Newsletter 3 (PCIG N3) - 30.11.2023

Welcome to the third edition of our newsletter!

PREFACE

This newsletter aims to serve as a means of internal communication of useful information and strengthen the engagement among the group members. This quarter's newsletter with the first edition (September – November 2023) consists of three main sections:

A. Research highlights, which represents the emerging technologies in particle characterisation.

B. People focus, which reveals the motivation and sharing from different researcher members.

C. Update corner, which summarises the new events, collaboration, and other opportunities.

Our current edition team includes **Tien Quach, Merel Bout, and Mel Disher**. We would like to express great appreciation to **the PCIG Committee** for encouraging and advising us to issue the first edition of PCIG Newsletter. Many thanks for the contribution from the people who are willing to co-operate with us. We look forward to your collaboration in the next editions!

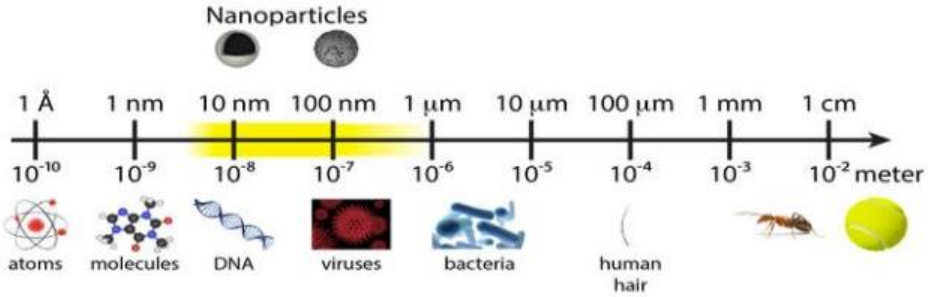
Welcome to the PCIG Newsletter,
where we network and work together for better particle technologies.

A. RESEARCH HIGHLIGHTS

Nanoparticles: Small but versatile

Written by *Merel Bout*

As we move from sub-nanometre particles (atoms) described in the previous edition, the next up on the scale are nanoparticles: a new subject applied in a wide range of fields with lots of continuous research to uncover new possibilities for them.



Representation of relative sizes of materials/objects (Image Credit: M. Bloemen (2015))

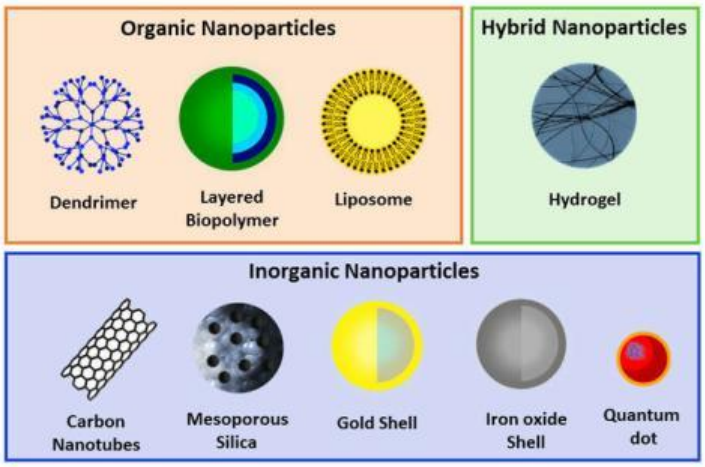
As can be seen in the graphical representation above, nanoparticles are incredibly small with dimensions typically in the range of 1 to 100 nanometres. Despite their small size, different fields can modulate their make-up resulting in various applications and possibilities. Given their increased modular surface area due to their decreased particle size, such materials can find applications across fields such as medicine, materials science, energy, catalysis, environmental remediation and electronics. Applications involve around drug delivery, structural additives, conductors, coating and imaging.

Although nanoparticles are associated with modern science, they have been used since ancient times. An intriguing example is the Lycurgus cup, a remarkable Roman artifact infused with gold and silver nanoparticles within the glass matrix. The presence of these nanoparticles give the cup unusual optical properties. When light is shone through the opaque green cup, the nanoparticles scatter the light and the cup turns to a glowing translucent red. Whether this effect was intentional or not remains unknown. Similarly, an ancient remedy for food poisoning involved activated carbon in the form of ground charcoal. The understanding at that time did not

The Lycurgus Cup changes colour depending on the light that is shine on it (reflected on the left) or through it (transmitted on the right).
Image credit: Amusing Planet (2016))

recognize that its efficacy stemmed from the high surface area of graphite layers or its particulate nature.

Nanoparticles exhibit diverse characteristics based on their size, shape, and material composition. They can be organic (liposomes) or inorganic (gold nanoparticles). Another classification is material based, like carbon, ceramics, semiconductors, or polymers. Additionally, they can be classified as hard (titanium dioxide) or soft (liposomes).



Different types of nanoparticles divided into categories (Image credit: S. Silva (2019)

Another concrete example of nanoparticles is sunscreen. In the 1990's, sunscreen contained mainly titanium dioxide and zinc oxide as physical blockers to protect against UV radiation. However, these blockers remain visible on the skin as a white cream. This caused people to avoid wearing sunscreen as users found that its cosmetic appearance was unappealing. There are now alternatives available, wherein titanium and zinc nanoparticles are incorporated into sunscreen. These particles are much smaller than those used in the original formulations, with the result that the sunscreen cream is making the cream transparent as the particles are much smaller.

(Image credit: The Guardian (2011)

Which techniques are used for nanoparticle analysis?

Two main categories of techniques are employed for nanoparticle detection: direct and indirect. For direct methods, microscopy techniques such as Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), and Atomic Force Microscopy (AFM) are typically used. These techniques enable imaging, size measurement, and shape inference but they are limited to studying a few particles at a time. In addition to that limitation, sample preparation for electron microscopy poses challenges such as introduction of artifacts or sample distortion. Nevertheless, these techniques are effective for obtaining fundamental nanoparticle information.

For indirect methods, X-rays or neutron beams are the techniques used to analyse the scattered or diffracted radiation from particles. Examples are: : X-ray diffraction (XRD), Small-Angle X-ray Scattering (SAXS), Small-Angle Neutron Scattering (SANS), GISAXS or GISANS (grazing incidence SANS or SAXS), and X-Ray or Neutron Reflectometry (XR/NR). The advantage of these techniques are that they enable simultaneously sampling and averaging large numbers of nanoparticles without specific sample preparation. Additionally, these techniques provide information about the composition and crystal structure of the samples as tested.

Currently, research efforts focus on the improvement of production methods aiming to synthesize a range of different nanoparticle types with appealing characteristics. This focus can then drive further advancements in a large variety of scientific and industrial fields.

References:

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2. https://didoofcarthage.tumblr.com/post/127854853094/the-lycurgus-cup
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4. https://www.researchgate.net/publication/330292807_Combination_of_Cell-Penetrating_Peptides_with_Nanoparticles_for_Therapeutic_Application_A_Review
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Techniques Behind Understanding Particle Properties

Written by Mel Disher

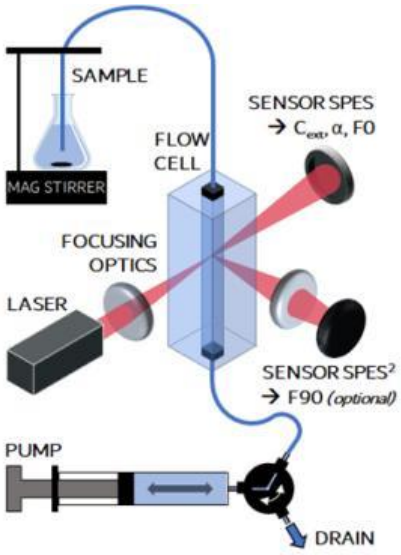
Within the PCIG we are always looking to discover new techniques to complement existing technologies in the particle characterisation field. When considering the needs of the members of the PCIG commonly desirable measurements such as size, concentration, composition, agglomeration, and internal and external loading are of interest to the research areas of group members. Samples that are difficult to characterise are of specific interest and include particles in biological, industrial, and environmental heterogeneous fluids.

In this edition of our newsletter, this article provides insight into a new technique that will be able to provide valuable insights for particles dispersed in solution. The aim of this article is to introduce readers to Single Particle Extinction and Scattering (SPES) and how the characterisation of heterogenous mixtures is made simple using this technique.

An example of set-up Single Particle Extinction and Scattering (SPES)

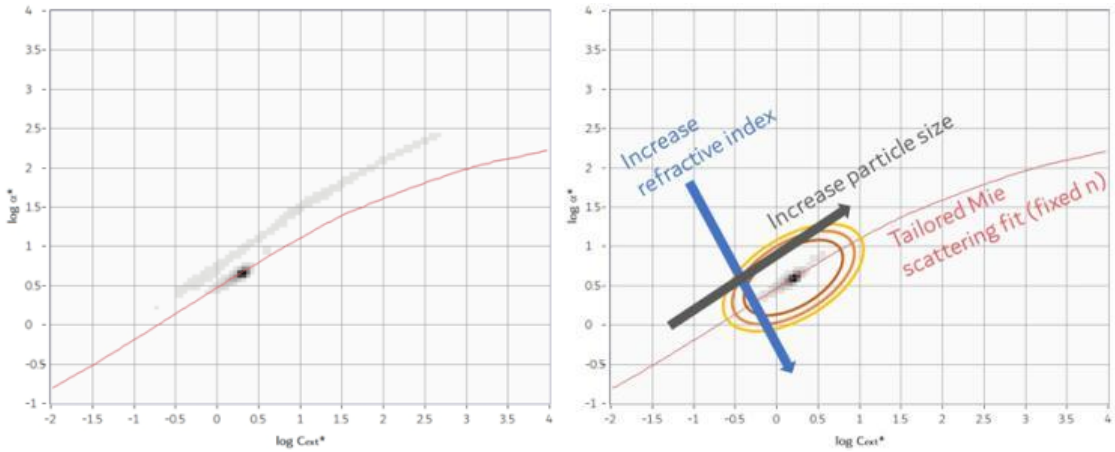
As its name suggests, this technique analyses single particles in the fluid by careful control of the flow of sample through a shaped and focussed laser beam. The particles are driven by laminar flow which enables single particles pass through the laser beam. The interference pattern between the transmitted beam and the forward scattered light is recorded on a

segmented photodiode. These interference patterns provide unique insights into the optical properties of the illuminated particle.



Particles pass through the laser beam in the SPES

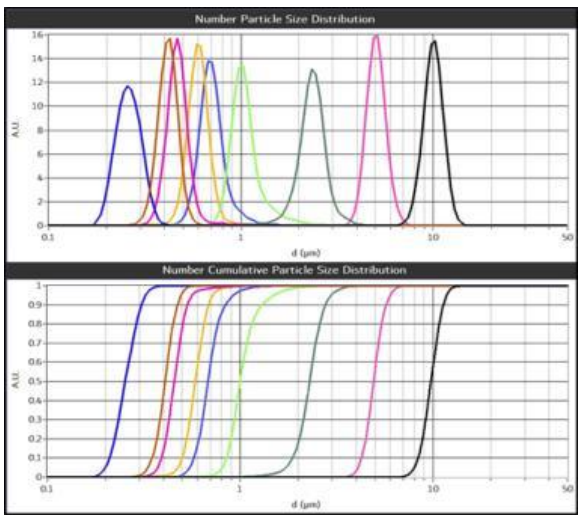
Characterisation of the scattered light provides single-particle measurements of two independent parameters: extinction cross-section (C_{ext}) and the polarizability (α). The extinction cross-section (C_{ext}), indicates the amount of energy removed by the particle when crossing the light beam and is directly related to the volume of the particle. The polarizability (α) is representative of a specific optical property which is associated to the way in which the particle interacts with the laser that illuminates it. For a sample containing dielectric particles, from the two properties (C_{ext} and α), it is possible to automatically obtain the particle diameter and effective refractive index (*n*) of the individual particles measured. The effective refractive index is ultimately related to the material, the shape, and the degree of compactness of each particle which allows the software e.g., to separate particles with similar hydrodynamic radius but with different compositions.



The refractive index is related to the particle's properties.

The two parameters (C_{ext} and α) are plotted as X and Y coordinates, respectively, to produce a two-dimensional histogram plot for all the particles in the measured sample. From the plotted coordinates, clouds develop on the histogram which are based on the optical properties of the particles within the sample. Particles of the same composition but with varying sizes produce elongated clouds, while particles of different compositions give rise to separate clouds on the histogram. From these histograms, the grey tones of the clouds indicate the numerical concentration of the particles at different sizes. Clouds can be isolated by the software and the characteristics of the particles within the clouds determined. These characteristics include but are not limited to particle size distribution, numerical concentration, sample loading and coating, as well as particle agglomeration.

Analysis can be performed on single samples or acquired in continuous flow analysis mode and particle size distributions can be determined as shown below.



Particles of different compositions produce separate clouds on the histogram.

SPES can be used to measure a broad size range of particles (from 100 nm to 20 µm) in numerous application areas from drug delivery to pigment and ink analysis. This new technique is an exciting step in particle characterisation not least due to the insights that can be gained for heterogeneous samples.

At the PCIG's next event 'Material Characterisation on the Nanoscale' on the 5th December 2023 at the RSC's Burlington House London the developer of the novel technique, Tiziano Sanvito from EOS instruments, will give a talk on SPES including a more in depth insight into the technique and examples of sample analysis.

Sign up to the event using the following link to attend this talk and many more exciting presentations on an array of particle characterisation techniques: Material Characterisation in the Nanoscale

References

1. Tiziano Sanvito et al. 'Single particle extinction and scattering optical method unveils in real time the influence of the blood components on polymeric nanoparticles'. Nanomedicine: Nanotechnology, Biology, and Medicine 13 (2017) 2597–2603

B. PEOPLE FOCUS

New series "Conversation with our inspirers"

WHY JOIN US?

+ We love to understand your technical and social experiences, especially your untold stories throughout the learning and working journey.

+ We would like to motivate more students - researchers to follow their passion and careers in particle science.

+ We believe a single effort and contribution to help make our world better should be recognised and spread out.

HOW?

If you are interested in participating, please contact us for more details!

Our first inspirer Phil Jackson

"Knowledge is Confidence"

Phil Jackson is a Technical Consultant at the Formulations Team, Lucideon Company. He is also a member of the PCIG Committee. He is speaking to Tien.

Briefly, what excites you about your work?

I work as a technical consultant for a company that provides material solutions for clients. The sheer variety of industrial sectors that I work with means that no job or day at work is ever the same. I also like that we get the hardest challenges - the easy stuff is usually solved by clients in-house, so we only get sub-contracted on the toughest assignments. We always work with the client, recognizing their in-house expertise and seeking areas where we can augment.

What is the coolest thing about your work/research?

The privilege of companies sharing with me (under confidentiality) issues that they have tried to solve in-house. I love the challenge of asking pertinent questions to arrive at a full understanding of the problem/challenge. Once I have a clear picture, I can propose work to enhance the client's understanding and ultimately provide solutions. I never work alone - having a team of trusted technical colleagues at Lucideon to call upon is essential to gaining

client trust and ultimately winning the business. I have found that the longer you work in the technical consultancy sector, the more likely you are to apply past learnings to new challenges.

How did you end up here? Why did you become a scientist? What drew you to this field? What makes you get up in the morning?

I graduated as a chemist and stayed on to study for a PhD. At that point, I decided that I had had enough of academia and wanted a fresh challenge that still allowed me to apply the Chemistry knowledge I had gained. Securing a job as a scientist at the (then) British Ceramic Research Association allowed me to learn about ceramic processing. The knowledge needed was based on the control of powders and powder suspensions, so I started to develop the skills of a material scientist rather than a chemist. As the UK ceramic industry declined, the company re-invented itself as a materials solution provider. Fortunately, it became apparent that control of powder and powder processing, together with knowledge of ceramic processing routes was relevant to a host of other sectors. Thus, I have faced client challenges in pharmaceuticals, consumer goods products, nuclear, and agriculture to name but a few.

The following slide illustrates some of the many products I have worked on as a consultant. It also explains how the transition from “ceramic-only” work came about.

Particle science or particle research that I have been working with (photo provided by the author)

How do you (re)gain your motivation in work/research at some challenging time?

Jon Binner (now at the University of Birmingham) told me "Never take yourself too seriously". If you have a big ego you have a long way to fall when you fail or start to struggle! Humility helps. I would also say walk away from the challenge for a while then come back refreshed.

Can you share with us the inspiring quote(s) that you will never ever forget?

I'll give you two! "Knowledge is Confidence". So, the more you work in your chosen area, the less likely you are to come across challenges that floor you. Instead, you are more likely to have previous experience to call upon and re-apply.

As part of gaining knowledge, it is important to ask open questions so that you get detailed answers. So, the following lines from a Kipling poem I found useful:

I keep six honest serving-men
(They taught me all I knew);
Their names are What and Why and When and How and Where and Who.

Get to know

We can understand the research interest and career pathways from our PCIG members. We will start with an overview of two of the Committee members, but please contact us to share your background and experience in future newsletters.

Karen Pardoe, MSc, MRSC CChem, FIFST

"Throughout my career, I have had the opportunity to work on the global scale through influencing individuals, providing technical support, and writing or advising on international test methods."

I am enthusiastic about Chemistry and enjoy engaging with people from all sorts of backgrounds. It is often highly entertaining to introduce myself as being a professional scientist. I have over 30 years of technical experience in laboratory analysis, legislative compliance, development, and auditing. Most of that time was within the food and animal feed sectors, but I have also worked in pharmaceutical monitoring and research.

Some of the pharmaceutical work I did include supporting the police in drug investigations, but there was also the opportunity to develop a novel HPLC separation as part of a fraud investigation. I have been working as an independent consultant, providing technical support in a variety of areas, since the department I worked in at British Sugar was made redundant. I am Canadian but have lived in the UK since the early 1990's. My BSc degree is from the University of Saskatchewan and my MSc is from the University of East Anglia. I was always most interested in instrumental and statistical analysis, so my MSc focussed on analytical chemistry. I have been responsible for developing and implementing a variety of test protocols, training procedures and industrial plant improvements over the years of my employment. Throughout my career, I have had the opportunity to work on the global scale through influencing individuals, providing technical support, and writing or advising on international test methods.

I have been a member of the PCIG for many years and have attended several events held by them. I have a keen interest in particle characterization, as both size distribution and shape can have significant effects on how bulk materials are handled and sampled for laboratory testing. There are many interesting areas that the PCIG can explore that would help people better understand their processes and products.

Steve Ward-Smith, PhD, MRSC

"Dr Steve Ward-Smith is a Large and Strategic Account Manager at Malvern Panalytical. He has been with the company since 1995 and was the first laser diffraction technical specialist in the business".

Steve has a PhD in Chemistry from Nottingham University (Colloids) a Masters from Leicester in Biomolecular technology and a Degree in Chemistry from Manchester University. He is the current convenor of Working Group 5 in displacement counters (Coulter principle) in ISOTC24 SC4 and is the chair of ISOTC281 in Fine Bubble Technology. With the latter post, Steve is interested in applications and measurements of all bubbles, particularly in the food and pharmaceutical sector

Inspiring stories

Do not hesitate to share your stories to motivate other researchers and students. You can write about the people, the events that motivated you throughout your learning, working and research (either the good or the bad things happened). We look forward to hearing from you.

C. UPDATE CORNER

PCIG committee member Phil Jackson recently attended the UK Society of Biomaterials annual conference at Ulster University, Belfast. We asked him about the event and his thoughts on the role particle characterisation is playing in the development of novel biomaterials. He is speaking to Mel.

Q: Firstly Phil, tell us a little about yourself and why you attended this conference!

A: I have worked at Lucideon Limited (formerly Ceram Research or the British Ceramic Research Ltd) for over 36 years. As the UK ceramic industry went into decline the company became a general Materials Consultancy and Testing organisation. We work with many industrial sectors on confidential one-to-one projects aimed at helping clients make existing products more efficiently or develop new improved products. As a company we also perform internal R&D to generate novel Intellectual Property for licence. My focus for the past 10 years has been healthcare and consumer products where powder suspensions and emulsions feature heavily. Since a good percentage of our projects relate to hard and soft tissue replacement, attending this event was important.

Q: That's interesting and leads on to the question "how do you know which industrial sectors (and so associated conferences) have a strong focus on control of particles?

From my days working as a Technology Translator with PowderMatrix (part of the Materials KTN) an oft-quoted fact was that 65% of all industrial production involves powders. So, in that respect, most material-related conferences are likely to feature powder processing. If you are interested in each industrial sector, it's useful to read up on the typical process steps used to see how regularly powders feature. There are certain methods of making powders (crushing then milling; precipitation) and processing steps (pressing of powders, extruding of high solids content pastes etc.) that feature in a wide range of industries.

Q: Could you provide a quick summary of the event?

A: It was a two-day event comprising a mixture of oral presentations and posters. The sessions featuring quickfire, 5-minute presentations (ideal for students who had just started their research work) were especially informative. Attendees were almost exclusively academic. The quality of presentations was excellent with a sound awareness of the healthcare needs and novel end products that research could ultimately deliver.

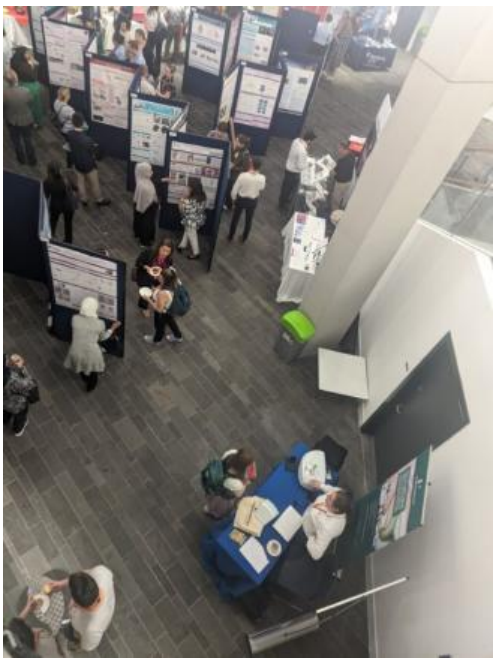


Image credit: Photo provided by Phil

Q: So, what are some of the key healthcare needs?

A: There was a lot of research presented on bone replacement driven by osteoporosis and diabetes. Including anti-bacterial coatings to prevent infection after implant was a strong driver as was the need for making gradient materials to mimic bone to soft-tissue cartilage junctions. Other hot topics included wound dressings, avoiding urinary tract infection from catheters, alternatives to antibiotics (in, e.g. inhalable drugs) and getting therapeutic actives to a key target area in the body.

Q: Where do you see particle characterisation playing a significant supporting role in biomaterials development?

A: The short answer is “everywhere”! But there were some especially strong connections for me. For example, with additive manufacture (AM) using powder / polymer composites featuring strongly in biomaterials research, understanding how weight% powder and powder particle size distribution affect rheological properties at room temperature (e.g. AM via ink jet printing) and elevated temperature (AM using Fused Deposition) becomes important.

Nanomaterials such as nano-hydroxyapatite are being seen as an important player in targeted drug delivery, so reliable nano-particle sizing becomes a strong need. The ability of the afore-mentioned nano-particles to attract and hold optimum levels of drugs or (positively charged) anti-bacterial agents depends very much on the initial surface charge (ζ-potential). Nano-particle surface charge also impacts their mobility through body fluids towards target sites.

Q: Thinking about students looking for an industrial career build around particulate processing and analysis, do you have any advice on what steps they might take?

Interestingly, UKSB 2023 did feature a short Q&A session in which students thinking about moving from academia to industry were able to ask for advice.

For students with a PhD, I would suggest they consider the Knowledge Transfer Partnership (KTP) scheme. KTP is about taking expertise at a university and implanting it in a company. At Lucideon we have a KTP associate setting up a cell test lab for us, something we've never been involved with before. Our associate is responsible for finding a site for the lab, buying the necessary equipment and demonstrating a functioning cell test lab for R&D purposes. Training existing Lucideon staff is also part of the brief. This happens over a 30-36 month period. At the end there is a good chance the associate is employed. Spending a prolonged period at a company is the best interview opportunity you can get! KTP is a government scheme that seems to be expanding rapidly now too.

Similarly, for undergraduates, I would suggest looking for 1-year placements as part of your degree. Again, speaking from experience, Lucideon has had tremendous success offering placements to students. The quality of student has always been excellent, and it's been rewarding seeing students grow during the year, gradually taking on responsibility for confidential commercial work (including presenting to customers).

Finally, Centres for Doctoral Training (CDT) also assist with the university to industry transition. If you wish to find out more, please follow this link to view abstracts for the talks / posters that featured at the event: https://www.uksb.org.uk/wp-content/uploads/2023/06/Abstract-Book-Programme.pdf

Upcoming event

The PCIG are delighted to announce that on the **5th December 2023**, we will be holding our latest conference **'Material Characterisation in the Nanoscale'** at the home of the **RSC Burlington House in London**.

This meeting is a great chance to hear talks on a wide range of characterisation techniques from experts in the field of characterisation. Our speakers include Dr Andy Stewart, UCL, giving a talk on Transmission Electron Microscopy for Nanoparticle Characterisation, Dr Tiziano Sanvito, EOS instruments, with a talk titled 'Deliver single particle optical classification of liquid mixtures via Classizer™ ONE based on SPES / SPES2 technologies.' alongside many of our committee members who will also be giving talks. This jam-packed day will be both educational and insightful with the aim of learning more about the complementary techniques that help us solve the jigsaw puzzle that is particle characterisation.

Material Characterisation in the Nanoscale

5 December 2023 09:30-16:00, London, United Kingdom

Sign up here: [Material Characterisation in the Nanoscale]

Apart from being excited for this conference a PCIG Committee Meeting will follow the event, which will be held in-person, for all committee members able to attend. Not only will we have future events to discuss but also new committee members to meet for the first time.

CONTACT US

Visit our website for further information: **https://www.rsc.org/membership-and-community/connect-with-others/through-interests/interest-groups/particle-characterisation/**

Do you have any questions, feedback or are you willing to contribute as a collaborative writer? Please email the RSC-PCIG Particle Newsletter Team via: **Particlenewsletter@gmail.com** and we will get back to you.