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Nanotechnology (T.H. Brock)

Since nanotechnology emerged in its own right towards the end of the 20th century, the number of new substances and materials – often of completely new types – has grown exponentially. A wave of new research institutions were founded, which subsequently led to an increase in the number of materials available for the development of new products. Due to the new types of properties of some nanomaterials and the associated technological possibilities, nanotechnology is commonly regarded as a promising new cutting-edge technology.

It is more appropriate to talk about nanotechnology in the plural (nanotechnologies) because there are many different technologies with one thing in common – the manufacture and use of minute amounts of matter, in most cases larger than single molecules but much smaller than conventional materials or dusts. It is not easy to give a precise definition.

Andrew D. Maynard, one of the leading figures in this field, explains the term as follows:

> *Nanotechnology – the ability to measure, see, manipulate and manufacture things between 1 nm and 100 nm in size – is regarded as the driving force behind a new industrial revolution resulting from the development of materials that bring with them new properties, benefits and potential risks on this tiny scale*.

The popular definition of nanomaterials is based on international standards and differentiates between nano-objects (individual portions of matter that measure between approx. 1 nm and 100 nm in one, two or all three dimensions, although the limits cannot be specified precisely – nanoplatelets, nanofilms, nanobars, nanotubes and nanoparticles) on the one hand and nano-structured materials (e.g. materials composed from a matrix with embedded nano-objects) on the other. The properties of such nano-objects are very different from those of smaller objects (molecules of gases and vapours) and larger ones (dust particles). They demonstrate quantum effects, for instance. Compared to the mass, the surface is huge and can also be chemically active. This is another of the host of special features that make these materials so interesting but also require them to be handled with particular care.

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German laboratory guidelines thus stipulate that nanomaterials should be treated in the same way as new substances if their specific properties have not already been adequately investigated, and that appropriate protective measures should be taken.

Ultra-fine dusts (nanomaterials that are of natural origin or an unintentional by-product of day-to-day processes) have always been part and parcel of our environment. Volcanoes, for example, produce inconceivably large quantities of nanoscale particles, but so does each and every candle flame. Nanotechnology has been used for centuries. Potters in Mesopotamia used copper and silver nanoparticles to achieve a special gloss effect on their pots. And although mediaeval glassmakers were naturally not familiar with the concept of nanotechnology or the physico-chemical background, they were still able to produce fiery red ruby glass from molten glass using nanoscale gold particles. The nanomaterials developed in recent years, though, have numerous new properties.

Nanotechnology is exerting a growing influence over the consumer sector and thus over the manufacturing and processing industries, health & safety, and environmental protection. Despite its beneficial effects, we should not ignore the fact that our knowledge of this technology is insufficient to enable a sound risk assessment. Human and environmental toxicology results show that further highly vigilant investigation is required into the effects along with preventive protection measures. The impact on fire and explosion behaviour also needs to be taken into account.

Germany currently plays a leading role in the development of this technology with considerable economic potential. It is predicted to generate up to US$ 2.6 billion on the world market and create 7 – 10 million new jobs.

Given the multidisciplinary nature of nanotechnology – encompassing natural sciences, engineering and medicine – virtually all sectors will be affected. There are known to be more than 800 products incorporating nanotechnology on the market, and around ten new ones are added every month. Despite this, nanotechnology is still in its infancy in terms of the theoretical possibilities. Whereas to date it has largely focused on using the material properties, far more intelligent uses are planned with active nanostructures and (molecular) nanosystems.

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A large number of applications are already well established on the market and many, many more are under development. The key areas of application include nanomechanics, nanoelectronics, nanobiotechnology, nanomedicine, nanochemistry, nanoanalytics, the manufacture and use of new nanomaterials, and the development of new market-ready products based on established nanomaterials. Direct benefits are apparent with surface coatings that improve the scratch resistance of varnishes or prevent soiling, agents offering UV protection, adhesive systems that react to magnetic fields, more efficient energy storage media, functional textiles, plastics with enhanced properties and active pharmaceutical ingredients. As a result, nanomaterials are increasingly common at the workplace.

This gives the ISSA a focus for its activities over the coming years. The rapid development of nanotechnology also has health and safety implications. It is important to learn much more about the properties and effects, to discover more about exposure levels at the workplace, to raise awareness at companies and to offer these companies practical assistance in effectively combating possible hazards. A risk assessment that holds weight is not possible based on what is known at present. A great deal of research work still needs to be done. Although we find ourselves managing uncertainty, we are not helpless in the face of the challenges that present themselves. As far as we know, the protective measures already available are effective. We simply need to apply them wherever nanotechnology is used.

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