

## Meeting of industry representatives with nanotechnology working group

**Wednesday 3 March 2004**

**Mercer Room 1, Royal Society**

**13.30 – 17.30**

### **Industry representatives**

Wolfgang Bosch, Filtronic

David Bott, ICI

Peter Cumpson, National Physical Laboratory

David Gittins, Imerys

Ruediger Iden, BASF

Derek Illsley, Sun Chemical Co

Amit Khandelwal, Chemical Industries Association

Kevin Matthews, Oxonica

David Merrifield, GSK

Barry Murrer, Johnson Matthey

Ian Pilkington, Ilford

David Sutton, ICI

Harry Swan, Thomas Swan

Tilo Weiss, Sustech

### **Nanotechnology working group members**

Roland Clift

Ann Dowling (working group Chair)

Nicole Grobert

John Pethica

Ray Oliver

Anthony Seaton

### **Royal Society/Royal Academy of Engineering Secretariat**

Sara Al-Bader

Andrew Dunn

Richard Ploszek

Prof Ann Dowling opened the meeting by explaining its purpose in the context of the joint RS/RAEng study into nanotechnology commissioned by Lord Sainsbury. She also explained that this meeting was one of a series to gather evidence for the working group. Ray Oliver outlined some highlights of the study including the fact that the working group had been gathering evidence since the summer of 2003 and held a number of workshops similar to this including:

- Scientists and Engineers Workshop

- Civil Society Workshop
- Health and Environment Workshop
- Regulators Workshop

Additionally, work had been commissioned on public perceptions of nanotechnology.

### **Benefits and Concerns**

After a round of introductions, Ray Oliver opened the discussion, stating that nanotechnology was moving from the science arena into the development of a wide range of materials and applications. Some of the scientific claims from nanotechnology had been significantly hyped, probably as a consequence of competition for funding. The views of the group were then sought concerning the benefits of nanotechnology and any concerns or uncertainties that the group had.

The point was made that many of the group were in areas of industry where nanotechnology was not considered to be that new. It was noted that nanoscale structures had been important to the catalyst industry for over 100 years. Perhaps the breakthrough had been that techniques were now available to specifically design materials for these nanoscale properties. Nanoscience was felt to be reasonably well understood with little today that was considered revolutionary. The revolution, if there had been one, was felt to be in the field of characterisation, leading to better understanding of properties of materials and their potential. The potential for revolutionary applications in the future was not ruled out.

There was an awareness of health and safety issues, but generally, it was felt that many nano products had been in use for years without major problems surfacing and that where nanoscale products were incorporated into matrices, few problems were anticipated. ETC's call for a moratorium on nanotechnology rather than a reasonable conversation focusing on specific concerns around particles was criticised. It was acknowledged that there were concerns around toxicity of nano particles as all toxicology before had been carried out on micron sized particles and above. However, the view was expressed that the chemical regulations should be able to deal with such issues, especially if companies are made aware of potential problems and the regulatory framework. Basic chemical regulations that dealt with bulk products were noted as having potential loopholes for some nanoparticles. For example, carbon nanotubes (CNTs), could be classified as graphite and thereby avoid further regulation.

The electronics industry did not see issues relating to the toxicology of particles to be of any relevance to its future product development except in very niche areas (such as super capacitors) where nanoparticles are used. The challenge in electronics was to fully understand quantum effects and to achieve better consistency in the manufacture of quantum devices. This is expected to be seen once high levels of series manufacture is a reality in much the same way as the problems surrounding GaAs devices were overcome once a market for them in mobile telephony had been established.

While the primary motive for developing nanomaterials was added functionality, it was cautioned that unexpected properties might also be engineering into products. These unforeseen properties were as likely to be beneficial as harmful, but the implications for product safety should be monitored.

The motivation for companies to develop nanomaterials was examined and it was felt that development was only undertaken if there was a potential profit to be made through more efficient use of material or harnessing novel properties. It was noted that all companies understood that it was not in their commercial interests to produce a novel product which ultimately turned out to be dangerous (such as asbestos), so they were strongly motivated to ensure the long-term safety of potential products.

It was noted that the pharmaceutical industry had well-established systematic processes to enhance the desirable qualities and diminish side effects which could be adapted for development of some nanomaterials.

The development of measurement technologies such as Atomic Force Microscopy (AFM) and Scanning Tunnelling Microscopy (STM) were seen as key to these developments.

In areas where the interest in nanomaterials was 2D, i.e. films rather than particles, health and safety issues were seen as less critical as any particles were normally dispersed in water or in some other substrate rather than being in dry powder form at any stage. Development drivers were seen as waste reduction (thinner packaging) and better protection of food products. For coatings, it was felt that many years of the use of pigments in ink gave a good understanding of property behaviour.

### **Measurement and Modelling**

In order to develop new products, industry needs accurate and repeatable measurement ability as well as modelling capabilities. The group was asked about their views on the state of the art in these fields.

It was felt that mathematical modelling had been improving in its ability to predict properties, with much improved computing power being a significant factor in its progress. These improvements were seen as across the board and not specifically for nanomaterials. However, a note of caution was raised in that some drug development software which was extremely expensive did not always give satisfactory results.

The drug development software that was available tended to concentrate on the reactivity of a single molecule and therefore had limited use outside the pharmaceutical field. It was accepted that developments and improvement in the field of modelling could be expected and that the approximations that were possible would improve with time.

### **A Disruptive Technology?**

Many commentators had suggested that nanotechnology was going to be a disruptive technology that would “change the world overnight”. In reality, there had been little evidence of this, but the group was asked if there was still potential for nanotechnology to be disruptive.

It was felt that the majority of claims that nanotechnology was going to be disruptive could be traced back to the USA. In a competitive market for research funding, claims of disruptiveness were being used. Rather than huge step changes, the group foresaw progressive improvements over time. Advances in hydrogen storage or fuel cells were seen a route to hastening the hydrogen economy, but were not seen as disruptive developments in themselves.

The group was unsure as to what a disruptive technology might be and how it might manifest itself. Polymer science was not seen as particularly disruptive in its infancy, but in hindsight, with our current reliance on plastics, it might now be described as such.

In the electronics field, the expected benefits of nanotechnology have been planned for over many years in the semiconductor roadmap, so could not be described as disruptive in any sense. Even where Micro-Electro-Mechanical Systems (MEMS) had been developed, such as mechanical resonators for signal filtering, they were, on the whole, radically scaled down versions of traditional technology. However, difficulties had been found in developing analogue to digital and digital to analogue converters and a disruptive solution, although not currently foreseen, would be welcomed by the industry.

The potential for disruptive applications was felt to be at the boundaries of the electronics and chemical disciplines, notably in the development of micro reactors and possibly, although more distantly, in nanofabrication.

## **What will happen Sooner / Later?**

As the group had decided that progress in nanotechnology was, on the whole, going to be evolutionary rather than disruptive, they were asked for their opinions on what developments could be expected to be seen in the near term and what could be expected in the further future.

Control of nanoparticles in emissions was seen as a key near term development, being driven by radical legislation especially in the automotive industry. The removal of nanoparticles for liquids was seen as another potential application. Overall, the control of nanoparticles was seen as probably been driven by regulation in all fields.

The development of new nanoparticles and nanostructures would be driven by the need for novel properties and functionality in all industries. While the science involved may not be disruptive, the use of such products may be. On a general note it was felt that although the development of individual components would be evolutionary, there were strong possibilities for the final consumer products to appear disruptive.

The use of information technology in the development of nanotechnology based components and products was seen to be some way behind other fields, but was catching up rapidly. The use of such modelling was seen as important, with examples being cited of products which were developed years before their efficacy could be proved. Allied to the use of IT, improvements in metrology were expected in the short to medium term. Imaging had improved substantially, but good comparative metrology was proving more difficult. In the longer term, development in measurement on the single molecule scale was expected.

For manufacturing, an evolution towards more consistency was seen. Synergy in different areas could be achieved, for example between optics and electronics. More functional packaging was envisaged in the short term with food packaging films designed to scavenge gasses in the mid-term and possibly, novelty moving images on packaging in the far-term.

In terms of consumer products, a range of items were seen, including self-cleaning clothes and photochromatic clothes. The driver for such products was seen as consumer wants.

## **Will Nanotechnology change the way we make things?**

The group's view was that very little on the horizon was genuinely new, but the possibilities of nanotechnology would lead to better ways of doing things.' An example of the scale of potential impacts was given as fuel-cells. The basic technology had been understood since 1839, but nanotechnology had the potential to make them more commercially viable.

Microfluidics was seen as a key area where manufacturing processes might change radically with microfluidics creating previously unobtainable opportunities for high pressure, high temperature reactions to be utilised.

While there was optimism that developments in manufacturing related to nanotechnology could ultimately lead to zero or very low waste manufacture, there was some concern at the lack of full lifecycle analysis generally in the field. However, it was noted that some of the companies involved had developed lifecycle cost analysis tools and that other companies were beginning to pick these up as well. While the lifecycle analysis tools currently available addressed the supply chain and waste minimisation, environmental aspects were not adequately addressed; for example, issues such as release to the environment as coatings wear in use was not covered.

## **Public Concern**

Asked how they felt about the public perceptions of nanotechnology, an interesting difference of views emerged between UK based group members and Germany based members. Public acceptance in Germany appeared to be high with consumers more interested in product functionality than what technology was involved. Additionally, there were no NGOs campaigning against nanotechnology in Germany and the main prime time technology television show had "Nano" in its title. The group was also told of the industries efforts to ensure that nanotechnology is publicly acceptable by funding a roadshow, which visits any community group that asks for it.

In contrast, public perception of nanotechnology in the UK was seen as negative with a number of NGOs involved in the debate. A factor in this situation was seen as the press coverage that NGOs have been able to get for their positions which are then not challenged.

In the case of nanotechnology in the electronics industry, it was pointed out that Filtronic and Intel, among others, who have nanoscale devices already in production, did not see a lack of public acceptance of their products.

The group made a strong link between public acceptance of nanotechnology and the effectiveness of regulation. Similarities were drawn between the GM debate and what might lie ahead for nanotechnology, but it was recognised that in the GM debate there was a public trust issue surrounding commercial organisations such as Monsanto.

### **Regulatory Issues**

Discussion about public concern led directly to the discussion of regulatory issues and the group was asked for views on whether regulation for nanotechnology needs to be revolutionary or evolutionary and how significant an issue it was for industry.

Overall, it was felt that regulation of nanomaterials should be evolutionary and the group felt that the current regulatory regimes should not have a problem adapting except in the area of nanoparticles. It was noted that TiO<sub>2</sub> was currently regulated as a powder at micron scale and nanoscale material was not being treated as "new" or requiring further regulation.

It was suggested that toxicity testing of new materials should be carried out by an independent body, as small companies in particular, with novel products, do not have the resources to carry out testing to satisfactory levels.

Although there was uncertainty about the toxicity of nanoparticles compared to bulk materials, it was stressed that uncertainty should not be interpreted as panic. With an understanding of the scale effects on reactivity of nanoparticles, it was felt that regulators should be able adapt regulatory standards where required in an evolutionary fashion.