הנדסת ביוטכנולוגיה ומזון

הטכניון מכון טכנולוגי לישראל TECHNION Israel Institute of Technology

The faculty of Biotechnology and Food Engineering

Seminar

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Sequence-encoded biomimetic pigment materials formed by molecular self-assembly and biocatalysis

Abstract

Biological systems employ a precise spatiotemporal control of enzymatic catalysis for construction of functional materials. This control is achieved by supramolecular templating of biocatalytic action or by compartmentalization of enzymes and reactants in confined spaces within the cell. Construction of functional synthetic materials, by contrast, is mostly focused on formation of bulk structures, with spatial and temporal elements only recently considered. A natural system which requires such regulation is the biosynthesis of melanins, a class of pigments found across all life forms and provide coloration, protection from photo- and free radical-induced cell damage,metal chelation and anti-oxidant activity. While these pigments are made from chemically simple building blocks,their biosynthesis and assembly relies on tightly regulated processes, which are both temporally and spatially controlled and further fine-tuned by incorporation of locally available metabolites. In contrast, the laboratory-based synthesis of melanin is a poorly controlled process resulting in formation of an insoluble material. Unlike supramolecular systems, where order dictates function, the disorder in melanin is important for its functionality,hence, balancing between order and disorder is key for controlling pigment properties. To address these major challenges, we use tyrosine-containing self-assembling tripeptides as precursors for the catalytic formation of polymeric pigments. We show that the supramolecular order of peptide substrates is encoded by their sequence, and demonstrate the sequence-structure relationships underlying these assemblies. The level of supramolecular order, in turn, controls substrate accessibility, leading to a sterically and kinetically controlled enzymatic oxidation and polymerization pathway, resulting in pigment materials with a range of properties, depending on the peptide sequence. Furthermore, inspired by the natural mechanism to attain variety of melanin pigments, we show that the chemical space of these pigments can be dramatically expanded by reactive incorporation of metabolites (unpublished). Thus, mimicking firstly the natural brown/black eumelanin from self-assembling tyrosine peptides and the yellow/red pheomelanin with cysteine added, but then taking it much further by including other amino acids in the feed, giving rise to new pigment particles with properties that go beyond those of natural melanins- including intense and tunable emission ranging from blue to near-IR. We show that the reactive incorporation of varying amino acid feeds, including combinations of amino acids allows rational fine tuning of the properties of these microparticles, where each feed encodes for distinctive optical properties. Building on my background in molecular self-assembly of proteins and peptides, and the exploitation of this process with biocatalysis to design functional materials, the aim of my future work is to establish fundamental mechanisms of spatiotemporally confined molecular self-assembly and enzymatic catalysis, and subsequently to translate my findings into design criteria, to fabricate novel adaptive biomaterials with controlled properties.

Wednesday, 12.12.18, 14:00 – 15:00, Room 300
Faculty of Biotechnology and Food Engineering