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Self-Assembly as a Flexible Route to Multifunctional Nanomaterials

By

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In recent years, a number of single-function nanomaterials (polymer nanoparticles, carbon nanotubes, gold nanoshells, quantum dots, etc.) have been developed for therapeutic and diagnostic applications. The next phase of research aims to construct multicomponent entities which combine several functional properties into an integrated system, permitting more effective therapeutic regimens, earlier and more accurate disease detection and non-invasive assessment of responses to therapies.

In this work, a modular technology for the preparation of biocompatible multifunctional nanoparticles using block copolymer directed self-assembly is developed. The technology allows for the integration of materials of diverse physical and chemical properties based solely on thermodynamic driving forces. The key to the process is the balance of times scales for micromixing, self-assembly, flocculation and nucleation/growth. Using this technology, stable and uniform composite nanoparticles (CNPs) simultaneously encapsulating nanocrystals and organic drug molecules are prepared with tunable sizes, high concentrations of encapsulated components and precise control of component compositions, enabling joint applications in drug delivery, medical imaging and diagnostics. The design and preparation of novel CNP constructs based on magnetic nanocrystals for MRI contrast enhancement and on up-converting phosphors for photodynamic therapy of deep tissue cancers will be presented. Finally, methods for selective targeting of CNPs to disease tissues via a synergistic combination of passive (size-directed) and active (ligand-directed) targeting strategies will be discussed. Overall, the technology provides a comprehensive and highly flexible platform for the tailored design and preparation of multifunctional nanomaterials based on economical and scaleable synthetic methods.

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