Nanotechnology in Chemistry: Small Particles, Great Potential?

Nanotechnology: is it more than a buzz word? Often mentioned in one breath together with biotechnology, information technology and communications technology as one of the key technologies of the New Age, are the high expectations we have of nanotechnology justified? I believe so – because this is one technology which has been undergoing such rampant development over the past few years that it has now begun to cross the threshold of the industrial and university and research laboratories and we are already seeing the emergence of actual products.

In contrast to the other key technologies mentioned, nanotechnology is much less well-defined and well-structured. So far, it has not formed its own industrial sector. What we are seeing instead is that nanotechnological materials and technologies are being increasingly incorporated into new and innovative products or are being used as 'tools' for their production. The term nanotechnology covers a whole range of very different developments, ranging from nanostructuring of surfaces important to the semi-conductor industry and biosensors, right up to nanoparticulate systems. The latter are relevant to the finishing of synthetics or for catalytic processes in 'chemistry'. Because of this wide variety of applications, it is not easy to describe how we benefit from nanotechnology. Nanoparticle technology, which is of particular relevance to the chemical industry, is primarily concerned with the special properties and the potential of nanoscale particles, usually defined as a size very much smaller than 100 nanometres. Particles of this type are not new per se. A well-known example are the brilliant and extraordinarily resilient dyes used by artists in stained-glass windows many hundreds of years ago. They are partly based on nanoparticles, although this was unknown at that time. In my opinion, modern

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nanoparticle technology will be determined by insight into the physico-chemical relationships between the special properties of these minute particles. If materials are broken down into their smallest dimensions, they can change their own fundamental properties or those of their environment. With nanoparticles, combinations of properties can be achieved which were not previously possible. For example, weatherproof UV protection or scratch-proof coatings for polycarbonates can be manufactured by incorporating nanoparticles, whilst preserving the transparency, tensile strength and hardness of synthetic materials. The large surface area of nanoparticles in comparison to their volume has long been exploited in catalysis, and has enabled the development of processes with markedly improved yields and selectivity for chemical products. Knowledge of the physics and chemistry of these nanosystems help in the designing of new and improved catalysts. A further example from medical diagnostics also illustrates their growing importance: in this area, nanoparticulate systems consisting of fluorescent semi-conductor materials or iridescent phosphors are increasingly being used in detection systems for antibodies and DNA sequences. Using such systems, it has been possible to achieve a much higher degree of simultaneous analysis, e.g. parallel testing for several pathogens in a blood sample, saving costs and time by doing so.

In addition to the propitious and individual new combinations of properties, nanoparticle technology also presents application technologists with a number of challenges. In general, nanoscale particles are difficult to manufacture and are equally difficult to maintain as separate particles. One reason for this is their marked propensity to agglomerate. The reason for this is that agglomeration reduces the enormous surface area in relation to the volume of the nanoparticles, since it is energetically unfavourable. Advances in technology will therefore be dependent on corresponding progress in application technology, which will have to supply cost-effective processes in particular, such as modern dispersant technologies, emulsifying and encapsulation processes, precipitation, gas-phase reactions and suitable grinding techniques.

Nanotechnology offers us extremely interesting possibilities of developing innovative products for many area of daily life, some of which have already been realised. We can therefore see great potential and fascinating perspectives for these minute particles.

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