Vials with representative nanomaterials in the JRC-Ispra repository. © EU, 2012.

and occupational particles and nanoparticles. He does not see differing definitions as a major problem for preparing regulations or standards.

"But," he says, "there must be validated methods for characterizing nanomaterials."

Noting that NIOSH has also issued recommendations for exposure levels, Oberdörster asks, "How do you correlate studies with different materials or material types in different situations or contexts? How do you relate these to exposure levels? How do you rank an unknown material? Which criteria should be used? And how should they be determined?"

"In the absence of a more developed science," says Dawson, "and except for specific examples that are now identified, we do not yet know if there are particular nanomaterial characteristics that could pose a threat."

Reference materials are emerging, though many of the early ones are oriented toward size measurements, Dawson says.

"The first reference materials enabling greater emphasis on standard positive and negative controls will be announced soon by the European Infrastructure for Nanosafety, Qnano (http://www.qnano-ri.eu)," he adds.

Jensen says there is ample evidence of increased hazards associated with many types of nanomaterials.

"The complexity increases with the complexity of the material," he says. "It is not only a simple change in scale with the associated change in properties and ability to reach other biological compartments than their bulk analog materials. Engineering at the particle level has also changed. Size, morphology, deliberate impurities such as catalysts, layers of inorganic and organic coatings, for example, are factors making nanomaterials unique for their intended use. But they potentially also change the toxicity of the material so it is no longer comparable to the bulk analog—if such an analog exists."

The NNI notes that nanomaterial environmental health and safety research is further complicated by the interaction of the materials' high reactivity surface with the microenvironment.

The JRC says more research is needed, including the development of methods tailored to assessing nanomaterials to get a better understanding of toxicity mechanisms. Moreover, data relevant for regulatory risk assessment (e.g., on potential exposure) are still scarce for many materials. More research is necessary just to keep pace with new developments.

According to Eric Gaffet, deputy director of the Institut Jean Lamour Materials Science Institute at the University of Lorraine in France, the toxicity and ecotoxicity of nanomaterials depend on at least eight major parameters.

"You can easily realize the variety of combinations you can get for a given chemically identical nanoparticle," he says. "More than 50 years may be needed to get information on the nanoparticles on the market, at a cost of €3–5 million Euros [USD$3.8–6.4 million] per nanoparticle to be tested."

But, Gaffet says, "Instead of considering toxicity and ecotoxicity after new properties have been researched and developed, some people propose considering the toxicity and ecotoxicity as equally important parameters during research and development."

This is the "safer by design" approach to product safety, Gaffet says. "It means developing processes confining nanoparticles, or not producing isolated nanoparticles, and also confining the chemistry of nanoparticles and stabilizing the eight parameters in order to decrease the interaction of a nanoparticle with its biological environment or to decrease its toxicity."

Michael de Laine

India launches fellowship to combine academic research with industry needs

Last November, Jaipal Reddy, India's new Minister for Science & Technology and Earth Science, launched the Prime Minister's Fellowship Scheme for Doctoral Research, being implemented jointly by the Science & Engineering Research Board and the Confederation of Indian Industry. With this initiative, 100 fellowships are to be awarded annually to research students in the fields of science, technology, engineering, agriculture, and medicine. The students are to partner with industry in order to pursue research that fulfills industrial needs. Speaking at a conference in New Delhi, Reddy said that "a seed is being sown today for a transformational change in the way research and development is being promoted in this country."

"The scheme," he said, "offers now a financial incentive for those who are able to align their research interests and engage their creative potentials to solving problems which are seeking solutions rather than to create solutions which would solve no one's problems." While lauding the recent 13–15% annual growth in research publications from Indian institutions, Reddy said that "the challenge is in the conversion of such knowledge into products of commercial value to the industrial users."

Reddy said that within the next five years, he aims to bring India to the fifth position in Global Science and Technology from the current twelfth position. □