Polymeric Nanocapsules via Emulsions: Challenges and Strategies

Dr. Chong Cheng, Department of Chemical and Biological Engineering, University at Buffalo, the State University of New York

Abstract: Polymeric nanocapsules have attracted significant interest for potential applications in biomedical and other areas. Controlled interfacial cross-linking within nanoscopic templates has allowed the synthesis of these nanomaterials with three-dimensional covalent architectures. Accordingly, synthetic accuracy and efficiency depends not only on the reaction or polymerization techniques but also on the template conditions. Relative to other templating approaches, emulsion-based methods typically are facile and eco-friendly, but may suffer from deficiency in precise control over the resulting nanostructures due to the limited kinetic stability of emulsions and sluggish crosslinking reactions. Specifically, the dynamic instability of small molecule surfactants at water-oil interface makes the precise synthesis of nanocapsules by covalently arresting surfactants within surfactant monolayers in emulsions an impossible mission. Moreover, no matter whether small molecule or high MW surfactants are used, photoreactions in emulsion systems generally have low efficiency because light cannot effectively penetrate emulsions. Furthermore, it remains challenging to synthesize nanocapsules with biodegradability and other preferred properties for biomedical applications. Our group’s research has addressed these challenges through a variety of strategies. According to the dynamic instability of small molecule surfactants in emulsions, “crystal-forming” emulsions have been developed to convert liquid-liquid interfaces of emulsions to solid-liquid interfaces; as a result, the dynamic stability of surfactant monolayers at interfaces is greatly improved and nanocapsules with precisely-controlled monolayer-thick shells have been achieved. In terms of low synthetic efficiency of photoreactions in emulsions, transparent miniemulsions have been developed as innovative synthetic templates to enable highly efficient synthesis of polymeric nanocapsules by UV-induced crosslinking. With our keen interest in applying polymeric nanocapsules in biomedical applications, three types of biodegradable polymeric nanocapsules have been synthesized by crosslinking polymer precursors in emulsions. By using the nanocapsules derived from cationic polylactide as novel nanoscopic scaffolds, the first example of nanocapsule-based drug-gene co-delivery system has been demonstrated.

Biosketch: Dr. Chong Cheng is an Associate Professor in Department of Chemical and Biological Engineering at University at Buffalo (UB), The State University of New York. He obtained his Bachelor’s degree in Polymer Materials from Hefei University of Technology in 1993, and earned his Master’s degree in Polymer Materials from Beijing University of Chemical Technology in 1996. He received his PhD in Chemistry from City University at New York in 2003. From 2003 to 2007, he worked as a postdoctoral associate in Professor Karen L. Wooley's laboratory at Washington University in Saint Louis. Dr. Cheng started his independent academic career as a tenure-tracked Assistant Professor at UB in 2007, and was promoted to an Associate Professor at UB in 2013. His current research focuses on the development of novel functional polymers and polymeric nanostructures for biomedical and other applications.