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Probing kinetics and dynamics of nanocomposites with grazing-incidence small-angle x-ray scattering.[1]

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Synthesizing complex nanocomposites and superstructures is of great interest in all areas of materials science and involving biology, chemistry, physics and engineering applications such as the fabrication of novel electronic, magnetic, and photonic devices. Since the entire synthesis and assembly process can take place far from equilibrium conditions, a controlled process has to be guided by a thorough understanding of the kinetics and dynamics in the composites. This requires measurement of the structure in situ and in real time with subnanometer spatial resolution and millisecond to subsecond temporal resolution. As an increasingly important structural-characterization technique, grazing-incidence small-angle x-ray scattering (GISAXS) finds vast applications in the research of nanostructures and nanocomposites at surfaces and interfaces. Most significantly, as a complementary method to conventional surface-sensitive tools such as scanning probe microscopy and electron microscopy, GISAXS can be used in situ and in real time to monitor the formation of the nanostructure or nanocomposite, which makes it most suitable for studying the kinetics of nanoassembly processes. The GISAXS technique can also be an integral part of numerous research, for example, those involving kinetics of mesoscaled ordered block copolymer thin films, kinetics of sol-gel processes, quantum dots, nanoparticles in ultrathin films, and dynamics and phase transitions 2D nanocrystal superlattices. Here, I will focus on the applications of GISAXS in real-time structure characterization, the dynamics in polymer/nanoparticle nanocomposies, and the challenges to elucidate nanostructure formation in nanoscience and nanotechnology.

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