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Protective Frameworks for Biomolecule Applications

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Biomolecules such as enzymes, DNA and other proteins are increasingly being used in various biotechnology and industrial applications. However, they rely on their structural complexity for activity and specificity [1] making them vulnerable to environmental factors such as temperature, pH, and solvents. Encapsulation of these molecules, especially enzymes, improves their stability and allows them to retain their activity, therefore increasing their utilisation in a range of applications such as industrial catalysis and biopharmaceutical delivery.[2]

We have been developing an encapsulation process using Metal-Organic Frameworks (MOFs) with inspiration from natural biomineralisation processes whereby molecular architectures are fabricated by living organisms to provide exoskeletal "shields" and structural support. Biomolecules of interest such as proteins and enzymes are used as agents to initiate the encapsulation process by introducing them into aqueous solutions containing the MOF precursors (organic ligands and metal cations). The MOF self-assembles around the biomolecules, forming a protective shield, analogous to the exoskeleton of the sea-urchin. The resulting bio-composites, are then simply separated via centrifugation and subsequent washing and can be released upon change in pH.[3]

Using Small Angle X-Ray Scattering (SAXS) at the Australian Synchrotron, we have been studying the formation mechanisms involved with the biomineralisation process. In this presentation we will discuss the investigation into crystallisation during the assembly, washing and releasing processes. Understanding the material behaviour and stability of the metal-organic frameworks is crucial for applying these materials in industrial applications.

[1] S. Mitragotri, P. A. Burke and Langer, R. Overcoming the challenges in administering biopharmaceuticals: formulation and delivery strategies. Nat. Rev. Drug Discov. 2014, 13, 655–672.
[2] a) U. T. Bornscheuer et al. Engineering the third wave of biocatalysis. Nature 2012, 485, 185-194; b) N. Savage, Logistics: keeping cool. Nature 2014, 507, S8-S9.
[3] K. Liang, R. Ricco, C. M. Doherty, M. J. Styles, S. Bell, N. Kirby, S. Mudie, D. Haylock, A. J. Hill, C. J. Doonan and P. Falcaro, Biomimetic mineralization of metal-organic frameworks as protective coatings for biomacromolecules, Nat. Comm., 2015, 6, 7240.

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