

#P001 - PROTEIN AGGREGATES FOR WATER PURIFICATION

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Water pollution is the contamination of water bodies including lakes, rivers, oceans and it is a leading global risk factor for illness and death for people, plants and living organisms. A principal source of water pollution is industry, from which increasing amounts of toxic pollutants are released including heavy metals such as cobalt, lead and copper. Today various technologies for purifying contaminated water can be applied, a lot of them being typically expensive, ion specific and characterised by low efficiency. For these reason, the search of new biocompatible materials with increased capabilities is strongly needed.

Protein aggregates have already revealed their potential as environmentally friendly, biocompatible, flexible materials for different application ranging from scaffold for tissue engineering to drug delivery.

In peculiar conditions, proteins may destabilise their structure and undergo different association processes leading to amyloid like aggregates. These highly ordered structures stabilised by H-bonds include fibrils, spherulites and particulates. By suitably varying solution conditions it is possible to tune aggregate size and morphologies as well as their physicochemical (hydrophobicity, hydrophilicity, swelling/deswelling properties) and mechanical properties. Amyloid fibrils have already revealed their potential for applications in water purification as fundamental components of carbon based filter membranes used for separating water from heavy metals. Here we present an experimental study where particulates are tested as new tuneable biomaterials for metal adsorption. Particulates are considered a generic state for protein aggregation they are perfectly spherical aggregates whose diameter ranges from hundreds nanometers to few microns. They can be readily formed at high temperature in water solutions at pHs close to the isoelectric point and have never been related to pathologies.

We used spectroscopy and microscopy methods to characterize the aggregates formation, structure and morphologies. Inductively coupled plasma Optical Emission Spectroscopy (ICP – OES) and Differential Pulse Anodic Stripping Voltammetry (DP-ASV) techniques are used to evaluate uptake/release of metal ions in different conditions as a function of time and of adsorbate – adsorbent ratio in kinetic and thermodynamic experiments. The most used kinetic and isotherm equations were used to fit experimental data in order to obtain information about adsorption mechanism.

Changing aggregation conditions and in turn molecular properties of aggregates, it is possible to highlight peculiar structural features essential for metal binding/adsorption. This knowledge can be used to develop efficient biomaterials for removing toxic heavy metal from wastewater, also, to exploit them for several cycles of purification with minimal reduction in performance.

#P002 - SPONTANEOUS INTERFACIAL FRAGMENTATION OF INKJET PRINTED OIL DROPLETS AND THEIR ELECTRICAL CHARACTERIZATION

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This work presents the fabrication of femtoliter-scale oil droplets by inkjet printing based on a novel mechanism for the spontaneous fragmentation at the interface with an immiscible water phase and the electrical characterization of the resulting immersed “daughter” droplets. [1] In particular, picoliter-scale fluorinated oil droplets impact on surfactant laden water phase at moderately high Weber number (10^1), and are subjected to spreading and capillary instabilities at the water/air

interface which ultimately lead to rupture in smaller sized droplets, according to reported models for macroscale droplets systems - [2] the emerging fragmentation results in “daughter” droplets having volumes of about 10-30 % with respect to the initial droplet volume. Remarkably, the picoliter scale downscaling leads to a novel surfactant-driven fragmentation due to the low Bond number (around 10^{-4} - 10^{-5}), meaning that droplet immersion is dependent on surface tension forces and not on gravitational forces. In fact, the non-ionic Polyoxyethylene (20) sorbitan monolaurate was observed to permit the droplet immersion in the water phase only if spiked in the water phase at concentrations equal or higher than its critical micellar concentration (i.e. around 0.003% v/v). The resulting oil “daughter” droplets are characterized by a chip with integrated microelectrodes, permitting to extract number, velocities and diameter distribution (peaked at about 3 μm) employing electrical impedance measurements. In accordance with reported models, the electrical characterizations show that the droplets have volumes in the femtoliter scale and are subjected to inertial focusing. [3] This work can be considered an important advancement for understanding the effects of downscaling on fragmentation phenomena at immiscible interfaces, leading to a knowledge platform for a tailored oil droplets fabrication applicable for drug encapsulation, pharmaceutical preparations, and thin-film wrapping around droplets. [4]

Bibliography

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#P003 - ON THE EFFECT OF DOWNSCALING IN INKJET PRINTED LIFE-INSPIRED COMPARTMENTS

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The fabrication of size-scalable liquid compartments is a topic of fundamental importance in synthetic biology, aiming to mimic the structures and the functions of cellular compartments. Here, inkjet printing is demonstrated as a customizable approach to fabricate aqueous compartments at different size regimes (from nanoliter to femtoliter scale) revealing the crucial role of size in governing the emerging of new properties. At first, inkjet printing is shown to produce homogenous aqueous compartments stabilized by oil-confinement with mild surfactants down to the hundreds of picoliter scale [1]. Raster Image Correlation Spectroscopy allows to monitor few intermolecular events by the involvement of protein-binding assays within these compartments [2]. Subsequently, in order to reduce droplet size at values below the nozzle size, a theoretical model from Eggers et al. [3] is experimentally reproduced permitting to obtain femtoliter-scale aqueous droplets from picoliter-scale microchannels [4]. As a remarkable difference to picoliter scale droplets, downscaling at the femtoliter-size triggers the spontaneous formation of molecularly crowded shell structures at the water/oil interface stabilized by a mixture of biocompatible surfactants. The shells have typical thickness in order of hundreds of nanometers, in accordance with theoretical models [5]. Molecular crowding effects in these systems are tested by using fluorescence lifetime imaging under the phasor plot approach [6], revealing different characteristic lifetimes of specific probe molecules in the confined volumes with respect to bulk solutions. The femtoliter-scale compartments autonomously trigger the formation of unique features (e.g., up-concentration, spatial heterogeneity, molecular