



## SETNanoMetro Report Summary

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### Periodic Report Summary 1 - SETNANOMETRO (Shape-engineered TiO<sub>2</sub> nanoparticles for metrology of functional properties: setting design rules from material synthesis to nanostructured devices)

#### Project Context and Objectives:

Titanium dioxide (TiO<sub>2</sub>, titania) has been among the most exploited semiconductor oxides in various technological fields for many years, including the almost endless existing and potential applications involving nanoparticles (NPs).

In this respect, the SETNanoMetro project will address the following topics:

1) Perform the preparation of sets of TiO<sub>2</sub> NPs, each highly defined and homogeneous in shape, size, surface structure, to be used as such and/or in highly controlled and reproducible aggregated or assembled forms on proper supports.

2) carry out an extensive and comprehensive metrological research devoted to the characterisation and production of standardised nanomaterials, that will allow the attainment of products with defined properties and sufficient homogeneity to be considered as candidate certified reference materials. These materials/systems will then be used for measurements under traceability conditions of operational performances in some selected, actual technological applications, namely:

- Degradative heterogeneous photocatalysis
- Dye-sensitized solar cells
- Bone-substituting prostheses

A number of challenges have to be faced and solved to achieve the targeted breakthroughs in producing affordable, high quality TiO<sub>2</sub> NPs and ensuring metrological traceability and reproducibility of measurement methods of the functional properties of interest. To this end, an excellent Consortium has been created, resulting in a network of European expertise able to generate tangible results. In particular three metrology institutes, Federal Institute for Materials Research and Testing (BAM, Germany), Danish Fundamental Metrology (DFM, Denmark), National Institute for Metrological Research (INRIM, Italy), and one standardisation body, the German Institute for Standardisation (DIN, Germany) are among the partners, resulting in a significant potential for the development of traceable measurements methods which can become the basis of international standards.

As a whole, SETNanoMetro participants expect to take a huge step-forward, demonstrating the effectiveness of European Metrology research for the development and validation of design rules for engineering nanostructured and nano-enabled materials and devices.

The main objectives of SETNanoMetro are:

#### Objective 1: Modeling and formulation of standard synthetic routes to shape and size controlled TiO<sub>2</sub> NPs

Based on the aforementioned issues, a primary objective of SETNanoMetro is the development of standard synthetic routes to engineered TiO<sub>2</sub> NPs with defined size, shape and surface properties and the development of models able to predict their results.

#### Objective 2: Metrological characterization of single NPs

Possible classification of types of measurement standards will be proposed, and the role of each type of standard, including the feasibility of its establishment, will be examined (WP4). A desirable interplay between measurement standards and documentary standards in establishing the traceability chain in particle measurements will be suggested and reported.

#### Objective 3: Preparation of films made of TiO<sub>2</sub> NPs with controlled shape and size

The attainment of an effective tailoring of the assembly/aggregation of TiO<sub>2</sub> NPs will result in the possibility of producing systems (supports of given size coated with layer(s) of TiO<sub>2</sub> NPs) that could be proposed as standards, thanks of their defined and reproducible (down to a nanometric level) properties.

#### Objective 4: Metrological characterization of TiO<sub>2</sub> NPs and films

As an outcome of this study, detailed and written instructions will be prepared for the various measurement stages in order to set up a series of rules to achieve uniformity in the characterization steps. They will result in specific Standard Operating Procedures (SOPs).

Hence, with the SETNanoMetro project, we would contribute to establish a bridge between the characterization, down to an atomic level, of TiO<sub>2</sub> single crystals and nanoparticles, as well as the project should produce original and seminal knowledge about well defined surfaces of TiO<sub>2</sub> nanoparticles, with no counterparts in single crystals.

In the SETNanoMetro project, the high homogeneity in shape and size of prepared TiO<sub>2</sub> NP will be exploited to disclose methods and procedures to attain assemblies as much ordered as possible, with controlled amount, shape and relative extent of particles/voids ratio, to attain an optimized balance between interparticle aggregation/junction (required for an effective transport of charge carriers) and space for the diffusion of reactant/functional molecules.

#### Project Results:

The work performed in the first six months of the project allowed was mainly focused on the preparation of some type of TiO<sub>2</sub> nanoparticles with well defined shape and size, in loop with thermodynamic modeling and preliminary metrological characterization. The first steps toward the design rules for the standardization of the performance measurements of nanostructured heterogeneous photocatalytic systems were established and some relevant dissemination activity towards companies and the scientific community were undertaken.

In particular, the main results achieved are:

- the preparation of one type of TiO<sub>2</sub> nanoparticles with well defined truncated bipyramidal shape, exhibiting a quite low size polydispersity index
- the setting of experimental designs for the interplay between nanoparticles preparation modeling and experiments
- the fabrication of a prototype of light source appropriate for the standardization of photocatalytic activity measurements
- the creation of the web site of the project: [www.setnanometro.eu](http://www.setnanometro.eu)
- the establishment of a External Stakeholder Committee
- the starting of the road-map toward the organization of an international workshop on nanoparticles with well defined shape and size which will be held at the Ettore Majorana Foundation and Centre for Scientific Culture in Erice-Sicily, at the end of July 2015.

#### Potential Impact:

The results of the project will address the urgent need for establishing "nano S&T" normative requirements agreed at an international level. Presently, numerous standard setting organizations around the world are active in defining nanotechnology standards. The ISO TC-229 (Technical Committee on Nanotechnology) has amongst its liaison partners the Bureau International des Poids et Mesures. This confirms the importance of a metrological contribution to the normative activity of this sector and the necessity of a multidisciplinary approach. According to European Commission [EC, COM (2012) 572, 3.10.2012], important challenges at a European level are related to the establishment of validated methods and instrumentation for the detection, characterization and analysis of nanoparticles.

The pre-normative research carried out in the framework of this project will provide the necessary tools to allow for the standardisation and regulation to be correctly implemented, according to the requirements of the European Programme Horizon 2020 [EC, COM (2011) 809, 30.11.2011]. The traceable measurement methods for production and characterisation of not spherical TiO<sub>2</sub> NPs with well-defined size and shapes will have the potential to become the basis of international standards.

The outcome of SETNanoMetro is also relevant to the Surface and Micro/Nano Analysis Working Group (SAWG) at CCQM/BIPM (Consultative Committee for Amount of Substance – Metrology in Chemistry / The Convention of The Metre by International Bureau of Weights and Measures) and to the Versailles Project on Advanced Materials and Standards (VAMAS). Moreover, SETNanoMetro will directly contribute to the implementation of the agenda of the Technical Committee of Metrology in Chemistry, which is a joint TC of EURAMET and Eurachem, and, in a particular, will help to advance the following general tasks of this TC are:

- To develop, improve and apply primary methods and reference materials for chemical measurements at nano scale;
- To support and act for the development of national and international chemical measurement structures in nanometrology;
- To provide a pragmatic approach to measurement traceability and measurement uncertainty and to establish links to SI where appropriate;
- To undertake regional key comparisons and supplementary comparisons and provide links with CCQM;
- To undertake research in metrology, to support different sectors in chemistry;
- To disseminate expertise and knowledge on metrology in chemistry through seminars, guides, conferences, comparisons, etc.

The three types of application domains, environment, energy, health, where the results of SETNanoMetro will be exploited, are among the technologies which can significantly contribute in improving the effectiveness of knowledge-based responses to some relevant social issues.

The RTD activities are aimed to define standard operational procedure useful for the measurement standardization of the performances of processes for the abatement of air pollutants based on the photocatalytic behavior of TiO<sub>2</sub> nanoparticles. As recognized by the EC, a clean air supply is essential to our own health and that of the environment, and the issue of air quality is still a major concern for many European citizens.

Also water pollution is a concern for nearly half of the European population, as indicated by the Eurobarometer, as well

as one of the target of UN Millennium Development Goals (MDG), to which EU is contributing, is to halve the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015.

Dye-sensitized solar cells is one of the technology where nanostructured materials and nanotechnology can provide new and effective perspectives for the production of energy from renewable sources. As reported in the Key Messages of the "World Energy Assessment: Energy and the Challenge of Sustainability", published at December 2000 by the United Nations Development Programme, social equity issues and environmental impacts are the two most critical energy-linked threats to sustainability.

Also the biomedical branch of SETNanoMetro is expected to produce standardization results with a beneficial impact on surgical practices of interest for a relevant amount of citizens. For instance, every year, about one million patients worldwide undergo total hip arthroplasty (THA) surgery. The resulting continuous intense research efforts have produced thousands of hip prostheses designs that differ in the materials used, their shape and size and their surface properties, this last point being the main topic of SETNanoMetro.

List of Websites:

[www.setnanometro.eu](http://www.setnanometro.eu)

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## Subjects

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[Scientific Research](#)

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