Publishable JRP Summary Report for JRP NEW03 (Nano ChOp) Chemical and Optical Characterisation of Nanomaterials in Biological Systems

Background

Materials with external dimensions or internal structures in the nanometre scale develop unique properties not present in their macroscale form. These properties are increasingly being used by companies to overcome scientific and technical challenges and have led to nanomaterials being incorporated into over 1300 commercial products in a global market currently worth €9.6 billion. These nanomaterials now impact all areas of human life from medical devices and solar cells through to paints, sunscreens and cosmetics.

Nanomaterials are usually characterised for their chemical, physical and optical properties in their pure form or in simple idealised matrices. However, when nanomaterials interact with biological systems their properties can change significantly affecting their functionality and behaviour and creating a potential risk to human health. For example, when nanomaterials come into contact with a biological fluid they may become coated with proteins and other biomolecules which influences their interactions with cells (uptake, intracellular trafficking, toxicity etc.). The nanomaterials can also be transported across protective biological barriers, with recent evidence showing that nanoparticles can enter the blood stream after inhalation or ingestion. However, the potential interactions of nanoparticles with biological systems may also be a desirable characteristic, for example, in nanobiotechnology or nanomedical applications. This could involve the coating of nanoparticles with proteins for therapeutic benefit to target specific locations such as the brain (apolipoprotein E coatings) or the coating of fluorescent nanoparticles such as quantum dots with immunoglobulins for diagnostic applications.

It is therefore important to be able to demonstrate that a nanomaterial meets a specified functional demand by characterising the material within an appropriate biological system using quantitative measurements traceable to agreed reference systems.

Aims of this JRP:

The overall aim of this JRP is to develop methods to characterise nanomaterials for their physical, chemical and optical properties in biological matrices. This will be achieved by developing a series of nanoparticle reference materials (WP1) composed of metal oxide materials (to develop methods for physical and chemical characterisation), fluorescently labelled metal oxide materials (to allow nanomaterials tracking within biological systems to be performed) and a quantum dot nanomaterial (to develop methods for the optical characterisation of fluorescent nanomaterials). These materials will then be used in the following workpackage (WP) objectives:

WP2 To validate the use of a range of physical and chemical techniques for measuring the size and chemical composition of nanomaterials in a serum based biological system. Measurement techniques will cover chemical analysis (ICP-MS), light scattering (MALS, DLS, NTA), X-ray technologies (SAXS, XPS, XRF, XANES) and novel nanopore technologies (Scanning Ion Occlusion Sensing).

WP3 To develop traceable methods for the characterisation of bulk optical properties of fluorescent nanomaterials, particularly quantum yield, absorption coefficient and corrected emission spectra. To develop methods for the characterisation of fluorescent nanomaterials at the single particle level including intermittency, photo stability and environmental sensitivity in a serum based biological system.

EMRP European Metrology Research Programme Programme of EURAMET

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WP4 To develop methods for the simultaneous characterisation of physical and chemical composition of nanomaterials in cell based biological systems. (SAXS+ASAXS and FFF+MALS+ICP-MS).

WP5 To develop measurement techniques for biotechnology diagnostic applications using fluorescent nanomaterials such as quantum dots labelled with antibodies.

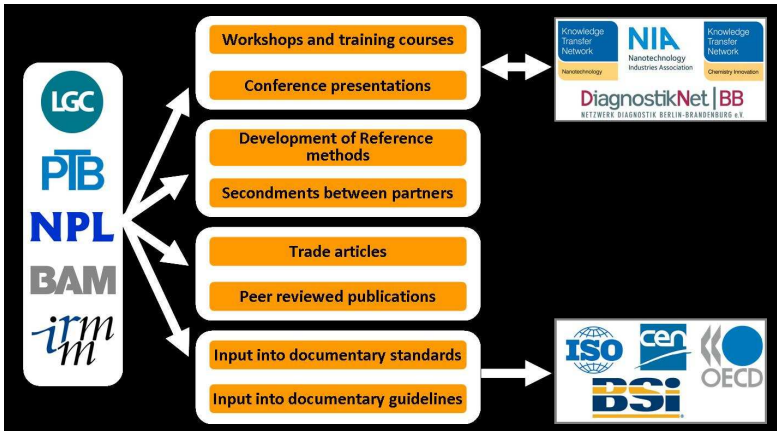
Impact of this JRP:
There is a clear concern in the EC and member states, regarding the widespread use of engineered nanoparticles due to their unknown biological interactions and associated hazard(s). This is exacerbated by a lack of robust methods to characterise nanomaterials in anything other than idealised simple matrices. In a 2011 report by an expert consortium in the Co-Nanomet project [1] which looked at the nanometrology needs across Europe, they found that "*With a few exceptions, metrology aspects (traceability and measurement uncertainty) in nanotechnology are poorly developed and often completely lacking*".

The research in this JRP will therefore address this issue through the combined expertise of the JRP-Partners (in the development of reference materials and the physical, chemical, optical and biological characterisation of nanomaterials), and will produce measurement techniques which can be used to directly characterise nanomaterials in biological matrices and be further developed as underpinning techniques to support the general nanotechnology community.

The methods developed in this JRP will enable the traceable and accurate measurement of the physico-chemical and optical properties of nanomaterials in biological matrices. The JRP-Partners will work with academic and industrial stakeholders to support and validate the reference measurement procedures developed and to demonstrate utility for assessing/validating end-user assays. A stakeholder workshop is planned to disseminate the JRP output to the target stakeholder community and a series of publications and conference presentations will disseminate the findings to the wider stakeholder community.

The JRP-Consortium will also directly interact with national knowledge transfer networks to disseminate the outputs of this project to industry and with national and international standardisation organisations to develop guideline documentation.

The figure opposite highlights how these interactions will work:



[1] Co-Nanomet, Nanometrology Discussion Papers (2011) http://www.euspen.eu/page1423/Resources/Discussion-Papers-2011

JRP start date and duration:	1st June 2012 (3 year duration)
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