Metal-Polymer Nanocomposites

By Luigi Nicolais and Gianfranco Carotenuto, Editors, Wiley, Hoboken, NJ, 2005, 320 pp., $130

The phenomenal buzz around nanotechnology has spawned a large number of books recently on various aspects of nanotechnology. A large body of literature exists, including many articles in chemical engineering journals, on the subject of fillers like clay (in its exfoliated form) or nanoparticles dispersed in polymers to form nanocomposites with enhanced mechanical properties. On the other hand, metal nanocomposites have been explored to a greater extent by material scientists and physicists, with only a small focus on novel synthesis routes, scale-up, and nanoreactors for nanoparticle formation.

The current book provides an excellent review of not only the physical and chemical property enhancements of metal nanoparticles (Chapter 1, 6, 7, 8, 9) but also methods of synthesis by cryochemical synthesis (Chapter 2) and controlled pyrolysis (Chapter 3), structured nanoreactors for metal nanoparticle synthesis (Chapter 4), and *in situ* and *ex situ* methods for metal-polymer nanocomposite synthesis (Chapter 5).

Metals show a considerable mesoscopic change in their electronic, magnetic, and optical properties when reduced to the nanometer scale. These are typically attributed to quantum size effects due to electron confinement and surface effects, with metal clusters (100 – 100,000 atoms) being less than the wave length of visible light. This leads to some unique properties like plasmon excitation and absorption at particle surfaces, near IR photoluminescence, and super magnetism, leading to advanced functional materials, with applications in embedded nanoparticles (Chapter 6), magnetooptics (Chapter 7), optical extinctions in polymers (Chapter 8), and optically anisotropic metal-polymer nanocomposites (Chapter 9).

In order to fully utilize these property enhancements, it is necessary to disperse these nanoparticles in a macromatrix. Retaining the nano characteristics during and after the process of dispersion has been particularly challenging since they have a tendency to agglomerate due to the large attractive forces between nanoparticles. Thus, the synthesis process becomes important not only to control the size to the desired range but also to keep the particles apart from one another once synthesized. The control of particle growth, size distribution, and particle-surface interactions are critical factors in determining their utility.

Cryochemical (Chapter 2) and pyrolysis and thermal decomposition techniques (Chapter 3) have been widely used in the synthesis of nano-sized metal-polymer composites. Various *in situ* (mainly thermal decomposition of organic metal precursors) and *ex situ* (mainly chemical synthesis via alcoholic reduction and polyol processes) methods have been explored and are summarized in Chapter 5, with particular emphasis on Au-based nanocomposites for applications in optics and photonics. The thermal decomposition and pyrolysis techniques, which are similar to those studied in metallurgy and combustion, offer a lower degree of size and morphology control as compared to precipitative chemical synthesis, and are also more complex systems from the stand-point of mathematical modeling.

The use of structured polymeric nanoreactors is a key variation for attaining particle size and morphology control and is adequately covered in Chapter 4. Interactions and reaction within polyelectrolyte gel-surfactant complexes, polyelectrolyte microgels, as well as within nanopores and nanocavities comprised of crosslinked polymers are discussed. The widely used method of metallation of micellar cores of block copolymer micelles is reviewed in detail.

Process optimization is typically achieved in related crystallization and particle precipitation processes with the aid of population balance models for the nucleation and growth processes involved in particle synthesis. Such a treatment for nanoparticle synthesis would have been an interesting addition to the book.

In summary, the editors have done a great job of compiling detailed reviews on various aspects of metal nanocomposites by inviting contributions from leading researchers from various material science and physics departments around the world. The book should serve as a good starting point for chemical engineers who are interested in further studying the scale-up and optimization of these systems and learning about the fascinating mesoscopic and macroscopic properties and applications that are rendered possible by metal nanoparticles and metallopolymer nanocomposites.

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Erratum

In the printed and online pdf file versions of "Equations to Predict Precipitation Onset and Bubblepoint Pressures of Asphaltenic Reservoir Fluids" (DOI: 10.1002/aic.11902, pp. 1814–1822, July 2009) by Lira-Galeana et al., there's a typographical error in the corresponding author's e-mail address. The correct e-mail address is clira@imp.mx.

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