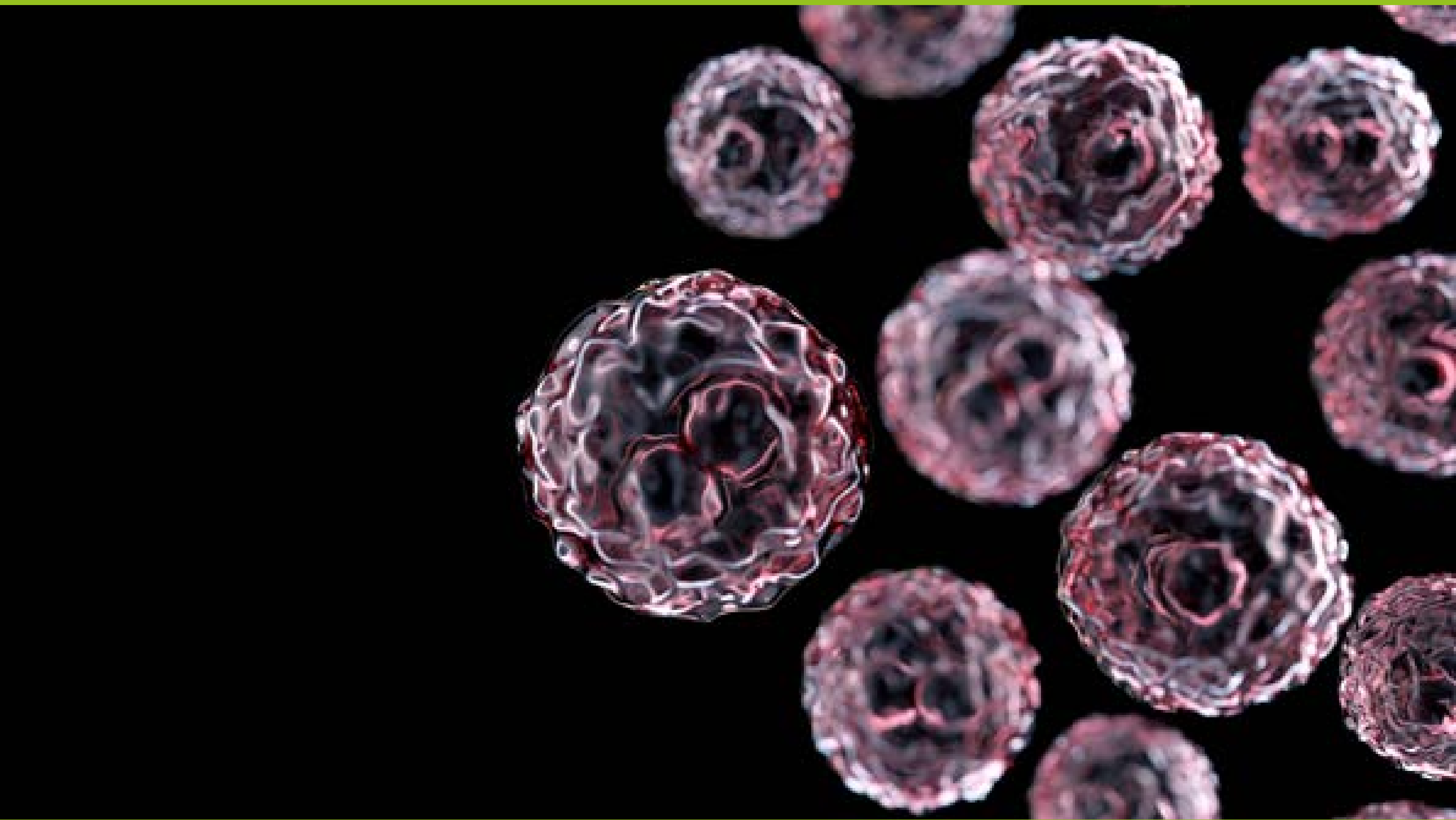
European Metrology
Research Programme
Delivering Impact



Measuring nanoparticle shell thickness

The use of chemically functionalised, coated nanoparticles is on the rise in a wide field of applications, including medical diagnostics, catalysis, and optoelectronics such as photovoltaic devices. However, industry required an ISO technical report as a first step to standardisation detail current best practice in the measurements of chemical surface properties and coating thickness ('shell thickness') of these core-shell nanoparticles.

Europe's National Measurement Institutes working together

The European Metrology Programme for Innovation and Research (EMPIR) has been developed as part of Horizon 2020, the EU Framework Programme for Research and Innovation. EMPIR funding is drawn from 28 participating EURAMET member states to support collaborative research between Measurement Institutes, academia and industry both within and outside Europe to address key metrology challenges and ensure that measurement science meets the future.

Challenge

Nanoparticles are becoming increasingly used in a wide range of areas, and thus are expected to soon have a significant economic and environmental impact. In health they are used for targeted drug delivery, and in the energy sector they are used in photovoltaic technologies to improve solar cell efficiency compared to conventional materials. Due to the wide range of fields that coated nanoparticles are used in, they are increasingly customised to have specific properties, thus increasing the need for accurate and traceable methodologies for nanoparticle characterisation. This project built on the EMRP project BioSurf which first started developing analytical protocols for nanoparticles. The shell thickness and surface chemistry of coated nanoparticles can give valuable information about the behaviour of the nanoparticle, and how it interacts with its environment. The shell thickness of coated nanoparticles can be measured with electron spectroscopy, for example X-ray spectroscopy (XPS) or Auger spectroscopy (AES). However, these measurements need to be reproducible and accurate, as well as consistent between different analysts and instruments. Before the ESCoShell project, there were no standards or technical guidelines regarding measurement of the shell thickness of coated nanoparticles.

Solution

The project worked through the International Organisation for Standardisation (ISO) to prepare a technical report, specifically within ISO Technical Committee 201 'Surface chemical analysis'. The report describes the state-of-the-art methods for using electron spectroscopy to measure shell thickness, discusses their benefits as well as their limitations and offers guidance on choosing the appropriate method to conduct measurements of nanoparticle systems. Different electron spectroscopy methods, including XPS, AES and synchrotron techniques, are described and how they can be used to determine the shell thickness as well as the chemical composition of coated nanoparticles. This information allows analysts in industry, academia and at national metrology institutes (NMIs) and designated institutes (DIs) to make appropriate choices when collecting and analysing spectroscopy data from coated nanoparticles. The project leader won an ISO excellence award for the publication of this ISO technical report. This ISO document forms a basis for the development of future full, normative ISO standards providing exact methodology to be able to measure shell thickness and chemistry of core-shell nanoparticles using electron spectroscopy.

Impact

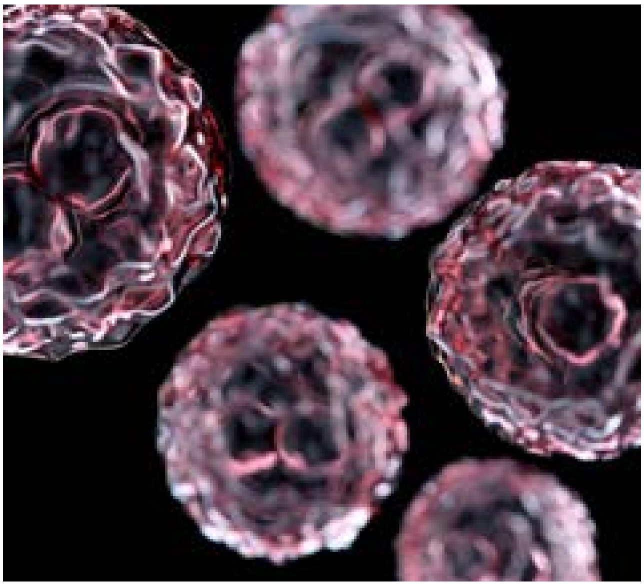
The ISO technical report 23173 provides guidance which helps enable industries to commercialise nanoparticle-based technologies more quickly and provide consumers with greater confidence in coated nanoparticle applications. Additionally, having a better understanding of these features is helpful in the development of novel nanoparticle technologies, as well as researching future applications of coated nanoparticles. The full extent of the wider economic impact of nanoparticle-based technologies will become clearer in future years. The market potential of nanoparticle/nanocarrier based technologies in drug delivery is expected to exceed $130 billion (USD) in the next five years. Similarly, nanoparticle-based catalysts are expected to have a market size of approximately $30 billion (USD) in the next 10 years. The ESCoShell project also has a positive environmental impact, as several nanoparticle-based technologies enable consumers and industries to use greener alternatives compared to conventional technologies, for example photovoltaic technologies or lighting and display applications. The new technical report will also help to create further impact from the EMRP project BioSurf, as it builds on their developments.

Establishing accurate and traceable measurements of nanoparticle properties

The ESCoShell project developed the first ISO technical report detailing current best practice guidelines for measurements regarding nanoparticle shell thickness and surface chemistry. It gives an overview of various electron spectroscopy techniques that can be used for measurements of nanoparticle systems, as well as offering guidance for choosing the appropriate method.

The project published two open-access papers to communicate their findings with the wider scientific community. The first paper discussed characterisation techniques to detect nanoparticles with non-ideal core-shell morphologies, while the second paper focused on identification and quantification of non-uniform shell thickness and incomplete encapsulation. Additionally, the project presented at 15 European and international conferences, which included six invited talks that highlight the interest of the measurement community in this project.

These results will help aid the development of new normative standards on the measurement of core shell nanoparticles that now need to follow. It will help develop nanoparticle-based applications, as well as aid the commercialisation of existing technologies by increasing confidence amongst the consumers as well as the manufacturers.



Abstract 3D nanoparticle spheres

EMPIR EURAMET

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

www.euramet.org/project-17SIP03

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11326/0623 - 17SIP03