Nanostructured assemblies

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It is interesting to reflect on the facts that benzene has a diameter of 0.5 nm and the distance between the source and the drain in the most advanced commercially produced transistor is 50 nm, whilst many biological systems, such as viruses, have length scales below 100 nm. The world of the chemist is meeting the engineered world at the nanometre scale, thus it is no wonder that there is such excitement in the scientific and engineering communities as to the potential of nanotechnology. It is therefore crucial to design materials whose properties can be controlled across length scales, and at the same time could be used as the building blocks for devices and functional systems in a new technological platform based on sustainable processes.

"Nanostructured assemblies" form a class of materials whose properties are defined by features smaller than 100 nm. One of the most alluring reasons for studying such assemblies and materials is the tailoring of properties, arising from the confinement effects of the building blocks, by the size. A few examples are the colour, chemical reactivity and magnetic behaviour of metal nanoparticles; the quantization of charge transport and excitation in semiconductor nanosized systems (wires, dots, particles).

By exploiting self-assembly and self-organization techniques of nanoscale building blocks which can be synthesized with molecular precision, it becomes possible to design materials and functional systems with well-defined architectures at different length scales. This allows the fabrication of materials using converging bottom-up and top-down strategies, leading to materials that start to resemble the complexity of form and function often seen in biological systems, but with the promise of a much greater level of control over function, a wider choice of properties and a much easier and improved manufacturability.

This Special Issue highlights and reviews a number of recent breakthroughs in the design, the assembling and the investigation of properties of nanostructured materials. Examples range from the formation of polymeric nanoparticles to molecular actuators, from systems designed for self-organization at surfaces and interfaces to those for carrying drugs and active systems in biomedical diagnostics, up to examples for using biomolecular templates to construct artificial assemblies. Reviews by Tour,[1] Ruben,[2] and Credi[3] illustrate the state of the art in the design, synthesis, and manipulation of single molecules with very complex shapes and functions. Often, such molecules are studied and manipulated on surfaces, for which a plethora of techniques has now reached a high degree of flexibility and sophistication, as reviewed in papers by Huskens[4] and Leggett.[5] In the more traditional area of nanoparticles, spectacular progress is made in the development of new materials based on core–shell silica (Wiesner[6]), polymeric (O'Reilly[7]) nanoparticles and novel methods to shape both polymers (DeSimone[8]) and metals (Wilcoxon[9] and Manna[10]) with unprecedented precision. Krishnan[11] and Zhang[12] review how bio-inspired approaches can yield nanostructured materials based on recognition motifs usually found in biological systems. These breakthrough in synthetic abilities to produce nanostructured materials with tailor-made properties will have an important impact in a number of areas, and Xia[13] gives an overview of one possible application of such structures in biomedical devices.

Looking to the future, potential applications of nanostructured assemblies are numerous and include (i) novel electronic devices in which organic molecular wires based on oligomeric acetylenes, polyphenylenes or polythiophenes could be connected to form nanoelectronic circuits, (ii) metallic nanoparticles and quantum dots could be used in quantum electronics for storing individual bits of information, (iii) single molecule sensing *via* integrating supramolecular recognition motifs on to condensed phase nanomaterials that can be read to and from, and (iv) drug delivery vehicles whereby the feature of biological transport that generally involves nanoscale structures can be hijacked to introduce drug molecules to such structures, to achieve targeted delivery, enhanced drug efficacy and reduced toxicity. However, chemists need to keep an eye on the broader implications on the nanoscience and the nanotechnology that may develop from it, which will include (i) the environmental impact of nanomaterials, as the properties are size dependent, and thus bring with it a whole host of issues with regard to their manufacture, use and subsequent disposal, and (ii) step-changes in technology with challenges that have not been thought of as yet. What is clear is that nanoscience is an extremely exciting research field for chemists, and that chemistry will play a central role in the construction and the development of the technological platform for nanotechnologies.

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