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Back **Nanotechnology comes of age**

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India could use its skilled manpower to graduate to the higher end of the value-added chain in nanotechnology.

Mr Konstant in Novoselov, 2010 Nobel Physics Prize winner, displays graphene, a new form of carbon that is 100 times stronger than steel, in this file picture.

Nanotechnology, the application of science to materials of the size of 1-100 nanometres (one billionth of a metre) in at least one dimension, has come of age. Twenty five years ago, fullerenes, made of carbon atoms arranged in the shape of a football, were discovered, and the 1996 Nobel Prize in Chemistry went to its discoverers. The 2010 Nobel Prize in Physics was awarded for the discovery of graphene, a form of carbon in a sheet one atom thick.

These are two examples of nanomaterials – nanometre sized in three dimensions, and one dimension respectively -- with remarkable properties. Also remarkable is that these novel forms of carbon took so long to be discovered, while graphite and diamond, conventional forms of carbon were known for long.

Between these two Nobel prizes is a long period of steady and rapid development of nanotechnology and nanomaterials. Strange things happen in the nano world. Nanomaterials have very large surfaces and can become very reactive chemically. The nano size results in quantum effects becoming important. This is a no man's land in between the atomic and nuclear world where quantum physics reigns and the normal macroscopic world of ordinary materials where classical physics prevails.

VARIED APPLICATIONS

Nanomaterials can be prepared in a vast variety of ways. One can play around with the composition, physical structure, solid-liquid-gas phases, etc. and come up with a wide variety of materials.

Graphene sheets rolled up can form carbon nanotubes, which can be of different types depending on how the sheet is rolled up with different properties. Nanomaterials have interesting properties which can be exploited for practical applications. The wide variety of nanomaterials and the possibility of tailoring them to meet specific needs make this field particularly interesting.

Practical applications of nanotechnology have been coming out of R&D labs at a steady pace. A low-cost water purifier recently marketed in India is one example. It uses a water purifier made of natural elements such as rice husk ash impregnated with nano-silver particles, produces clean and safe water without using electric power or running wateroften not available in rural areas.

The cartridge is packed with a purification medium which has the capability to kill bacteria and disease-causing organisms. A graphene transistor that could revolutionise electronics has been recently developed in a laboratory.

There are already about 1,000 commercial products using nanotechnology. The largest group is health and wellness products accounting for 60 per cent, over 50 per cent coming from the US. The most common material mentioned in the product descriptions is now silver (25 per cent) followed by carbon (8 per cent), zinc, silicon, titanium and gold.

FUND ALLOCATION

Given the importance of this field, several governments have been funded development programmes. The US launched a National Nanotechnology Initiative (2001), and till 2011 about $14 billion has been provided. The EU spent €1.3 billion during 2001-2006 and plans to spend €3.5 billion in the next five years . One report estimated global nanotech funding at $18.2 billion in 2008, including $8.4 billion from government sources, and $8.6 billion from corporates, and $1.2 billion from venture capital.

India's Department of Science and Technology launched the Nano Science and Technology Initiative (NSTI) in 2001 with an allocation of $15 million over five years. This was followed by a nanoscience and technology mission in 2007 with a funding of Rs 1,000 crore for five years. However, nanotechnology R&D is still largely in government laboratories, with the private sector involvement small. A growing number of foreign companies have established nanotechnology subsidiaries or joint ventures to exploit lower manpower costs in India for their manufacturing operations using foreign developed technology.

NEED FOR REGULATION

Some concerns over the risks of nanotechnology products have been expressed. For example, studies have shown that airborne nanoparticles can have toxic effects. However, enough information is not yet available. Regulatory bodies in the US and the EU have concluded that nanoparticles form the potential for an entirely new risk and that it is necessary to carry out an extensive analysis in this regard.

Regulations worldwide do not specifically cover materials in their nanoscale form; therefore nanomaterials remain effectively unregulated if they have already been approved in bulk form. Even on the approach to regulation, there are differing views – whether to adapt existing systems for nanotech products, or to have a separate regulatory system .

Recently, it was announced that India would establish a “national level regulatory framework for nanotechnology”. However, so far, nothing concrete has been spelt out. An appropriate

regulatory system would be important to guide the development of the industry in India and to enable it to participate in the international trade in nanoproducts and services. It would be important to take a balanced and reasoned approach to nanotechnology regulation, and not succumb to unscientific activism.

There is no international regulation of nanoproducts or the underlying nanotechnology, or any internationally agreed protocols for toxicity testing of nanoparticles, and no standardised protocols for evaluating the environmental impacts of nanoparticles. Since products that are produced using nanotechnologies will in future enter international trade, it will be necessary to develop guidelines on nanotechnology standards.

Given the right mix of policies and a well-constructed support programme, India could use its skilled manpower in research in the field of nanotechnology. Indian companies should aim to graduate out of the "call centre" end of nanotechnology to the higher end of the value-added chain. It is time for a major broad-based initiative in this field involving all Ministries.