STANDARDS FOR NANOTECHNOLOGY IN MEXICO

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Abstract
Nanotechnology has become important for societies, a number of products based on n-materials are already found in the market. Nanometrology is following up to support measurements in science, technology development, manufacturing, use and disposal of such products. We present the status and trends of nanometrology in Mexico, along with the needs of research and development organizations, industry and society, and consideration to the scientific findings on human health.

Introduction
Nanometrology, n-metrology, is vital for nanotechnology. n-metrology is a recently named discipline that gathers a number of previous activities with a high level of development. Micrometrology turned into n-metrology when one or more dimensions of interest was contracted into a scale of 1 to 100 nm, the accepted scope of n-metrology [RS]. Papers on thin layers written years ago lie now under n-technology; more recently, systems showing two (n-tubes) or three (n-particles) dimensions within the n-metrology scope deserve the attention of n-metrology as well. Besides length, other quantities like hardness, chemical activity, thermal conductivity, and other properties are subjects of study for n-metrology as well.

Usually some period of time elapses from scientific discovery to the establishment of suitable measuring standard. Now, n-metrology is already demanded for supporting n-measurements. Calibration of optical and electron microscopes by means of diffraction gratings is already extended; calibration of gratings by optical diffractometry is regarded as a suitable technique for this purpose [Bisi]. Metrological services addressing length n-metrology are starting to appear in the database of the CIPM-MRA, as examples, calibration services of gratings from 100 nm, [IMGC-MRA and NIST-MRA] as well as thin layer thickness measurement services starting at 5 nm [PTB-MRA] are already published. Evidence of improving reproducibility on some n-length measurements is now available through intercomparisons on pitch and height gratings measurements [Koenders]. However, the need to further efforts on metrological references at the nano level should be recognized, in such a way to avoid the inconveniences of the top-down processes. Dimensional features of crystal structures seems best suited for this purpose. In conclusion, there is a number of issues in n-metrology for which measurement methods, properly established, validated and accepted are still to be developed.

On the other hand, as in other scientific and technological advancements –radioactivity and mercury vapours as examples-, society is already exposed, often without prior notice, to products –including services- containing n-materials, whose innocuousness to the human health has not been sufficiently assessed: n-materials included in industrial products like paints and coatings in cars, and daily used products based on n-materials like cosmetics, sunscreens, treatments for avoiding odours in cloths, air purification services, are already found in the end-user market, see [tipe] as example. In this work, addressing human health implies environmental issues as well.

There are indications that the large surface characteristic of n-materials leads to high chemical reactivity and thus to a greater risk compared to the same material in other, larger-scale, presentations [Oberdöster]. Some authors propose the presence of transition metals as an explanation to these effects [Donaldson], others have found that the presence of other apparently innocuous materials like carbon may represent a risk factor when are in the form of n-materials [Brown]. So, it may be assumed that due to their dimensions and state of aggregation, n-materials present potentially high risks for human health, especially if the exposure times are long like in manufacturing plants of products using n-materials or scientists working on research in this area.

It is not surprising that some warnings have been raised on the potential risks of the indiscriminated handling of n-materials without some certainty about their toxicity [Coe]. While more research needs to be done on this issue, governments have an option to at least reduce those possible harmful effects, by developing normative standards that require verification through actual measurements, as it seems already done in some economies.

Status and trends in Mexico

Mexican researchers have been quite active in the field in highly mature research and development groups, most of them located in the academy, working in areas like properties of thin layers, and most recently in properties of n-materials, whose results amount to numerous papers in widely recognized journals [see CIMAV as an example]. By contrast, Mexican industries have shown scarce interest in n-technology, as oppose to those economies where the main drive for technology development comes from industry. Many major industries in Mexico are foreign-owned and use technology from abroad, often following policies from their corporate offices.

Some efforts have been done in Mexico to promote technology development. In order to address Micro Electro Mechanical Systems -MEMS- technology, a program was started in 2002 resulting in the implementation of a network of laboratories in four academic organizations to characterize and test prototypes, manufacture sensors and devices at a lab scale, and encapsulate MEMS [CAPMEMS]. Recently, the proposal NANOMEX has been submitted to the National Council for Science and Technology –CONACYT- aimed at n-technology and n-metrology developments.. Up to now, this initiative brings together 23 R&D organizations and 8 industries to develop n-technology, including CENAM. This project is a synergic effort to better use the national capabilities on n-technology.

CENAM participation in this proposal does not preclude its attention to service demands coming from others out of the proposal, neither on n-metrology nor any other fields. Obviously, CENAM resources to attend these demands are not and will not be enough, so selection of projects and cooperation with national and foreign organizations are imperative.

CENAM has experience in particle size measurements, and participated and coordinated intercomparisons at values around 100 nm in polystyrene samples. It is also experienced in measuring grids at the micrometer level.

Development lines on n-metrology at CENAM

Taking into consideration the specific situation in México, CENAM has included as a strategy to continue or extend the n-metrology activities along the following main lines:

I. Measuring standards focused in n-metrology.
II. Quantification of n-materials with high potential risk for the human health.

The first line is a duty for CENAM. As an NMI, it is expected to respond to current and expected demands for reliable reference measurement standards, mainly to support Mexican research, development and manufacturing. The second one focuses on the protection to society about the use of n-materials, specially to take care of the working conditions in organizations and industries using n-materials that would risk the human health, thus, looking for contributions to improve the living standard of the population.

CENAM projects on n-metrology

There is a number of projects in every development line, each one with its own timeline according to its pertinence, urgency, convenience and viability.

At this time, the CENAM projects corresponding to the development lines are:

I. Measuring standards devoted to n-metrology.
I.1 Certification of reference materials for particle size.
I.2 Measurement / calibration of diffraction gratings

II. Quantification of n-materials with high potential risk for the human health.
II.1 Quantification of n-particled metallic oxides, particularly of silica, iron, zinc and titanium.
II.2 Identification and characterization of n-materials: n-particles, n-tubes, n-cables, n-crystals, n-fibbers, dendrites, n-layers.

Project I.1 is fairly well developed. Some services have been performed in the range around 150 nm, and participation and coordination of intercomparisons have been done around the 100 nm value. Its extension down to the nano region is regarded as convenient.

Project I.2 is aimed at providing traceability to the measurements of microscope users, mainly in R&D organizations. It takes advantage of CENAM competences, equipment and infrastructure on measurements of grids at the micrometer level and it requires relatively low funding to complement its equipment. It is expected to offer services in the short term.

The objective of Project II.1 is to prepare chemical identification and measurement of amount of substance of those n-materials potentially harmful to human health, depending on the findings of the research on that respect. Considering CENAM competences on similar activities for other substances, some supplementary equipment is required which implies additional funding.

Project II.2 encompasses Project II.1, and it is planned to start after obtaining additional, and considerable, investment for equipment. CENAM competences are judged able to start it.

Another line on development of new n-materials and other projects on n-biotechnology, n-hardness, electrical properties of n-materials, physical-chemical characterization of n-materials manufactured by MOCVD (Metal organic chemical vapour deposition) as candidates to become certified reference materials, are being assessed.

Conclusions

Mexico has some developments on n-technology at a international level from R&D organizations, for which there is an incipient interest in industry. CENAM present capabilities, equipment and infrastructure enable it to start or extend its activities and services into n-metrology: Measurement of particle size and diffraction gratings, as well as quantifying n-materials that pose a risk to the human health are considered high priority.

Acknowledgements

The author wishes to recognize the contributions to this paper from and valuable discussions with Norma González-Rojano, José A. Salas-Téllez and Miguel Viliesid-Alonso. Also, he is indebted to Ismael Castelazo-Sinencio for reviewing the text.

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