiency testing. Given the explicit requirements and use of this standard within the proficiency testing arena, it will not be considered further within this article.

ISO/REMCO

There has always been and will continue to be collaboration between individual producers of reference materials (RMs). However, many years ago, RM producers recognised that the growing need by the analytical community for a number and variety of RMs as well as a need for the assurance of the quality of RMs called for collaboration at the international level. This has been achieved through REMCO, the Council Committee on Reference Materials of the International Organization for Standardization (ISO), which celebrated its 25th anniversary in 2001. The evolution of this organisation and its conversion into the formal ISO Technical Committee, TC 334 – Reference Material in 2021 will be discussed in detail in the next article.

Accreditation

Accreditation is the formal recognition of the competence of a body or an organisation for a well-defined purpose. Accreditation of a laboratory to ISO/IEC 17025 involves assessment of the **technical competence and capability of the laboratory and its personnel**. In practice it is the procedure by which a laboratory is assessed to perform a specific range of tests or measurements. Specific areas examined include infrastructure and staff qualifications; in addition to checks that an adequate QM scheme is in place. The accreditation covers the range of materials tested or analysed, the tests performed, the method and equipment used, the accuracy or precision expected, and is specific to the facility and the test. This combination of technical and QM requirements is also found in ISO 17034, and will be discussed later.

1st Generation: the years between 1940 and 1975

Until the 1970s, most laboratories had used home-made test solutions or relied on the manufacturer to calibrate their instruments as part of routine maintenance. At the time, the only available references with internationally recognised and certified calibration values were those from National Measurement Institutes (NMIs) such as the National Institute of Standards and Technology (NIST) in the United States, whose products were trademarked as Standard Reference Materials (SRMs), but these were expensive and production capacity was limited. However, two important developments in this area of accreditation were the foundation of the Australian National Association of Testing Authorities (NATA) in 1947 and the New Zealand accreditation body TELARC in 1973. Obviously recognised within their own sphere of influence, the history of these organisations was only recognised on a worldwide basis with the formation of the International Laboratory Accreditation Cooperation (ILAC) in 1977.

2nd Generation: the years 1975 to 2000

ILAC first started as a conference, which was held on 24–28 October 1977 in Copenhagen, Denmark, with the aim of developing international co-operation for facilitating trade by promotion of the acceptance of accredited test and calibration results.

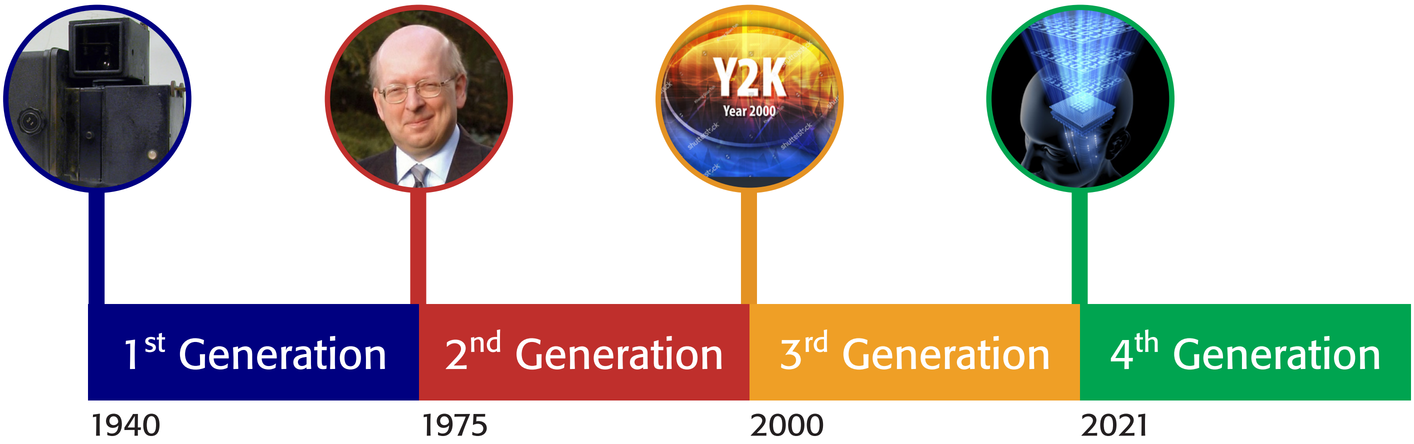
There then followed a relatively quiet period, until towards the end of this generation, a range of publications and events accelerated progress in this area, with the publication of key documents by the International Cooperation for Traceability in Analytical Chemistry (CITAC).[3,4]

Within these publications, and as the above organisation name suggests, a key and evolving concept is that of "Traceability". Traceability means different things to different people. If we look at the ISO International Vocabulary of Basic and General Terms in Metrology, ISO, 1993 definition:

"Traceability is the property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons all having stated uncertainties."

But this definition continues to evolve and has to be broadening into what this requirement means in an international marketplace. An excellent summary document is the CITAC paper on *Traceability in Chemical Measurement*.[5] This positioning paper clearly described the role that traceability has to play in a global marketplace, where ISO/IEC 17025 accreditation has the anchor role to play as the technical and Quality system standard implemented by the accreditation bodies.

In 1994, Accreditation in Europe is based on guidelines set out in the European Standard *General Criteria or the Operation of Testing Laboratories* EN45001 and the newly published (1990) ISO/IEC Guide 25 *General Requirements for the Competence of Calibration and Testing Laboratories*. The guidance was applicable to the performance of all objective measurements, whether routine, *ad hoc* or as part of research.



Most national laboratory accreditation schemes based their standards on these two documents. In the UK either EN 45001, or the identically worded BS7501, was used. This standard was implemented in the UK by The National Measurement Accreditation Service (NAMAS), which was formally established by the UK Government in 1985, and was administered by an Executive, based at the National Physical Laboratory (NPL) in Teddington. In May 1990, NAMAS contributed to a "memorandum of understanding", the Western European Laboratory Accreditation Co-operation (WELAC), which obtained mutual recognition agreements with the following countries:

Australia, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hong Kong, Iceland, Ireland, Italy, Netherlands, New Zealand, Norway, Portugal, Spain and Switzerland.

NAMAS has subsequently become, in 1995, the United Kingdom Accreditation Service (UKAS).

In 1996, ILAC became a formal co-operation with a charter to establish a network of mutual recognition agreements among accreditation bodies.

In 2000, the 36 ILAC Full Members, consisting of laboratory accreditation bodies from 28 economies worldwide, signed the ILAC Mutual Recognition Arrangement (ILAC MRA) in Washington, DC, to promote the acceptance of technical test and calibration data for exported goods. The ILAC MRA for calibration and testing laboratories came into effect on 31 January 2001.

To achieve international recognition, the laboratories calibrating the references would need to be accredited to an international standard. ISO/IEC Guide 25 was first released in 1978 and covered "General requirements for the competence of calibration and testing laboratories". Later, the need to achieve compatibility with ISO 9001 led to a revision of the standard to ISO 17025, issued in 1999.

From a personal perspective this culminated in the accreditation of our (then Unicam) Calibration Laboratory to the new ISO/IEC 17025 standard for spectrophotometric transmittance measurements of Neutral Density optical filter glasses, by the then UK accreditation body (NAMAS).

As part of this process, we asked "How can instrument manufacturers assist with NAMAS compliance?"

The following five suggestions were given as the considered response from a co-ordinator and an assessor within the NAMAS organisation:

- User-friendly work instructions.
- Easy self maintenance.
- Advice on performance tests—what should you do to check?
- Filters traceable to International Standards (not own company standard).
- Ease of calibration.

These formed the basis for future developments in this area on a personal basis.

ISO/IEC 17025 was initially issued by the International Organization for Standardization in 1999. There are many commonalities with the ISO 9000 standard, but ISO/IEC 17025 is more specific in requirements for competence and applies directly to those organisations that produce testing and calibration results and is based on somewhat more technical principles. Laboratories use ISO/IEC 17025 to implement a quality system aimed at improving their ability to consistently produce valid results. It is also the basis for accreditation from an accreditation body.

There have been three releases, in 1999, 2005 and 2017, which have essentially evolved and revised the standard. The 2017 release is discussed (as the current version) in the 3rd Generation below.

3rd Generation: the years 2000 to 2020

So, as we enter this generation, ISO/IEC 17025 has "come of age" as the standard that provides the international aspect to any laboratory measurement process, and provides the control framework to assist the production of comparable measurements.

At this point it is interesting to review this extract from the ILAC news publication of 2000.

ILAC News, 2 November 2000

Signing of International Arrangement to Enhance Trade

An international arrangement, signed in Washington, DC, on 2 November 2000, will enhance the acceptance of technical data accompanying goods crossing national borders. The Arrangement, which involves 37 member bodies from 28 economies represented at the General Assembly of the International Laboratory Accreditation Cooperation (ILAC), means that goods tested in one country by a laboratory that is accredited under a signatory to the Arrangement, will be accepted by other signatories. This is a major step towards reducing or eliminating the need for re-testing of the goods by the importing country.

The Arrangement enters into force from 31 January 2001.

Belinda Collins, Chair of ILAC, noted the significance of the signing, "For many years, the retesting of goods by an importing country has been considered as a major technical barrier to trade. The World Trade Organization (WTO) identified such technical barriers as a major concern to world trade since the mid-1970s. Such barriers can not only add significant cost to goods entering a country, but can also delay, and in some cases prevent, the goods being accepted by foreign markets."

Dr. Collins further explained that "ILAC has been working towards overcoming these technical barriers for the last two decades by encouraging the development of regional recognition arrangements culminating in today's global recognition arrangement among representative bodies in each country. This will facilitate the acceptance of goods already tested by an accredited laboratory. Thus, goods tested in one country should enjoy easier access to foreign markets participating in the Arrangement."

The key to the Arrangement is the developing network of accredited testing and calibration facilities around the globe that are evaluated and recognized as being competent by specific authorities, known as laboratory accreditation bodies. These bodies are located in many economies and many of them participate in ILAC.

The following economies will participate in the Arrangement:

Australia, Belgium, Brazil, Canada, People's Republic of China, Czech Republic, Denmark, Finland, France, Germany, Hong Kong, China, India, Ireland, Italy, Japan, Republic of Korea, The Netherlands, New Zealand, Norway, Singapore, South Africa, Spain, Sweden, Switzerland, Chinese Taipei, United Kingdom, United States of America, Vietnam.

A cornerstone of the new Arrangement is the utilization of existing or developing regional arrangements established in the Americas, the Asia Pacific region, Europe and Southern Africa. The bodies participating in these regional arrangements are responsible for maintaining the necessary confidence in accreditation bodies from their region that are signatories to the new ILAC Arrangement.

Mike Peet, Chair of the ILAC committee that developed the new Arrangement, explained the basis for the Arrangement's implementation by the international community: "Now that the Arrangement is in place, the next crucial step is for governments to take advantage of this Arrangement by using it to further develop or enhance trade agreements."

"There is now a firm foundation in place for manufacturers and exporters that have their goods tested by accredited laboratories to enjoy greater market access, less costs associated with re-testing, and overall greater competitiveness in global markets", he explained.

Established in 1977, ILAC is the peak international forum for the harmonization of laboratory accreditation procedures as a means of reducing technical barriers to trade, and the promotion of laboratory accreditation as a mechanism to enhance confidence in testing and calibration facilities, both domestically and internationally.

The ILAC MRA was then extended in October 2012 to include the accreditation of inspection bodies. In May 2019 it was further extended to include the accreditation of proficiency testing providers and in May 2020 for the accreditation of Reference Material producers. It is interesting that the message "Tested Once—Accepted Worldwide" is still being pursued, as shown below; although some may say that even 20 years later, we are still to fully achieve this "level field" across all countries and continents.

ISO/IEC 17025

The most significant changes between the 1999 and 2005 release were a greater emphasis on the responsibilities of senior management, explicit requirements for continual improvement of the management system itself, and communication with the customer. It also aligned more closely with the 2000 version of ISO 9001.

The 2005 version of the standard comprised five elements: Normative References, Terms and Definitions, Management Requirements, and Technical Requirements. Management Requirements are primarily related to the operation and effectiveness of the QM system within the laboratory. Technical Requirements include factors that determine the correctness and reliability of the tests and calibrations performed in the laboratory.

The 2017 version of ISO/IEC 17025 has modified this structure to be Scope, Normative References, Terms and Definitions, General Requirements, Structural Requirements, Resource Requirements, Process Requirements, and Management System Requirements. General Requirements and Structural Requirements are related to the organisation of the laboratory itself. Resource Requirements cite those issues related to the people, plant and other organisations used by the laboratory to produce its technically valid results. Process Requirements are the heart of this version of the standard in describing the activities to ensure that results are based on accepted science and aimed at technical validity. Management System Requirements are those steps taken by

Table 1. ILAC regional co-operations (taken from International Laboratory Accreditation Cooperation, ilac.org).

Recognised regional co-operation body		Scope of ILAC MRA recognition
IAAC	Inter American Accreditation Cooperation (IAAC)	Calibration: ISO/IEC 17025 Testing: ISO/IEC 17025 Medical Testing: ISO 15189 Inspection: ISO/IEC 17020 Proficiency Testing Providers: ISO/IEC 17043
EA EUROPEAN ACCREDITATION	European co-operation for Accreditation (EA)	Calibration: ISO/IEC 17025 Testing: ISO/IEC 17025 Medical Testing: ISO 15189 Inspection: ISO/IEC 17020 Proficiency Testing Providers: ISO/IEC 17043 Reference Material Producers: ISO 17034
APAC ASIA PACIFIC ACCREDITATION COOPERATION	Asia Pacific Accreditation Cooperation Incorporated (APAC)	Calibration: ISO/IEC 17025 Testing: ISO/IEC 17025 Medical Testing: ISO 15189 Inspection: ISO/IEC 17020 Proficiency Testing Providers: ISO/IEC 17043 Reference Material Producers: ISO 17034
arab accreditation ARAC الجهاز العربي للاعتماد	Arab Accreditation Cooperation (ARAC)	Calibration: ISO/IEC 17025 Testing: ISO/IEC 17025 Medical Testing: ISO 15189 Inspection: ISO/IEC 17020
AFRAC AFRICAN ACCREDITATION COOPERATION	African Accreditation Cooperation (AFRAC)	Calibration: ISO/IEC 17025 Testing: ISO/IEC 17025 Medical Testing: ISO 15189 Inspection: ISO/IEC 17020

the organisation to give itself QM system tools to support the work of its people in the production of technically valid results. In addition, for the first time, there is an increased emphasis on the assessment (and measurement) of risk.

ISO 17034 (formerly ISO Guide 34)

The synergistic association of ISO 17034 with ISO/IEC 17025 is driven by the fact that invariably Certified Reference Materials (CRMs) produced under ISO 17034 will provide the traceability and uncertainty budget requirements for ISO/IEC 17025 accreditation, and in fact 17025:2017 explicitly states that where possible RMs produced under ISO 17034 should be used.

The role of ISO 17034 in the production of RMs that are "fit for purpose" has been frequently reviewed and discussed in several articles during this period in this publication.[6–14]

First published in 2000 as ISO Guide 34, alongside the evolution of ISO/IEC 17025, and in line with the already discussed expansion of laboratory accreditation during this period, its evolutionary path was directed by an ILAC resolution in 2004, which suggested that, after much debate, RM producers should be accredited to a combination of ISO Guide 34 and ISO/IEC 17025 accreditation, with the accreditation to ISO/IEC 17025 being used for the measured value(s) assigned in any CRM.

From a personal perspective, and working for an ISO/IEC 17025 accredited (in 2001) RM producer at the time, we were in involved in a UKAS pilot study into this process in 2005, which ultimately resulted in our accreditation to this "standard" in 2006.

As ISO Guide 34 was now being used for this process, the 2009 revision effectively revised and restructured the content of this guidance document into the required 17000 series standard in all but name, but as stated at the start of this article, the production and control of these standards fall under the auspices of ISO/CASCO. So how to solve this issue? The obvious way was for ISO to form a joint CASCO/REMCO sub-committee, tasked with the conversion of Guide 34 into 17034, and in 2016 this duly completed.

As a consequence, since that point in time our (Starna) Calibration Lab has been jointly accredited to both ISO/IEC 17025 and ISO 17034.

4th Generation: from 2021 forward

In 2021, our (Starna) accredited processes continue to evolve, in no small part accelerated by the global COVID-19 pandemic that we have all been experiencing and changing our working practices. In the context of this article, our UKAS full re-assessment to both standards was effectively and efficiently performed using a remote assessment, aided by the video technology we are now all familiar with.

From a standard maintenance perspective ISO 17034:2016 is due for review in 2021, and ISO/IEC 17025, next year in 2022. Given the extensive revision undertaken in producing these standards, it is unlikely that significant changes will occur—but we will of course keep you updated.

However, the same cannot be said for the ISO/REMCO structure and organisation, that has supported this interlinked science of laboratory accreditation and the use of RMs etc., and is now formed as ISO/TC 334.

For this reason, the next article in the series is dedicated to this ISO Technical Committee, and I welcome you back to this discussion in the near future, where we will continue the "Don't risk it" message.

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Theory of Sampling application: toward a theory of tumour sampling

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Editor's introduction: There has been a long wait for the Theory of Sampling (TOS) to make any inroads within the medical profession. Indeed, a few intrepid explorers have tried, but this has resulted only in getting nowhere fast… so far. This column lays out what can only be described as a *paradigm shift* within the field of tumour diagnostics, nothing less. And it all came about because of a young scientist's inspired application of the TOS; indeed "all that was needed" was… a blender. Here our readers are treated to a fascinating summary of what happened, and how. *Talk about structured heterogeneity; talk about a clean break with grab sampling; talk about inspired use of blending—this column is a shear TOS delight!*

A lightbulb moment

Thirty seconds after I was told by Kate Leith, PhD, to "get a blender" I realised she was right. By the time I returned to my desk I had stopped thinking the suggestion was the most ridiculous thing I had ever heard, and began wondering about where I was going to get the right blender. You see I am a cancer biologist looking to solve a specific spatial heterogeneity problem, and Dr Leith is a biostatistician who is an expert in statistical power analysis. In the days following the sentence that forever changed my career back in 2015, I came to better understand Pierre Gy's Theory of Sampling (TOS) and have been working to apply representative sampling to cancer diagnostics ever since.

Background: cancer biology

A tumour develops from a single cell that has incurred enough DNA mutations for the cell to begin to proliferate uncontrollably, as the normal checks and balances within a cell are broken. From that single cell, a tumour composed of billions and billions of cancer cells begins to form. However, as the tumour grows, individual cancer cells continue to gain unique mutations. Some of these unique mutations will aid in tumour development and, therefore, that cancer cell will generate more cells. This process happens over and over within a growing tumour and can generate many distinct populations of cancer cells, with each population containing unique mutations. Thus, solid tumours are a heterogeneous mass of distinct cancer cell populations: a process cancer biologists call *tumour heterogeneity*.

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A great analogy for thinking about tumour heterogeneity, borrowed from my collaborator Dr Charles Swanton, is a tree. The trunk of the tree represents all of the DNA mutations found in every cancer cell within a tumour because they were the first set of mutations that led to the formation of the tumour. The bottom branches represent early DNA mutations that generated distinct populations of cancer cells with unique growth properties within the tumour. As you move up the tree, each branch is yet another set of DNA mutations generating yet another distinct population of cancer cells within the tumour. The movement from the bottom of the tree to the top represents the lifespan of the tumour, such that the base of the tree is the initiating cell, and the leaves are the most recent cells. In this way, a palm tree is similar to a tumour with a very recent burst of DNA mutations (low tumour heterogeneity), whereas an oak tree represents a tumour with significant DNA mutations throughout the lifespan of tumour development (very high tumour heterogeneity).

How it is done traditionally

While readers of this column are very familiar with Gy's TOS, and have applied the kind of composite sampling needed to counteract spatial heterogeneity many times over, we in cancer biology have only come to appreciate the full scale of this problem over the last decade. While many researchers had understood that cancer cells within a tumour are not identical for over a century, only after the technology that enabled the sequencing of the human genome was applied to tumours did we fully appreciate the scale of the heterogeneity of solid tumours. In fact, the initial paper that demonstrated the sampling problem in solid tumour diagnostics was published in 2012,[1] amazingly recent given the long history of the practice of medicine.

The endeavour of cancer biology is well over 100 years old, and many of the techniques and methods used to sample and process tumours date back to the late 1800s. These innovations enabled scientists and doctors to cut out portions of a tumour, cut them into thin slices (less than half the diameter of a strand of hair), and place them on a glass slide for microscopic examination. This approach has served the medical profession, and patients well—but they are not fully optimised as we came to realise.

The same instruments and methods are still used today to provide samples for cancer diagnosis and more advanced complex DNA-based tests. Applying this sampling approach to the tumour tree analogy, the current solid tumour sampling method is akin to taking the trunk and a single branch from an oak tree. We can tell it is an oak tree, and can likely determine what DNA mutations caused the first branch to form, **but we are *blind* to the rest of the tree**. To continue the tree analogy, once we have taken the sample of the tree and determined what type of tree it is, we burn the rest. Quite literally, unused surgical tumour tissue is routinely and universally incinerated. My lab takes tumour tissue that would otherwise be discarded and uses it as the input for representative sampling through homogenisation.

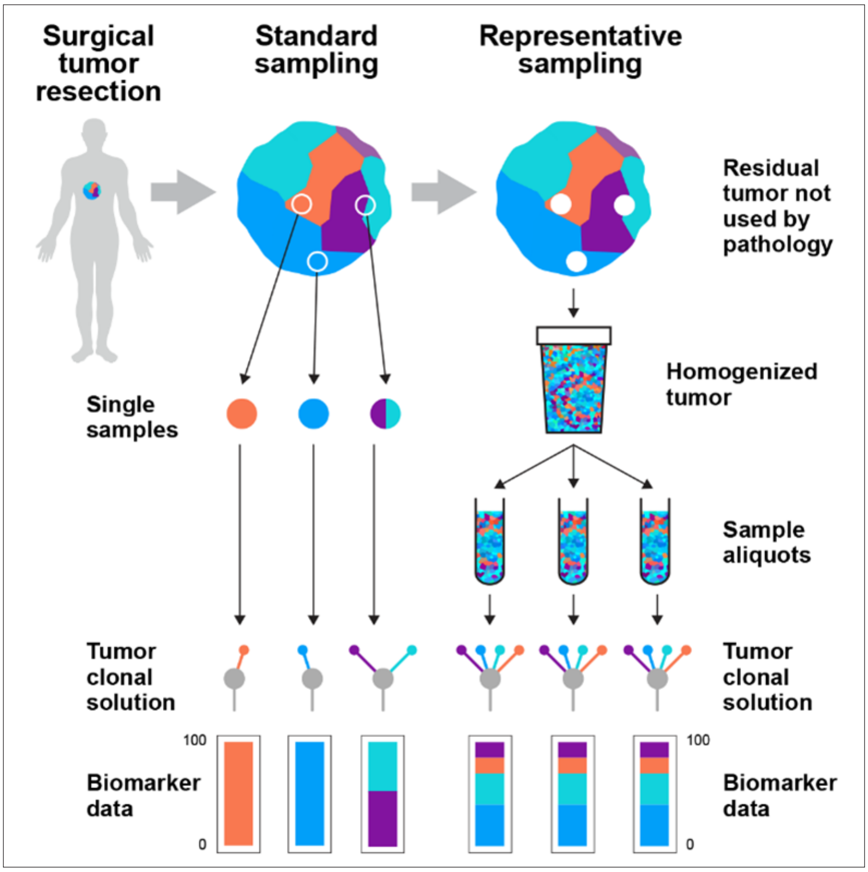

Figure 1. Tumours are spatially heterogeneous mixtures of multiple populations of cancer cells with distinct DNA mutations. Current sampling strategies fail to address the heterogeneity of tumours as individual biopsy samples cannot capture the diversity of the entire tumour—they are in fact just **grab samples**. These standard samples generate biased data depending on the area of the tumour that was sampled, being blind to the area that was not sampled. Representative sampling through blending of the residual tumour tissue not taken by pathologists creates a homogenate that contains the full diversity of the original solid tumour mass. Reproduced from K. Litchfield *et al.*, "Representative sequencing: unbiased sampling of solid tumor tissue", *Cell Rep.* **31(5)**, 107550 (2020).

What's new

In collaboration with teams led by Dr Samra Turajlic at the Francis Crick Research Institute and the Royal Marsden Hospital, NHS Foundation Trust, we published the first manuscript describing our new representative sampling approach for solid tumours in 2020.[2] In this article we compared homogenisation of tumour tissue to many individual standard biopsy samples taken from different spatial locations (65 in total), all from the same tumour. A standard tissue biopsy sample is akin to drilling out a core sample in soil or a drill core through a mineralised rock (ore)—a cylindrical excision from solid tissue.

In what may not be all that surprising to practitioners of the TOS, representative sampling of solid tumour tissue enables the detection of *more* DNA mutations than do individual samples. Representative sampling also generates *reproducible* aliquots of the original homogenised sample, whereas each individual standard biopsy sample will contain different combinations of DNA mutations (Figure 1). We are very excited about this new approach and are currently working to expand these findings to more tumours and across more tumour types (we originally focused on kidney cancer).

Further refinement

Another aspect of the TOS that we have integrated into our work (although I must admit I only realised this after the fact) is defining the appropriate particle size for analysis of a heterogeneous lot.[3] The tumour tissue that we are homogenising is transformed from a pliant soft material to a very ridged and dense material through a process called formalin fixation. Homogenising fixed tissue in a blender (very similar to, or possibly the same blender you have at home in your kitchen) generates fragments of tumour tissue containing hundreds to thousands of cells. We can take that homogenate and immediately purify DNA or protein molecules by taking a sub-sample of the homogenate and breaking down all of the molecules into a liquid, and specifically purifying just the DNA. However, as the unit of heterogeneity within our sample is a single cell, we wanted to be able to further process the homogenate *into single cells*.

Next, we developed a protocol to break the fragments of tumour from the homogenate into individual nuclei. The nucleus of a cell contains the DNA molecules that we are testing, so nuclei are an appropriate proxy for individual cells. We can then assess the characteristics of millions of nuclei taken from a representative sample of a tumour, and collect only the nuclei from cancer cells, separating them away from the nuclei of other normal cells that innervate the solid tumour mass. This process dramatically improves our analytic sensitivity to DNA mutations because we are testing predominantly cancer nuclei, rather than a combination of cancer and normal nuclei (which do not have the DNA mutations).

Impact on patient care: personalised healthcare

In solid tumours, every distinct population of cancer cells *could* harbour genetic mutations that confer resistance to therapeutics. Armed with this knowledge, over the past few decades, treatment strategies have evolved from treating all patients with the same type of cancer with the same drug, to linking specific DNA alterations to specific drugs. This strategy is called *personalised healthcare* and has produced amazing results for some patients. Researchers and clinicians continue to look for new personalised targets of therapy in hopes that the personalised healthcare strategy can expand to include more and more patients. Fundamental to this work is our ability to find mutations that can be linked to specific therapies, **hence applying the TOS to heterogeneous tumours is critical**.

My initial conversations with Kate (“*pre-TOS enlightenment*”) were simply *thought experiments*, focused on determining “how many individual samples were needed to detect DNA mutations present in a small portion of a large tumour”. At this point I was “functionally fixed” to the current standards, hoping that if we simply did more of what we currently do, we could solve the sampling problem.

The problem with this line of thought is that it misses one of the most important aspects of the TOS. In order to be able to design a sampling plan—“how much” should be sampled and “how”—one must first understand, and be able to characterise, the level of heterogeneity present in the original sample material. This intuitive feature of the TOS has had the most impact on my thoughts around how solid tumours *should* be sampled. There is no way of knowing *upfront* how heterogeneous a solid tumour is at the level of DNA. Yet linking the right treatment to the right patient requires that we detect *as many* of the DNA mutations within a tumour *as possible.*

Therefore, in solid tumour oncology, representative sampling is truly a matter of life or death.

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Nelson Alexander received his PhD in Cancer Biology from the University of Arizona in 2005, followed by a post-doctoral fellowship at Vanderbilt University for two years. Wanting to have a more direct impact on patient care, he joined Roche Tissue Diagnostics (RTD) in 2007 where he has held multiple roles in R&D, as well as in Research & Early Development. During his time at RTD, Nelson became very interested in the interface between tumour heterogeneity and sampling bias. Nelson currently leads a research team within Roche Diagnostic Solutions that is pioneering a new sampling process that enables evaluation and quantification of tumour diversity at the genomic, transcriptomic and cellular levels from entire solid tumours.
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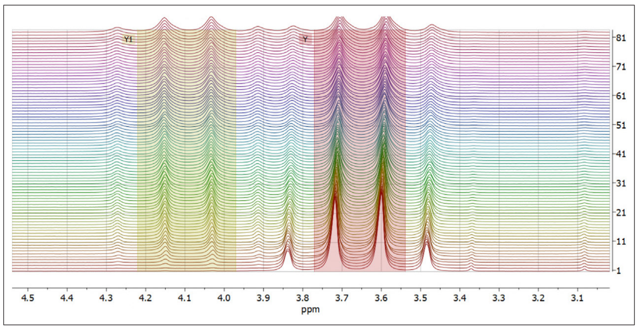
Esterification monitoring using X-Pulse: calculation of activation parameters

Esterification is a chemical reaction involving an alcohol and a carboxylic acid (or an acid anhydride). Many esters have distinctive fruit-like flavours and they naturally occur in essential oils and plants. For example, ethyl isovalerate smells of apple, ethyl butyrate smells of pineapple and ethyl nonanoate smells of grape.

In this application note, an X-Pulse spectrometer equipped with a flow cell is utilised to monitor an esterification reaction. Ethyl ethanoate (also known as ethyl acetate) is synthesised from ethanol and ethanoic acid (acetic acid) using an acid catalyst. The reaction proceeds through a series of equilibria and this means that unless the water that is produced is removed, the reaction will not go to completion. Ethyl ethanoate is important industrially as it is used as a solvent in enamels, lacquers and nail polish removers. Furthermore, ethyl ethanoate is used in the decaffeination process of tea and coffee. A flow setup will be used to monitor the formation of ethyl ethanoate over time and at different temperatures. Using this data, the activation parameters will be calculated using an Eyring–Polanyi plot.



Overlaid ^{1}H NMR spectra showing the decrease in intensity of the ethanol CH_2 peak (Y) and the increase of the CH_2 peak of ethyl ethanoate (Y1).

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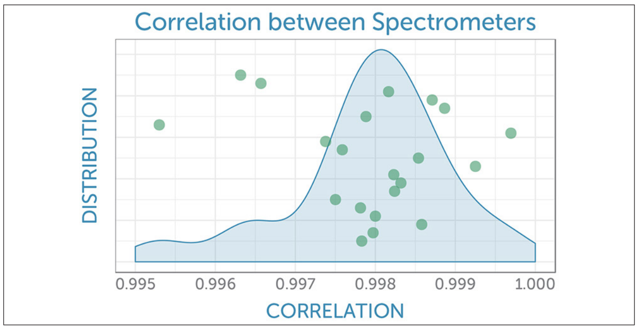
Reproducible Raman

Variety may be the spice of life, but variability is not—particularly for OEM instrument developers who must guarantee an answer based on the quality of a Raman spectrum. These answers matter, to their customers and to those affected by the decisions made based upon those outputs. A good-quality OEM spectrometer should, by design, exhibit low unit-to-unit variability from the start, and any remaining small differences should be corrected in order to achieve the most robust and repeatable analytical outcomes in the field. In this Tech Note, a method to correct for slight variations in the wavenumber and intensity response of multiple units is described, achieving better than 99.5% agreement between any two spectrometers across seven Raman spectrometers of the same model and configuration.



Wasatch Photonics

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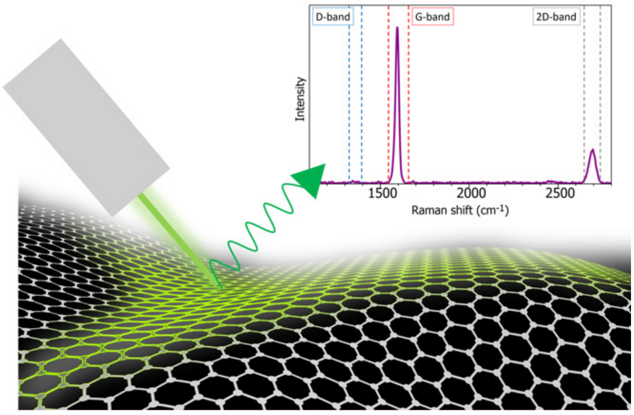

Raman microscopy of graphene

The structure and bonding of graphene make it well suited for analysis by Raman spectroscopy. Graphene is one atom thick carbon; the carbon atoms are arranged in a hexagonal lattice. The sp^2 carbon bonds result in highly polarisable ϖ bonds which give an intense Raman signal. This is because the vibrational mode is "Raman active" and this occurs when the molecular polarisability changes during the vibration. Raman spectroscopy can be used in the evaluation of graphene quality and thickness. Since Raman microscopy is non-destructive and has high spatial and spectral resolution, the technique is well-suited for gathering detailed information about the graphene film. There is also minimal or no sample preparation required for Raman spectroscopy, further adding to its ease of use and low damage risk. In this application note, an Edinburgh Instruments RM5 Raman Microscope is used to highlight how Raman microscopy an essential tool for any material scientist researching graphene.

Edinburgh Instruments

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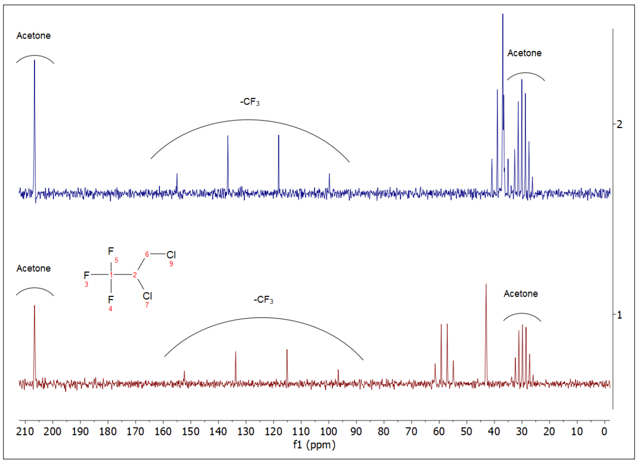
Chemical reaction feedstock troubleshooting with benchtop NMR

Benchtop NMR has many advantages over similar analytical techniques due to its high degree of chemical specificity, especially when combining information from multiple chemical nuclei. Minimal or no sample preparation and quick data generation allows the deployment of benchtop NMR in QA/QC environments without the need for operation by R&D scientists. This



saves significant time and money. One example is in the quality control of reaction feedstocks which are the raw chemical materials required to supply large-scale chemical manufacturing processes.

To confirm that lab technicians in a QA/QC environment, as well as organic, polymer and pharmaceutical chemists, can identify good or bad feedstock from a single, quick measurement, a specific industrial use case was investigated. A manufacturer of fluorochemical products sent us two samples from different suppliers. Both samples were reported to be the same reaction feedstock compound. One of the samples worked as a reaction feedstock but the second one did not. Could the samples be efficiently screened to identify the ineffective failed chemical? Importantly, was this failure due to degradation of the material, contamination, or was there another explanation?

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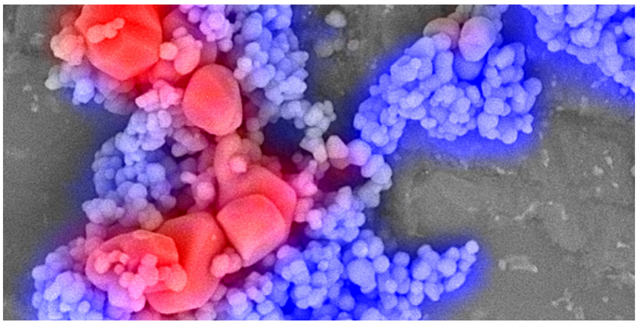

On the RISE: Correlative confocal Raman and scanning electron microscopy

RISE Microscopy combines Raman Imaging and Scanning Electron Microscopy. Raman imaging enables the identification of molecules, their allotropes and polymorphs, the determination of their orientation, purity and crystallinity, and the detection of strain states. SEM allows for the imaging of surface structures on the nanometre scale. A RISE system incorporates the advantages of both in the same vacuum chamber to facilitate the most in-depth characterisation of a sample. This application note describes its principles and associated hardware before presenting example measurements from geology, polymer science, biology, carbon nanomaterial development and transition metal dichalcogenide (TMD) research.

WITec

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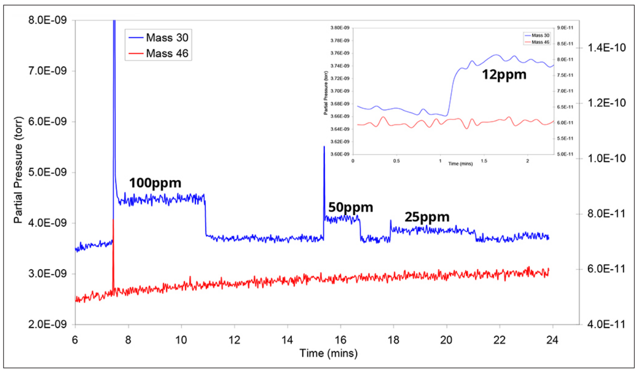

NO_x detection

One important aspect of catalysis research is the reduction of NO_x in such applications as car exhausts and power plants. This research involves many challenges in meeting current emission legislation whilst keeping catalyst cost low. Several NO_x reduction technologies have emerged in previous years, some of which have now been commercialised including selective catalytic reduction (SCR) with NH_3, urea and hydrocarbons, and NO_x storage and reduction (NSR). NSR technology consists of two cyclic steps that occur on a lean NO_x trap (LNT) catalyst. The LNT catalyst readily stores NO_2 as compared to NO. For this reason, NO should be oxidised to NO_2 to achieve an acceptable level of NO_x storage. This application note describes the measurement of NO_2 using the m/z 46 peak and the NO/NO_2 ratio in a research application using the Hiden HPR-20. The data highlights the ability of the QIC series gas analysis systems to deconvolute and quantify low levels of NO in high concentrations of NO_2.

Hiden Analytical

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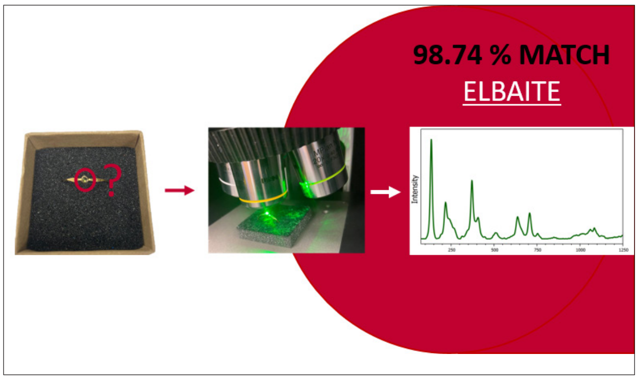
Gemstone identification using Raman microscopy

Gemstones are pieces of mineral crystal cut and polished for use in the gem and jewellery industry. The term gemstone covers a wide variety of gems, roughly over 200 types of natural gemstones exist. Gemstones can be separated into two classifications: precious stones, such as sapphires, and semi-precious, such as garnet. The value of these stones depends on their colour, size, quality and rarity. Gemstones are generally further classified into species based on their chemical composition, and these species can have several varieties. For example, quartz, with the elemental configuration SiO_2, has a large list of varieties, depending on impurities such as citrine and amethyst.

The market frequently suffers from imitation gemstones being sold claiming to be more valuable gems. Even an experienced



jeweller cannot always distinguish between real and "fake" gems and therefore additional analytical techniques are required for accurately identifying gemstones and determining quality. Raman microscopy is an ideal method for analysing gemstones and other geological samples. Raman scattering is highly sensitive to crystalline structures and the presence of minor components within a sample.

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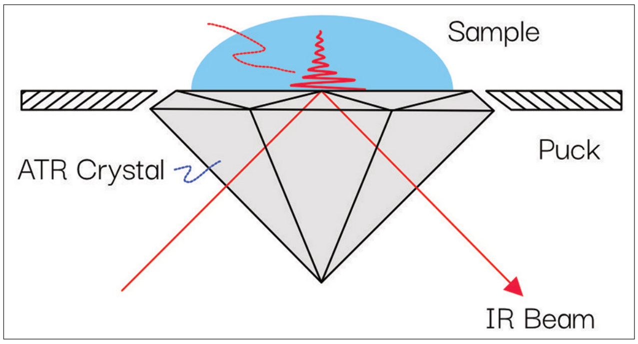

Basics of ATR spectroscopy

ATR has become the dominant method for collecting an FT-IR spectrum of solid materials. It requires little or no sample preparation and is effective at both qualitative and quantitative measurements. Compared to the older method of preparing a KBr pellet for transmission spectroscopy, important differences emerge. An ATR spectrum is not directly comparable to a transmission spectrum, although software algorithms are available in most commercial spectrometers capable of converting an ATR spectrum into a transmission-like spectrum should the analyst wish to compare them. This note outlines the basics of the ATR method, providing the analyst with the information they require to gain the most out of the technique.

Specac

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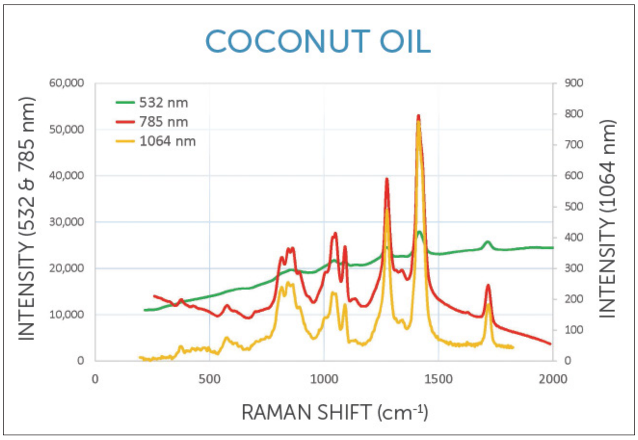

The "new" Raman

Raman spectroscopy is powerful and versatile analytical tool that is applied in a vast array of applications from materials science to medical diagnostics. In this white paper, Pro-Lite explains how a new class of spectrometers developed by Wasatch Photonics results in compact Raman spectrometers far faster and more sensitive than typical compact spectrometers.

Pro-Lite

- Download Application Note

Product Focus on Mass Spectrometry

ACD/Labs

Tel: +1 416 368 3435
info@acdlabs.com
https://acdlabs.com

PRODUCT: **MS Workbook Suite**
APPLICATIONS: Deconvoluting LC/MS and GC/MS data ▪ Extracting known and unknown components ▪ Predicting fragmentation and matching against spectra ▪ Characterising components by spectral match
KEY FEATURES: Support for data in all major instrument-vendor formats ▪ Characterising known and unknown components in complex samples ▪ Databasing of MS data in searchable format

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PRODUCT: **MS Structure ID**
APPLICATIONS: Deconvoluting LC/MS and GC/MS data ▪ Searching for unknown compounds by spectral match ▪ Searching for unknown compounds by formula mass ▪ Ranking structural candidates by predicted retention time or fragment pattern
KEY FEATURES: Automatic deconvolution and spectral searching ▪ Support for data in all major instrument-vendor formats ▪ Databasing of MS data in searchable format

BaySpec

Tel: +1-408-512-5928
info@bayspec.com
www.bayspec.com

PRODUCT: **Portability^{TM} – Portable Mass Spectrometer**

APPLICATIONS: Security ▪ Food safety ▪ Chemical warfare ▪ Pathogen detection ▪ Controlled substances ▪ Environmental air monitoring
KEY FEATURES: Portable and light weight ▪ Direct sample analysis ▪ Real-time results ▪ Rapid deployment ▪ MS/MS capability

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PRODUCT: **Continuity^{TM} – Portable Mass Spectrometer**

APPLICATIONS: Clinical diagnostics ▪ Pathogen detection ▪ Controlled substances ▪ Food safety ▪ Security ▪ Chemical warfare ▪ Environmental air monitoring
KEY FEATURES: Portable & compact ▪ Direct sample analysis ▪ Real-time results ▪ High sensitivity ▪ Large mass range ▪ MS/MS capability

Hiden Analytical Ltd

Tel: +44 1925 445 225
info@hiden.co.uk
https://www.HidenAnalytical.com

PRODUCT: **QGA**

APPLICATIONS: Environmental gas analysis ▪ Fermentation off-gas analysis ▪ Catalysis ▪ Thermal analysis mass spectrometry ▪ Gas purity analysis/contamination studies
KEY FEATURES: Multiple gas and vapour analysis—200 amu mass range, 300 amu option ▪ High sensitivity: detection to 100 ppb ▪ <300 ms response time to changes in gas concentration ▪ Fast data acquisition: up to 650 measurements s^{-1} ▪ Custom interfaces for a wide range of TGA instruments for evolved gas analysis

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PRODUCT: **pQA**

APPLICATIONS: Groundwater studies ▪ Pollution monitoring ▪ Denitrification studies ▪ Sludge and soil core analysis ▪ Oceanic gas measurements
KEY FEATURES: Multi gas/vapour analysis—user configurable ▪ Versatile user configurable instrument with a range of sample inlet systems ▪ Low volume MIMS inlet for denitrification studies ▪ Transportable case configuration with 12V operation for field studies (24V Option) ▪ Soft ionisation for reduced spectral fragmentation and simplified data interpretation

---

PRODUCT: **HPR-40 DEMS**

APPLICATIONS: DEMS – Differential Electrochemical Mass Spectrometry
KEY FEATURES: Compact bench-top mass spectrometer system ▪ Mass scanning and time/intensity trend monitoring of multiple species ▪ Modular, user configurable system including DEMS cell, Fast response (<1 s), nano-porous electrolyte/MS interface ▪ DEMS off-gas analysis capillary sampling option with micro flow inlet

PRODUCT FOCUS

JEOL USA

Tel: +1 (978) 535-5900
salesinfo@jeol.com
https://www.jeolusa.com/

PRODUCT: **JMS-T2000GC AccuTOF™ GC-Alpha Mass Spectrometer**

APPLICATIONS: Materials ▪ Petroleum ▪ Environmental ▪ Food ▪ Forensics

KEY FEATURES: GC-TOFMS with a high mass resolving power of 30,000 and high mass accuracy of 1 ppm ▪ Instrument detection limit: IDL = 18.7 fg ▪ High speed data acquisition: 50 Hz ▪ Wide mass range: up to *m/z* 6000 ▪ Available ion sources/direct probes: EI, CI, PI, FI, FD, DIP, DEP and LIFDI

PRODUCT: **JMS-TQ4000GC Triple-Quadrupole Mass Spectrometer**

APPLICATIONS: Pesticide analysis ▪ Dioxin analysis ▪ Environmental contaminants

KEY FEATURES: GC-MS/MS with short collision cell for higher sensitivity, higher throughput with shorter acquisition times ▪ Fastest SRM switching speed in the industry – 1000 transitions/sec ▪ Rapid pulsed ion ejection without crosstalk ▪ Available ion sources/direct probes: EI, CI, PI, DIP and DEP

PRODUCT: **AccuTOF™-DART 4G Mass Spectrometer**

APPLICATIONS: Forensics ▪ Natural products ▪ Materials analysis/troubleshooting ▪ Environmental testing ▪ Synthetic chemistry

KEY FEATURES: The original Ambient Ionization Toolbox™ with easy switching between ambient and atmospheric ionisation methods ▪ Powerful problem-solving tool with unlimited applications ▪ Rugged contamination-resistant analysis of wide range of substances ▪ Award-winning technology

SepSolve Analytical Ltd

Tel: +44 (0) 1733 669222
hello@sepsolve.com
https://www.sepsolve.com

PRODUCT: **BenchTOF2 – Time-of-Flight Mass Spectrometer for GC and GCxGC**

APPLICATIONS: Biomarker discovery ▪ Cannabis profiling ▪ Flavours & fragrances ▪ Petrochemical fingerprinting ▪ Odours and emissions ▪ Total petroleun hydrocarbons ▪ Environmental monitoring

KEY FEATURES: Enhanced sensitivity ▪ Superior spectral quality ▪ Improved selectivity ▪ Extended dynamic range ▪ Hydrogen carrier ▪ Both hard- and soft-EI ▪ GC and GC×GC

Shimadzu Europa GmbH

Tel: +49-203/76870
shimadzu@shimadzu.eu
www.shimadzu.eu

PRODUCT: **Red Dot awarded MALDImini-1**

reddot winner 2021
best of the best

APPLICATIONS: High-sensitivity MS^n measurements ▪ Complex structural analysis ▪ Research on glycans-related substances in the context of the COVID-19 disease

KEY FEATURES: Simple configuration ▪ Small footprint reduced to a size if paper ▪ Minimum time and micro-quantity sample volume ▪ Ion trapping up to 70,000 Da

NEW PRODUCTS

ATOMIC

Handheld LIBS analyser provides metal alloy analysis

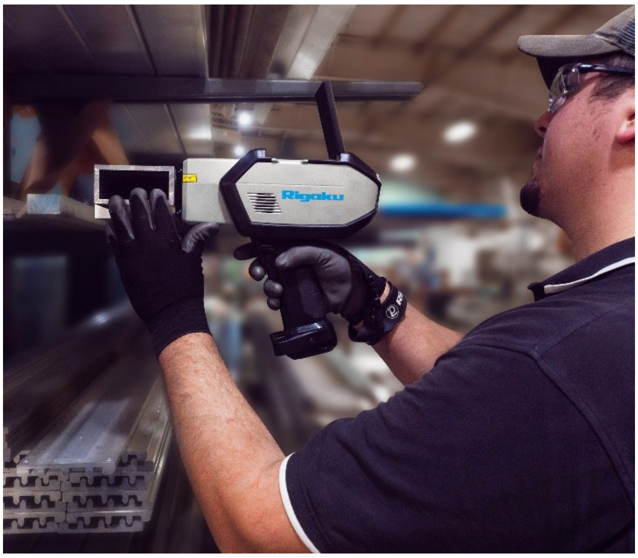
Rigaku Analytical Devices has launched the KT-500 handheld laser-induced breakdown spectroscopy (LIBS) analyser. The Rigaku KT-500 features a carbon-capable, miniaturised, high-resolution echelle spectrometer, known as HiRES Technology. It provides identification of elements that were difficult to see with previous generation handheld LIBS analysers such as carbon. This capability gives the user the ability to analyse ferrous and non-ferrous alloys on one device. The KT-500 also provides the user with better analysis of low alloy steels, stainless steels, nickel and cobalt alloys, and now carbon steels. Additionally, its carbon analysis, along with low detection limits for other key elements, makes it suitable for determining carbon equivalence as well as solving many of the key applications required in petrochemical facilities including sulfidation, corrosion and residual elements.

Designed specifically for use in industrial applications, the KT-500 has a lightweight aluminium housing, IP54 rating for protection, hot swappable batteries, multiple access user interface, facilitating single-handed operation, includes flip-up touchscreen, oversized keypad, side quick keys and integrated micro-camera, WiFi, the ability to access and download data without using third party software, and optional front plate for analysis of welds and a docking/charging station.

The Rigaku KT-500 will initially be available in North America, with global distribution later in 2021.

Rigaku Analytical Devices

- https://link.spectroscopyeurope.com/692-P1-2021



IMAGING

Vis/NIR hyperspectral microscope

The IMA from Photon etc is a hyperspectral microscope covering the visible and short-wave infrared wavelengths (400–1620 nm). This system maps photoluminescence, electroluminescence, fluorescence, reflectance and transmittance. The IMA is based on high throughput global-imaging filters, which are faster and more efficient than standard point-by-point or line-scan based systems.

SphereOptics

- https://link.spectroscopyeurope.com/1507-P1-2021

NEW PRODUCTS

MASS SPEC

New mass spectrometer from SepSolve Analytical

SepSolve Analytical has launched the BenchTOF2™, a next generation time-of-flight mass spectrometer for GC and GC×GC, that has enhanced sensitivity, improved spectral quality, heightened selectivity and an extended dynamic range. The new BenchTOF2 is small and compact and can be coupled with all popular GCs, as well as being ideal for GC×GC. It is also fully certified for use with hydrogen carrier gas. The BenchTOF2™ has detection limits of less than 20 fg, improved match factors and isotope abundancies, mass accuracy of less than 50 ppm and advanced software that includes new features such as isotope overlays, tools for automated filtering of chromatograms and a mass-to-formula calculator. It also benefits from a dynamic range spanning five orders of magnitude. Furthermore, the BenchTOF2 incorporates SepSolve Analytical's patented Tandem Ionisation®, which offers simultaneous hard- and soft-ionisation in order to simplify structural elucidation.

SepSolve Analytical

- https://link.spectroscopyeurope.com/1905-P1-2021

RAMAN

New features for Renishaw Virsa

The latest version of Renishaw's Virsa™ Raman analyser, with new WiRE™ 5.5 software, enables users to analyse samples using remote fibre-optic probes. The new system has LiveTrack™ focus-tracking technology and the new Monitor™ software module. These enable it to perform real-time analysis on large samples that have irregular surfaces, are changing shape as they undergo phase changes or that move, such as those on production lines. The Versa has a modest footprint and can be used on a bench or mounted in an industry-standard 19″ rack.

The Monitor software module allows the processing and analysis of a constant flow of Raman data, enabling changing chemical concentrations or other sample properties to be monitored. It is applicable to many applications and suited to users who are looking to understand and monitor processes in development or production stages, as well as scientists looking to track spectral changes as their experiments progress. The Monitor software module can be applied to a wide range of sampling situations including: sampling liquids with immersion probes; examining, via a window, materials in containers, vessels or reactors; and analysing the surface of a material in conjunction with Renishaw's LiveTrack focus-tracking technology.

Also new is the PLS analysis module, which has industrial and academic applications, especially in fields such as pharmaceuticals. It is now available as part of the WiRE 5.5 software. You can generate and test PLS models, and then predict values in real time (when used with the Monitor software module). Values can be predicted for any material which exhibits a spectral change, for example concentration or crystallinity changes.

Renishaw

- https://link.spectroscopyeurope.com/655-P1-2021

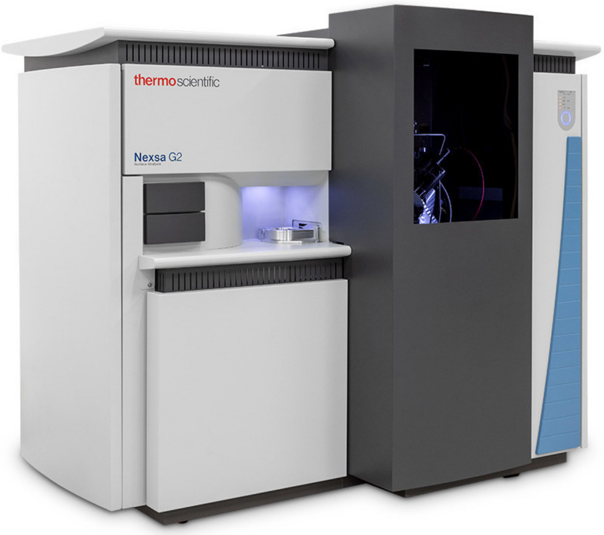
SURFACE ANALYSIS

XPS spectrometer

Thermo Fisher Scientific has announced the Thermo Scientific Nexsa G2 surface analysis system, an automated X-ray photoelectron spectroscopy (XPS) instrument. Compared to the previous Nexsa model, the new instrument's improved sensitivity detects weak signals below 0.1 Å more easily and produces reliable, high-quality data. Software improvements and improved automation enable users to strengthen data integrity and easily correlate information obtained from a range of integrated analysis techniques. New features of the Nexsa G2 include: integration of multiple analytical techniques, including a Raman spectroscopy option; sample heating and electrical biasing; next generation Thermo Scientific Avantage Data Software for instrument control, data acquisition and processing, and flexible reporting functions; a MAGCIS dual beam ion source that facilitates depth profile analysis of soft and hard materials using gas cluster or monatomic ions, which has been designed to minimise surface damage and enable research on a wide collection of materials; automation that facilitates remote access and operation.

Thermo Fisher Scientific

- https://link.spectroscopyeurope.com/106-P3-2021



UV/VIS

UV-Vis spectrometer for teaching labs

PASCO Scientific has released a new UV-Vis spectrometer primarily designed for teaching labs. The SE-3607 spectrometer provides high speed spectral scans from 180 nm to 1050 nm and includes easy-to-use spectrometry software with built-in features that improve collaboration between lab members. The spectrometer warms up in less than ten minutes and eliminates the need for complex calibrations. It is durable and has specialised features such as an internal drain, an external cuvette marking and a stabilised optical bench that ensures consistent accuracy over time (±1 nm).

The system has USB connectivity and the accompanying, cross-platform spectrometry software enables full spectral scans to be collected on a computer or laptop in less than 1 s. Once collected, spectral data can be saved, exported to Excel, printed or shared and reviewed with lab members using PASCO's free spectrometry software. A free, fully functional spectrometry app that enables students to manipulate and review their spectral data inside or outside of the lab is also available.

PASCO Scientific

- https://link.spectroscopyeurope.com/6381-P1-2021

NEW PRODUCTS

VACUUM

Corrosive gas version of diaphragm pump

Diaphragm pumps work entirely without oil, which makes them ideal for all tasks and numerous applications where a clean, dry vacuum is needed. These include laboratories, analytical systems, leak detection and research & development. Pfeiffer Vacuum has introduced the MVP 030-3 C DC, a new corrosive gas version of the diaphragm pump. This version features a gas ballast valve and excellent chemical and condensate compatibility. The special choice of materials ensures significantly increased robustness in a wide range of processes. The diaphragm pumps have a noise level below 45 dB(A). Due to their compact design and low weight, they fit very easily into small analytical systems, mass spectrometers and turbo pumping stations. As backing pumps, they complement the turbopumps from Pfeiffer Vacuum's HiPace range. Due to the reciprocal controllability, intelligent functionalities like boost mode and stand-by mode can be parameterised resulting in shorter pump down times, less power consumption and reduced wear. The diaphragm pump and turbopump can be controlled via a single Pfeiffer Vacuum control unit and supplied with power via a single common cable. This reduces the amount of cabling effort and results in lower costs.

Pfeiffer Vacuum

https://link.spectroscopyeurope.com/1821-P1-2021

DIARY

Conferences

2021

20–24 June, Duesseldorf, Germany. **51st International Symposium on High Performance Liquid Phase Separation and Related Techniques.** Michael Lammerhofer, ✉ michael-laemmerhofer@uni-tuebingen.de, 🕸 https://www.hplc2021-duesseldorf.com/

18–23 July, Boston, MA, United States. **XXIX International Conference on Magnetic Resonance in Biological Systems (ICMRBSXXIX).** 🕸 https://www.icmrbs2020.org

1–6 August, Freiberg (Sachsen), Germany. **Geoanalysis 2021.** ✉ geoanalysis2021@hzdr.de, 🕸 https://geoanalysis2021.de

23–26 August, Online. **11th International Conference on Advanced Vibrational Spectroscopy (ICAVS 11).** ✉ icavs2021@targi.krakow.pl, 🕸 http://www.icavs.org/gb/

6–10 September, Heraklion, Crete, Greece. **NanoBio Conference 2021.** ✉ info@nanobioconf.com, 🕸 https://nano-bioconf.com

8–9 September, Sheffield, UK. 🕸 **41st BMSS Annual Meeting.** https://www.bmss.org.uk/41st-bmss-annual-meeting/

20–24 September, Online. **11th International Workshop on Infrared Microscopy and Spectroscopy with Accelerator Based Sources.** ✉ WIRMS2021@spring8.or.jp, 🕸 http://www.spring8.or.jp/en/WIRMS2021/

30 September–1 October, Online and Porto, Portugal. **SensorFINT Workshop.** 🕸 https://www.sensorfint.eu/events/first-sensorfint-international-workshop-smart-spectral-sensors-for-agri-food-quality-and-process-control/

18–20 October, Trondheim, Norway. **2nd Nordic Metabolomics Conference.** ✉ mila.knoff@ntnu.no, 🕸 https://www.ntnu.edu/isb/nmc2021

31 October–4 November, Philadelphia, PA, United States. **69th ASMS Conference.** 🕸 https://www.asms.org/conferences/annual-conference/future-annual-conferences

16–20 December, Honolulu, Hawaii, United States. **The International Chemical Congress of Pacific Basin Societies 2021.** 🕸 https://pacifichem.org

2022

31 May–2 June, Kristiansand, Norway. **10th World Conference on Sampling and Blending (WCSB10).** ✉ contact@wcsb10.com, 🕸 https://wcsb10.com

5–9 June, Minneapolis, Minnesota, United States. **70th ASMS Conference.** 🕸 https://www.asms.org/conferences/annual-conference/future-annual-conferences

4–7 July, Skagen, Denmark. **International Association for Spectral Imaging (IASIM).** ✉ 2020@iasim.net, 🕸 https://2020.iasim.net

2023

29 January–3 February, Ljubljana, Slovenia. **2023 European Winter Conference on Plasma Spectrochemistry.** Johannes T. VanElteren, 🕸 http://www.ewcps2021.ki.si

Courses

2021

7–9 June, Online. **X-ray Photoelectron Spectroscopy (XPS) and Data Processing Short Course.** ✉ j.grant@ieee.org, 🕸 https://surfaceanalysis.org/Online_Short_Courses.html

10–11 June, Online. **Computer Aided Surface Analysis for X-ray Photoelectron Spectroscopy (CAsaXPS) Short Course.** ✉ j.grant@ieee.org, 🕸 https://surfaceanalysis.org/Online_Short_Courses.html

Exhibitions

2021

15–16 June, Online. ACHEMA Pulse. 🕸 https://www.achema.de/

23–25 September, Hyderabad, India. **analytica Anacon India and India Lab Expo.** ✉ sheron.david@mm-india.in, 🕸 https://www.analyticaindia.com/

28–30 September, São Paulo, Brazil. **Analitica Latin America.** 🕸 https://www.analiticanet.com.br/

3–4 November, Madrid, Spain. **Farmaforum 2021.** 🕸 https://farmaforum.es/

15–17 November, Dubai, United Arab Emirates. **ARABLAB 2021.** ✉ info@arablab.com, 🕸 https://www.arablab.com

2022

5–9 March, Atlanta, GA, USA. **Pittcon 2022.** 🕸 https://www.pittcon.org

4–8 April, Munich, Germany. **ACHEMA.** 🕸 https://www.achema.de/

24–26 November, Istanbul, Turkey. **Turkchem.** 🕸 http://www.chemshoweurasia.com/

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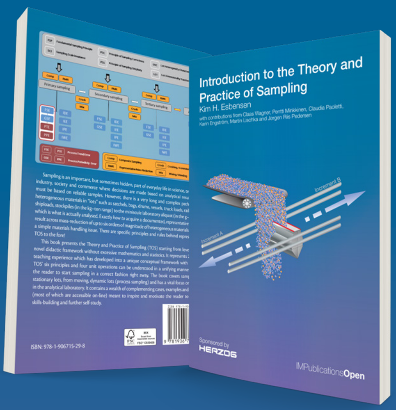
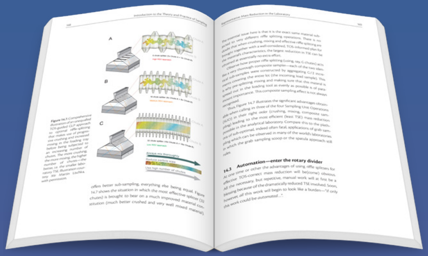
Introduction to the Theory and Practice of Sampling

Kim H. Esbensen

with contributions from Claas Wagner, Pentti Minkkinen, Claudia Paoletti, Karin Engström, Martin Lischka and Jørgen Riis Pedersen



“Sampling is not gambling”. Analytical results forming the basis for decision making in science, technology, industry and society must be relevant, valid and reliable. However, analytical results cannot be detached from the specific conditions under which they originated. Sampling comes to the fore as a critical success factor before analysis, which should only be made on documented representative samples. There is a complex and challenging pathway from heterogeneous materials in “lots” such as satchels, bags, drums, vessels, truck loads, railroad cars, shiploads, stockpiles (in the kg–ton range) to the miniscule laboratory aliquot (in the g–µg range), which is what is actually analysed.

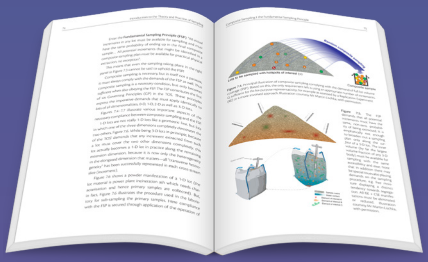


This book presents the Theory and Practice of Sampling (TOS) starting from level zero in a novel didactic framework without excessive mathematics and statistics. The book covers sampling from stationary lots, from moving, dynamic lots (process sampling) and has a vital focus on sampling in the analytical laboratory.

“I recommend this book to all newcomers to TOS”

“This book may well end up being the standard introduction sourcebook for representative sampling.”

“One of the book’s major advantages is the lavish use of carefully designed didactic diagrams”



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