ABSTRACT

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Modern technologies using nanoparticles often demand precise control of nanopartricle structures at atomic/molecular levels. The work discussed in this thesis demonstrates development and studies of novel nanomaterials that have precisely designed atomic/molecular structures for tailored applications, including cancer imaging, therapy, and energy storage.

The first example is $CaWO_4$ (CWO) radio-luminescent nanoparticles (NPs). CWO NPs have the potential for use in biomedical imaging and therapy because of the unique ways this material interacts with high-energy radiation. We developed CWO NP formulations that are suitable for in vivo applications; the formulated NPs are sufficiently small, chemically and biologically inert, and stable against aggregation under physiological conditions. Our study demonstrates that CWO NPs are promising materials for use in CT contrast and also in cancer radio sensitization.

In the second avenue of research, we explored a new approach for ultrasound (US) contrast enhancement; this approach uses gas-generating NPs as a precursor for producing micro bubbles (MBs) in situ. Our NP design uses the poly(propylene carbonate) (PPC) chemistry; PPC degrades to CO_2 at high temperature. PPC-based amphiphilic block copolymers (BCPs) were used to create self-assembled NPs (micelles) in which gold nanorods (GNRs) were encapsulated. These NPs are first delivered to the site of interest, and gas MBs are then produced from the NPs at that location by near infrared (NIR) radiation which causes GNR heating and thus induces

thermal degradation of PPC. Results support that GNR-encapsulating PPC-based BCP NPs are indeed promising contrast agents for US imaging.

In another project, we developed facile and scalable low-temperature post-treatment techniques that can be used, for instance, (i) to convert solution-synthesized core/shell metal oxide NPs to porous ternary complex NPs, or (ii) to convert metal NPs grown on metal oxide NP surfaces to hetero-structured composite NPs. Novel porous Co_2MnO_4 NPs prepared by Method (i) were found to possess superior electrochemical properties, including high capacity and remarkable stability under fast charging/discharging cycles, and are thus very promising cathode materials for use in lithium-ion batteries. $Cu_{3.8}Ni$/CoO and $Cu_{3.8}Ni$/MnO hetero-structured NPs synthesized by Method (ii) were found to be capable of significantly improving lithium ion mobility and electron transfer when used as anodes; these hetero NPs are also very promising high-power/energy-density anode materials for lithium-ion batteries.