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Investigation of nanoparticle transformations to guide the design of greener products and processes[1]

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Nanoscale particles and products containing nanoparticles hold promise as higher performance materials; however, there are concerns that the production and use of nanoparticles might negatively impact human health or the environment. Within the context of greener nanoscience we aim to maximize the benefits, while minimizing hazards, of nanoscale products. A significant gap in the knowledge needed to develop greener products and processes is our understanding of the formation and transformation of nanoparticles. Such studies of nanoparticle dynamics are technically challenging and few studies have been reported. In this presentation, I will describe convenient methods to monitor nanoparticle dynamics and show how knowledge of nanoparticle transformations can guide the design of greener products and processes. In one example, chemically-modified transmission electron microscopy (TEM) grids are used to directly visualize silver nanoparticle transformations on surfaces. By indexing the TEM grids, it was possible to examine the same nanoparticles repeatedly throughout exposure to different environments. These studies show that larger particles can act as a source of smaller nanoparticles and that much larger particles also produce nanoparticles. With this knowledge, an improved design of nanoparticle coatings for antimicrobial fabrics was developed. A second example involves the use of small angle x-ray scattering (SAXS) to monitor nanoparticle formation reactions in solution in real-time. A combination of beam-line and lab-scale SAXS measurements, combined with simultaneous optical studies, showed that particle growth and coalescence compete under typical synthesis conditions, leading to loss of structural definition of the product. This mechanistic insight, in turn, guided the design of efficient and greener syntheses of well-defined nanoparticles.

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