Nanometrology: An Emerging Priority for the Asia-Pacific Region

Metrology Asia Pacific

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Key messages

- **Nanomaterials are in widespread use in numerous sectors, including energy, food, health, environment, industry, and infrastructure.**
- **To safeguard human health and environmental well-being, and to promote responsible innovation, it is vital to prioritize reliable, accurate characterization of nanomaterials.**
- **Utilization of internationally recognized measurement standards and definitions for nanomaterial characterization will help ensure consistency and comparability across different products and regions.**
- **Policies, regulations, or legislation are required to support the development of nanomaterials metrology across the Asia-Pacific region.**

What's the issue?

According to the International Organization for Standardization (ISO), a nanomaterial is a *"material with any external dimension in the nanoscale or having an internal structure or surface structure in the nanoscale"*, with the nanoscale defined as the *"length range approximately from 1 nm to 100 nm"*. [9]

At this length scale, unique properties can emerge in materials, with nanomaterials behaving very differently from their bulk form. This has resulted in significant research interest and a growing understanding of how to create and tune nanomaterials to optimize them for use in a wide range of applications.

Over the past decade, nanomaterials of all types have become increasingly common in a range of sectors, including energy, food, health, the environment, the automotive industry, and infrastructure.[1] Everyday consumer products such as sunscreen, cosmetics, sports equipment, textiles, and electronics have been enhanced using nanomaterials.

However, there are still unanswered questions about the use of nanomaterials; not least their potential impact on human health. For example, there is evidence that chronic exposure to certain nanomaterials could lead to genetic damage and that nanomaterials may be able to accumulate in internal organs (e.g. the heart and liver). [3, 8]

In addition, measurement standards and techniques that can be used to reliably characterize nanomaterials are still under development, and not widely accessible to all economies. In some cases, disagreement remains around the definition and classification of nanomaterials.

Nanomaterials (NMs) classification based on dimensionality

Chart adapted from Amer S. El-Kalliny et al. (2023)
DOI: 10.1186/s11671-023-03787-8

Why is this important?

Metrology, the science of measurement, is vital for scientific and technological progress, supporting manufacturing, trade, and consumer confidence. Similarly, nanometrology – which focuses on measurements and standards related to nanomaterials – needs to be at the heart of all future applications of nanomaterials. It provides the ability to assess any potential hazards and to ensure the safe handling, usage, and disposal of nanomaterials, minimizing the risks to human health and the environment.

Efforts to harmonize nanomaterial information and guide their regulatory use already exist, such as a European Commission recommendation aiding nanomaterial identification.[4] Adopted in 2022, it is now being used to support vital legislation like REACH – the main European Union (EU) regulation on industrial chemicals.[16] In contrast, the Asia-Pacific region lacks a unified approach, with each economy following its own regulations.

Initiatives for assessing and approving nanotechnology -based products, to enhance consumer protection and promote development, exist in countries such as India, South Korea, Iran, and Taiwan (i.e. Nano Science and Technology Initiative, Nano Mission Program in India; National Nano-safety Strategic Plan (2012/2016) and Guidance on Safety Management of Nano-based products in South Korea).[1]

While these countries lead in the Asia-Pacific, they lack specific nanomaterial legislation. Only Australia, China, Malaysia, and Thailand have enacted legislation, such as "The Nanotechnology Industry Development Act" and "The Nanotechnology Safety-Related Act" in Malaysia.[11,13] In some economies like the Philippines, nanometrology initiatives remain in the planning stage.[2]

The Asia-Pacific region is home to 60% of the world's population, and it is experiencing an increasing demand for nanomaterials in electronics, medical equipment, and automotive products[17]. In 2022, the region's nanotechnology market was valued at USD10 billion, and it is projected to grow in the coming decade.[12] With nanomaterials becoming increasingly common in products manufactured, bought, and sold in the Asia-Pacific region, it is more important than ever that all economies have access to nanometrology-related tools, standards, and international collaborations.

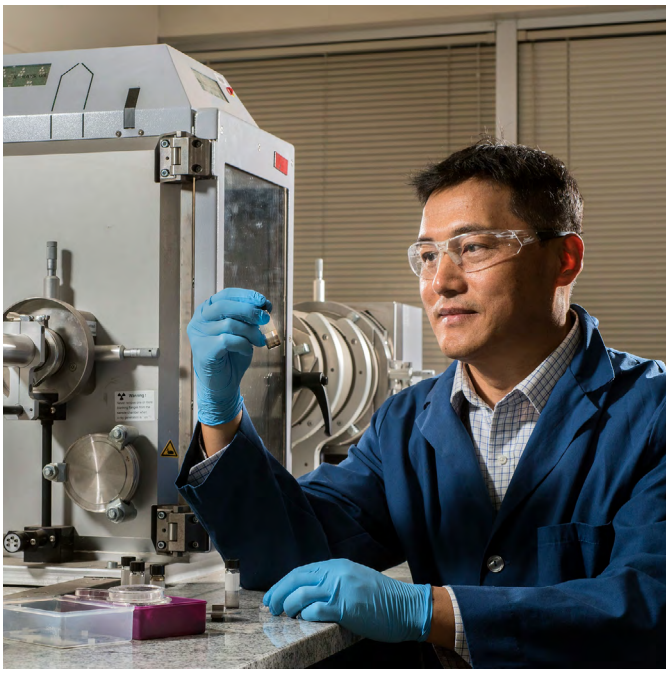
The role of metrology

Nanometrology focuses on nanomaterial characterization. It plays a pivotal role in ensuring the safety of nanomaterial-based products, through the provision of accurate measurement tools, standardized testing and characterization protocols, and standards.[15]

One of the primary functions of nanometrology is to offer precise measurement techniques for identifying the size, shape, and other critical properties of nanomaterials.[15] Unlike traditional materials, nanomaterials exhibit unique properties due to their extremely small size, necessitating specialized characterization methods. Nanometrology provides the understanding and protocols to accurately characterize these properties, ensuring that nanomaterial-based products meet safety and quality standards. Moreover, it facilitates the development and dissemination of standards and reference materials with known characterization parameters. These standards serve as benchmarks for quality assurance, calibration, and interlaboratory comparisons, ensuring consistency and reliability in nanomaterial characterization across different laboratories and organizations.

Additionally, nanometrology plays a crucial role in regulatory compliance by providing standardized measurement techniques and reference materials that enable companies to meet regulatory requirements for the commercialization of nanomaterial-based products. By adhering to nanometrology standards, companies can ensure that their products are accurately characterized and safe for consumer usage.

Overall, nanometrology is instrumental in enhancing consumer confidence, standardization, traceability, and regulatory compliance in nanomaterial-based products by providing accurate and reliable information. It contributes to safer consumer usage of nanomaterials, thereby fostering trust and promoting the responsible development and commercialization of nanotechnology.



What should policy makers do?

To ensure that the rapid advancements in nanotechnology and nanoscience are met with responsible and safe practices, collaboration across all relevant sectors is important (e.g. government bodies, policymakers, scientists, experts, engineers, and stakeholders). This collaborative effort must aim to establish clear regulatory frameworks focused on safety standards and testing requirements, thereby ensuring the safe commercialization of nanomaterials.

We encourage policymakers in the Asia-Pacific region to allocate resources for research and support for experts in the field (e.g. training opportunities for future nanometrologists, new laboratory facilities, calls for research, and more). In addition, we encourage them to establish connections between different government bodies within their economy and to work collaboratively with those focused on legal metrology.

Policymakers should contribute to building a robust regulatory framework for nanomaterials, learning lessons from international best practices, and ensuring that any new legislation is relevant across borders.

Efforts to raise public awareness about nanomaterials are also important. Policymakers should invest in campaigns to educate and engage with the public on the potential hazards and benefits of nanomaterials, empowering individuals to make informed decisions and contribute to responsible usage.

Monitoring and evaluation mechanisms should be implemented to assess the usage of nanomaterials and identify any potential hazards. This includes evaluating the environmental impact of nanomaterials, such as the contamination of water sources with nanoplastics. Comprehensive evaluation ensures the safety of the public and the environment.

By taking these proactive measures, policymakers can support the establishment of nanometrology and promote the safe and responsible use of nanomaterials. Collaborative efforts will contribute to building a robust regulatory framework, fostering innovation, and safeguarding public health and the environment in the rapidly evolving field of nanoscience and nanotechnology.

Local example: Philippines

In the Philippines, metrology is still an emerging sector and is being led by the National Metrology Laboratory of the Philippines, Department of Science and Technology, Industrial Technology Development Institute (NML Phil – DOST ITDI). We provide calibration services for measurement instruments for a range of sectors across the country, as well as acting as a source of reference materials and proficiency testing for independent testing laboratories. With the growing use of nanomaterials for different purposes, there is an urgent need to initiate a dedicated nanometrology programme and develop a globally-recognized competence in nanotechnological matters.

In 2009, the Department of Science and Technology-Philippine Council for Advanced Science and Technology Research and Development Council (DOST-PCASTRD) created a 10-year strategic roadmap that established nanotechnology as a priority for the Research and Development sector. [5, 6, 14] A preliminary budget of USD 60 million prioritized research in the areas of semiconductors, information and communication technology, energy, agriculture, health, and the environment concerning nanotechnology. [2]

This initiative supported the development of the nanobiotechnology laboratory at the University of the Philippines Los Baños, which focuses on the creation of nanofertilizers and nanobiosensors for plant growth and yield, as well as the detection of biological and chemical contaminants in agriculture and food safety applications.

Notable products that have resulted from this work include nanosilica-based fertilizers, fruitect® coating technology, and nanoencapsulated plant growth regulators. It also supported various biotechnology research projects, including one on disease detection, conducted by the National Tuberculosis Reference Laboratory of the Research Institute for Tropical Medicine in Muntinlupa City, and the Alocilja Nano-Biosensors Lab of Michigan State University. [14]

Other milestones include the development of organic packaging materials made from clay and starch with nanotechnological advancements, and the creation of Nanolabs, a company that provides technical services and "nano" solutions for local industries. Nanolabs and other cooperating agencies have since facilitated research initiatives into topics such as nanostructured solar energy devices, nanosensors for environmental assessment, mesoporous silica nanoparticles for gene transformation of plant and animal cells, carbon nanotubes for fabricating stronger materials, and more. [5, 7, 10] In 2021, DOST published a new Nanotechnology Roadmap that looks to 2028. [18]

Creating a dedicated nanometrology focus in the Philippines will support nanotechnology advancement in the country and, through the provision of accurate and reliable information, will enhance consumer confidence, standardization, traceability, and regulatory compliance in nanomaterial-based products.

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