CEP Chemical Engineering Progress

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Good Things Come in Small ChE Packages

With two brothers over six feet tall (while I barely reach 5-ft, 2-in.), I hear more than my fair share of "short" jokes. My retort is a paraphrase of the old adage: good things come in short packages. Today, with numerous writers and editors invoking the cliché in connection with nanotechnology, it's time for another paraphrasing: good things come in small, chemically engineered, packages.

Those packages come in a wide and expanding variety of shapes, sizes, and compositions, and the pace of growth in the field of nanotechnology can make it hard to keep track of the latest nanomaterials. In one of this month's On the Horizon articles (pp. 28–32), Rice Univ.'s Sravani Gullapalli and Michael Wong provide a guide to the most common nano-objects, including nanoparticles (*e.g.,* buckyballs, nanocubes, and quantum dots), nanorods (*e.g.,* nanofibers, nanowires, and nanotubes), and nanoplates (and nanoribbons).

In the other article (pp. 21–27), Mihail Roco, of the National Nanotechnology Initiative and National Science Foundation, discusses the potential for nanoscale science and engineering to transform medicine, productivity, sustainability, and quality of life. He points out that progress in some areas has been better than expected — for example, researchers made unanticipated discoveries in several science and engineering disciplines, such as metamaterials, fluidics, drug delivery, and synthetic biology, and industry involvement has expanded significantly.

Roco outlines the challenges for the future and says that "chemical engineers can make essential contributions to nanotechnology — serving as a bridge from scientific discoveries to integration of knowledge and innovation, thereby creating a path to manufacturing." Among the areas of particular importance to chemical engineers working in nanotechnology, he says, are: synthesis, assembly, and processing of nanostructures using colloids, aerosols, plasma, and other multiphase systems; molecular self-assembly and design of programmable macromolecules that assemble into larger structures; precise control of the composition and structure of nanocatalysts; energy conversion, storage, and conservation; polymeric nanostructures by design; and safer-by-design nano-enabled products.

Mike Kelly, a professor at the Centre for Advanced Photonics and Electronics at the Univ. of Cambridge, recently raised eyebrows with a paper in the journal *Nanotechnology*, in which he claims that 3 nm is the limit below which nanomaterials cannot be mass-produced. Although he focused mainly on top-down techniques, such as deposition, lithography, and etching, he also cast doubt on the viability of bottom-up approaches, which piece together small units (such as molecules) to build larger structures, saying that these methods are too unpredictable for defect-free mass production of arrays.

These statements seem rather short-sighted. Bottom-up manufacturing is within the realm of chemical engineering, and chemical engineers are likely to lead the development of the necessary techniques. The main challenge, Roco says, is to create new bottom-up methods that can be precisely controlled and then integrate those with the top-down methods.

It might not be easy to do, but it's certainly not impossible for chemical engineers.

Cynthia F. Mascone, Editor-in-Chief