**Development of Architectural Polymers for Biomedical Imaging and Therapy**

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 Polymer and nanoparticle-based devices have evolved to significantly enhance therapeutic efficacy. However, in order to be truly effective, these polymeric devices must maintain their physical and chemical integrity under physiological conditions – this can only be achieved by developing a strong understanding of the fundamental properties of the nanomaterial-delivery system, in addition to identifying and successfully *delivering* new therapies. Central to the development of these future therapeutic platforms, is the field of theranostics. This is the premise that future medical devices need to be capable of delivering a therapeutic dose to the correct site within the body, but must also possess mechanisms for online diagnosis, monitoring of disease progression and visualisation of drug delivery, release and efficacy of treatment. Such materials require significant advancements in chemistry, materials science and engineering such that the nanomedicine is complementary with the biological milieu. These materials are often complex in nature, but are designed with the express intention of providing further insight into the complex mechanisms that dictate nanomaterial behavior in biological systems.   
   
While there are countless examples of polymer or nanoparticle systems that show efficacy in animal models, the ability to rationally-optimise the materials is hindered by the inability to directly assess the behaviour of the materials *in vivo*. For example, improvements in administration for most biologically-targeted polymeric nanomaterial systems are achieved by monitoring efficacy in animals rather than monitoring the fundamental behaviour of the nanomaterial itself (e.g. measuring efficacy, rather than quantifying how a change in material properties results in a biological response). In this presentation, we describe recent efforts to develop self-reporting nanomedicines for a truly closed-loop approach to medicine, where nanomaterial behaviour is monitored in real-time using molecular imaging as a function of therapy. These materials are based on architectural polymers that form a scaffold allowing combination of imaging and therapeutic modalities. Molecular imaging provides a route to validate how structure and property affects function in animals. We offer insight into how advanced imaging techniques, such as positron emission tomography (PET), can be utilized to directly assess concentration of free drug in a particular volume upon its release from a polymeric carrier. Furthermore, new strategies to monitor therapeutic efficacy, rather than delivery, upon administration of nanotherapeutics will be discussed.