Universität Basel

Research Project

BIOINSPIRED MULTIFUNCTIONAL BIO-SYNTHETIC SUPRAMOLECULAR ASSEMBLIES

Third-party funded project

Project title BIOINSPIRED MULTIFUNCTIONAL BIO-SYNTHETIC SUPRAMOLECULAR ASSEMBLIES
Principal Investigator(s) Palivan, Cornelia ;
Co-Investigator(s) Huwyler, Jörg ; van Doorslaer, Sabine ;
Organisation / Research unit
Departement Chemie / Physikalische Chemie (Palivan)
Departement Chemie / Makromolekulare Chemie (Meier)
Department
Departement Chemie / Physikalische Chemie (Palivan)
Project start 01.04.2022
Probable end 31.03.2024
Status Completed

Various domains require materials that integrate emerging properties with multifunctionality to efficiently solve complex issues (e.g. early detection and treatment of severe pathologies, sensing and correction of food quality issues, simultaneous determination of the presence of pollutants in water, biofilm formation). Amongst the most promising strategies is the use of bio-inspired bottom-up approaches based on interfacing biomolecules (enzymes, proteins, DNA)
with synthetic assemblies (micelles, vesicles, particles). This combination can produce bio-synthetic materials that surpass conventional systems in terms of efficacy and functionality as they profit from the activity and specificity of the biomolecules whilst the synthetic matrix provides the necessary stability and robustness.

The objective of this project is to create bio-inspired multifunctional supramolecular assemblies, in which activation and responses are stimuli-triggered. These multifunctional supramolecular assemblies will serve either as multiplexed reaction spaces at the nanoscale with magnetic controlled propulsion or as active surfaces patterned with responsive nano-assemblies. These directions, connected by biomolecules serving as active components, are inspired by aspects of natural organelles and cells, including signalling pathways, responsiveness and triggered production of molecules. Overall, this interdisciplinary project combines physical chemistry, nanoscience, surface science and enzyme biochemistry.

The first subproject plan is to create clusters of active Janus-multicompartments by DNA-mediated self-organization of magnetic Janus nanoparticles and catalytic compartments based on polymersomes equipped with active molecules. Two different types of catalytic nanocompartment will be specifically attached to the lobes of Janus nanoparticles and
activated by stimuli present in the environment. The intrinsic activity of the encapsulated molecules inside the catalytic nanocompartments will induce multifunctionality into the clusters, whilst the Janus nanoparticles will serve as “shuttles” to support the directional propulsion of the clusters in the presence of a magnetic field. To demonstrate the potential of the system in photodynamic therapy, we have selected enzymes and photosensitizers, respectively, as model compounds inside each type of catalytic nanocompartments. Clusters of active Janus-multicompartments have the advantages of segregation of protected spaces for active molecules and dual functionality with time, and space precision due to the stimuli-responsive manner of their activation and propulsion.

The second subproject aims to construct multifunctional “active surfaces” by specific immobilization of different types of biomolecule-loaded nano-assembly (peptide nanoparticles and polymersomes) on solid supports. These active surfaces will exhibit dual functionality in the presence of stimuli: polymersomes containing enzymes will act as catalytic nanocompartments for sensing pH changes, whilst peptide nanoparticles will release their cargo upon changes in
temperature. A controlled surface pattern will be achieved by combining two approaches for immobilization of nano-assemblies on solid supports: DNA-mediated connection for polymersomes and covalent binding for peptide nanoparticles. To illustrate one of the possible applications, we have selected enzymes and flavonoids for sensing and correcting early changes in food quality. Such active surfaces have several advantages including versatility and modularity of specific patterning and multifunctionality associated with simultaneous responses to external stimuli.

Knowledge gained from the fundamental study of the molecular factors, interactions and conditions that are essential to build such multifunctional bio-synthetic assemblies will support their development as efficient platform for solving complex issues in various fields, including medicine, food science, environmental sciences, and technology.

Financed by
Swiss National Science Foundation (SNSF)

Add publication

Add documents

Specify cooperation partners