**Designed Chemical Synthesis and Assembly of Uniform-sized Nanoparticles for Medical and Energy Applications**

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Over the last 10 years, our laboratory has focused on the designed chemical synthesis, assembly and applications of uniform-sized nanocrystals. In particular, we developed a novel generalized procedure called as the “heat-up process” for the direct synthesis of uniform-sized nanocrystals of many metals, oxides, and chalcogenides.1

Recently our group has been focused on medical applications of various uniform-sized nanoparticles. Using 3 nm-sized iron oxide nanoparticles, new non-toxic MRI contrast agent was realized for high resolution MRI of blood vessels down to 0.2 mm.2 We reported the first successful demonstration of high-resolution in vivo three-photon imaging using biocompatible and bright Mn2+ doped ZnS nanocrystals.3 We fabricated tumor pH-sensitive magnetic nanogrenades composed of self-assembled iron oxide nanoparticles and pH-responsive ligands for theranostic application, enabling the visualization of small tumors of < 3 mm via pH-responsive T1 MRI and fluorescence imaging and superior photodynamic therapeutic efficacy in highly drug-resistant heterogeneous tumors.4 We synthesized tumor pH-sensitive nanoformulated triptolide coated with folate targeting ligand to treat hepatocellular carcinoma (HCC), which has one of the worst prognosis for survival as it is poorly responsive to both conventional chemotherapy and mechanism directed therapy.

We reported the large-scale synthesis of magnetite nanocrystals imbedded in a carbon matrix and hollow iron oxide nanoparticles. We demonstrated galvanic replacement reactions in metal oxide nanocrystals. When Mn3O4 nanocrystals were reacted with iron(II) perchlorate, hollow box-shaped nanocrystals of Mn3O4/γ-Fe2O3 (“nanoboxes”) were produced.5 These iron oxide-based nanomaterials exhibited very high specific capacity and good cyclability for lithium ion battery anodes.

1. "Ultra-Large Scale Syntheses of Monodisperse Nanocrystals," Nature Mater. **2004**, 3, 891.

2. “Large-scale Synthesis of Uniform and Extremely Small-sized Iron Oxide Nanoparticles for High-resolution T1 MRI Contrast Agents,” J. Am. Chem. Soc. **2011**, 133, 12624.

3. “High-Resolution Three-Photon Biomedical Imaging using Doped ZnS Nanocrystals,” Nature Mater. **2013**, 12, 359.

4. “Multifunctional Tumor pH-Sensitive Self-Assembled Nanoparticles for Bimodal Imaging and Treatment of Resistant Heterogeneous Tumors,” J. Am. Chem. Soc. **2014**, 136, 5647.

5. “Galvanic Replacement Reactions in Metal Oxide Nanocrystals,” Science **2013**, 340, 964. Highlighted in “Perspectives: All Change for Nanocrystals,” Science **2013**, 340, 935.