

**The Royal Society of Chemistry (RSC) and the Institute of Physics (IOP) welcome the opportunity to present their views to the Council of Science and Technology in its review of progress on actions set out in the Government's response to the Royal Society (RS) and Royal Academy of Engineering's (RAEng) report '*Nanoscience and Nanotechnologies: opportunities and uncertainties*'.**

The RSC is the largest organisation in Europe for advancing the chemical sciences. Supported by a network of 43,000 members worldwide and an internationally acclaimed publishing business, its activities span education and training, conferences and science policy, and the promotion of the chemical sciences to the public.

The Institute of Physics is a scientific membership organisation devoted to increasing the understanding and application of physics. It has an extensive worldwide membership (currently 35,000) and is a leading communicator of physics with all audiences from specialists through government to the general public. Its publishing company, Institute of Physics Publishing, is a world leader in scientific publishing and the electronic dissemination of physics.

Nanotechnology is a multidisciplinary field. Advances in the area will require the expertise of chemists, physicists, materials scientists, biochemists, molecular biologists, engineers, toxicologists and medical scientists working together. Chemistry and physics are central to most nanotechnologies and both the RSC and IOP have nanotechnology interest groups for their respective members. Success in nanotechnology is reliant on the collaboration of academics highly skilled in their own disciplines and for nanotechnology to flourish, the existing breadth and depth of core science must be well supported in the UK to underpin relevant advances.

This document represents the views of both learned societies whose charters oblige them to serve the public interest by acting in an independent advisory capacity. The RSC and IOP together with the EPSRC funded network 'NANOsafE' and the Institute of Materials, Minerals and Mining held a workshop on 4 October 2006 to discuss regulation, infrastructure and research policy developments in nanotechnology and the evidence submitted here comes from discussions held at this workshop.

## 1. Funding and co-ordinating research into the health, safety and environmental impact of nanotechnology

1.1 Whilst enthusiastic about the potential benefits arising from nanotechnologies, the RSC and IOP acknowledge that the lack of clear and authoritative information on the health and safety risks posed by engineered nanoparticles is a significant issue that needs addressing. The Government's response to the RS/RAEng report: '*Nanoscience and nanotechnologies: opportunities and uncertainties*' (February 2005) states:

*'The Government is strongly committed to filling gaps in knowledge through an immediate programme of research aimed at reducing the uncertainties relating to toxicity and exposure pathways for nanoparticulates, as well as developing instrumentation to monitor these in the workplace and the environment.'*

However, this commitment does not seem to have been fulfilled. No additional funding has been made available for basic research into the toxicology of nanoparticles, but rather the Government has relied on Research Councils to support such research through their standard responsive mode funding programmes.

1.2 We are disappointed that no additional or ring-fenced funding has been allocated for research into this crucial issue. The research necessary to ascertain the nature of the risks posed by nanoparticles and to quantify these risks, cannot be easily funded *via* responsive mode. Such research, although crucial, does not compete well against other general research proposals funded in this way that often appear more novel or exciting to selection panels. Additionally, the interdisciplinary and multidisciplinary nature of the research can lead to proposals falling at the boundaries of the Research Councils where obtaining funding is notoriously difficult.

1.3 The RSC and IOP welcome the work carried out by the *Nanotechnologies Research Co-ordination Group* (NRCG) in formulating 19 research priorities for characterising the potential risks posed by engineered nanoparticles and believe the group is soon likely to publish future work, carried out by its five task forces, to assist in the co-ordination of research. However, this group seems to have made slow progress in carrying out this prioritising exercise and we would have hoped that further progress would have been made in the 21 months since its first meeting.

In addition, it is clear that the scientific research community is largely unaware of the progress that has been made by the NRCG. We believe that the committee needs to adopt a higher profile and engage all stakeholders in its work.

1.4 The RSC and IOP therefore believe that if the Government is committed to a programme of research characterising the potential risks posed by engineered nanoparticles they must provide ring-fenced funding, which must be coordinated at the level of RCUK to ensure that the multidisciplinary approach required is enabled.

In its response to the RS/RAEng report, the Government recognises the benefits of interdisciplinary research in this area, but no steps have been taken to support such endeavours. In fact, interdisciplinary and multi-disciplinary research is crucial to the investigation of the toxicology, environmental fate of nanoparticles and the prerequisite development of metrological standards. Aside from the formation of the NRCG, and the limited EPSRC support for two academic networks (NANOsafeNET and NanoMIST) no steps have been taken to facilitate, support or engineer such research.

We believe that funding should not be channelled into a single Interdisciplinary Research Centre as suggested in the RS/RAEng report, but should be available for all of the excellent research groups working in this area throughout the country. This research will involve chemists, physicists, materials scientists, biochemists, toxicologists and physicians whose work will require coordination: the establishment of a virtual centre of research excellence would represent an effective *modus operandum*. Such centres, with adequate funding, would support interdisciplinary research and prevent duplication of work. The model used by the Universities of Edinburgh and Aberdeen, known as the SnIRC (Safety of Nanomaterials Interdisciplinary Research Centre (<http://www.snirc.org/>)) might provide a useful starting point.

1.5 Although funding is necessary for research on all of the 19 areas set out by the NRCG, some priorities are becoming apparent. Thus there is an immediate need to formulate short-term toxicity testing protocols. Here we believe that some of the approaches used in parallel and combinatorial screening may well have a valuable contribution to make, for at present toxicologists are not able to keep up with the speed at which the nanotechnologies industries are developing and to cope with the wide range of forms in

which particles of the same materials may be produced. There is also a need to focus efforts on the types of nanoparticles already being used by industry, as these pose the most immediate exposure threat to humans and the environment. Similarly we need to consider carefully the areas likely to be of interest to industry in the future. The current industrial focus is moving towards metals and metal oxides, rather than carbon nanotubes and fullerenes.

There are indications that an important mechanism of nanoparticle toxicity is oxidative stress (OS). Oxidative stress is a general term used to describe the level of oxidative damage to a cells, tissues or organs, caused by reactive species such as free radicals or peroxides. Such species may be formed by the interactions of nanoparticles (such as carbon black) with organic species and/or metals. Oxidative stress can be measured quantitatively and this may provide a short-term testing strategy for identifying and measuring the toxicity of nanoparticles. There may be other mechanisms at play in the toxicity of nanoparticles and funding must look to cover all research angles.

The similarity between carbon nanotubes and asbestos fibres has been highlighted by the toxicology community and is an issue of potential concern. Carbon nanotubes exhibit some characteristics that are similar to asbestos fibres with regards to shape, size and bio-persistence. Whether this indicates a similar toxicity is not known at present and research is needed urgently despite the responsible attitude adopted to their handling in the wider scientific community.

## **2. Nanometrology, toxicology and risk management**

2.1 From a health, safety and environmental perspective it is important to identify the unique properties of nanoparticles, and the hazards and risks that they may present. In most cases, nanoparticles will be in bonded or encapsulated within a matrix suggesting low risk of exposure during most scenarios of normal use, although disposal protocols will need to be developed carefully. Nonetheless, research based on existing toxicological protocols will be required to determine exposure scenarios and standards need to be linked to toxicology. For the present, it is likely that some use of *in vivo* techniques will be required for toxicological studies, but internationally acceptable and validated high-throughput toxicity screening and *in silico* techniques need to be developed and can make a significant impact.

2.2 Further research is still urgently required on the development of standardised characterisation techniques, thresholds, and exposure limits for engineered nanoparticles. We are encouraged to note UK Government initiatives and in particular the work of the British Standards Institution (BSI) nanotechnology committee on the development of internationally recognised standards and metrology in the nanosciences. This is a crucial element of developing toxicity tests for nanoparticles; without rigorous standards, toxicity assessments are impossible. However, we believe that the dissemination of information with regard to the work being undertaken needs to be more effective.

2.3 Global harmonisation in the field of nanomaterials metrology is of vital importance and is a prerequisite for the development of effective risk management and control policies. The UK Government must continue to engage at the highest levels within the EU, and continue to co-operate with international organisations such as the OECD and UNESCO.

### **3. Regulation**

3.1 While the aim of control measures should be to reduce or eliminate exposure to harmful particles as far as is practicable, regulation must not stifle innovation or create unnecessarily high costs for SMEs where many advances in nanotechnologies are made. Such measures must be practicable and appropriate and should take into account the benefits of nanotechnologies in relation to their risk. Indeed it may be possible to adjust existing regulations covering safe manufacture and the use of materials and products and environmental, health, safety and waste controls. Wide stakeholder consultation is important in the development of such regulations.

3.2 The Voluntary Reporting Scheme, recently launched by DEFRA, is a welcome step on the way to developing understanding of many aspects of nanotechnology research, but it has the potential to compromise commercial confidentiality. The scheme creates a tension between industry's need for commercial confidentiality and the Freedom of Information Act, which allows for public access to information collected by DEFRA. If a reporting scheme is to be continued after the initial two-year period, agreements will be needed on the uses and restrictions of the information collected. One solution may be to channel the reporting of information through trade associations so that company-specific information is removed; another may be to seek specific exemption from the Act for information deposited under this scheme.

#### **4 Engaging the public - social and ethical implications of nanotechnologies**

4.1 In its response to the RS/RAEng report, the Government stated that '*properly targeted and sufficiently resourced public dialogue will be crucial in securing a future for nanotechnologies*'. The RSC and IOP wholeheartedly agree with this statement.

Nanotechnology will need a supportive environment in which to flourish and this will depend on the Government, industry, scientists and policy-makers embarking on a dialogue to understand public concerns surrounding the development of new nanotechnologies.

We believe the Government must ensure that this process is carried out *via* the appropriate agencies and since the publication of the RS/RAEng report in 2004 there have been several small-scale initiatives (such as Small-talk and Nano-jury UK). However, the majority of the public are still unaware of the potential benefits and risks that nanotechnologies may offer. A greater effort is needed in the interests of science, industry and the public.

#### **For further information**

Dr Rachel Brazil MRSC  
Manager, Science Policy Communications  
Royal Society of Chemistry  
Burlington House  
Piccadilly  
London  
W1J 0BA

Tel: 0207 440 3305

Email: [brazil@rsc.org](mailto:brazil@rsc.org)

Tajinder Panesor MInstP  
Policy Officer  
Institute of Physics  
76 Portland Place  
London  
W1B 1NT

Tel: 020 7470 4939

Email: [tajinder.panesor@iop.org](mailto:tajinder.panesor@iop.org)