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Editorial: Celebrating 1 year of Frontiers in Soft Matter

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Editorial on the Research Topic
Celebrating 1 year of Frontiers in Soft Matter

Soft matter encompasses materials between traditional liquids and solids, which includes complex fluids, liquid crystals, colloidal suspensions, surfactants, emulsions, polymeric networks in liquid media, gels, foams, and most biological materials. As an echo to the launch of the Frontiers in Soft Matter, one modest goal of this anniversary collection is to raise awareness of the breadth of soft matter as a scientific discipline. The Research Topic articles were curated with the goal of showcasing exciting topics in soft matter research. It is anticipated that a broader range of topics will be covered over subsequent anniversary issues.

Four prominent articles have been published in this Research Topic issue. The Research Topic includes two mini reviews, one original article, and one extensive review. The first mini review is related to the recent advances in biosurfactant-based microemulsions and the second one is on surfactant-free self-assembled mesoscale structures in multicomponent mixtures comprising nanoparticles, nanodroplets, and nanobubbles. The original research article is entitled “Dual mechanical impact of β-escin on model lipid membranes.” The fourth article is an extensive review, entitled, “Applying soft matter techniques to solve challenges in cryopreservation.”

In the minireview on biosurfactant-based microemulsions led by Hellweg et al., a specialty chief editor of the journal, the team of three scientists bring to the spotlight bio-surfactants of plant and microbial origins. Microemulsion systems formed by mixing oil and water with biosurfactants, such as saponins and rhamnolipids, are hugely significant in the context of sustainability as the world moves away from the petroleum industry. In contrast to most synthetic surfactants based on petrol-chemistry, biosurfactants naturally produced by plants and microbes require mild synthesis conditions, are natively biocompatible and biodegradable, and have superb pharmacological properties. Saponins, extracted from plants, such as horse chestnuts, soapbark, and foxglove, have been widely used in food, drugs, cosmetics, and the pharmacological industry. This review briefly compares the structure and properties of saponins with synthetic surfactants. These surfactants of distinct origins are widely used as emulsifiers. The second class of biosurfactants reviewed are rhamnolipids, produced most notably by the bacterium *Pseudomonas aeruginosa* (Soberón-Chávez et al., 2005). Fine-tuned by genetics and evolution, rhamnolipids have a strong surface activity. Specifically, the ability of rhamnolipids to reduce surface tension by a factor of two facilitates the crucial functions of swarming motility and biofilm growth, properties that are key to the infectivity of this opportunistic animal and human pathogen.

The mini-review, by Sedlak, provides an insightful perspective on surfactant free emulsions, which contain nano-particles, nano-droplets, or nano-bubbles. Such structures are common in multi-component mixtures with both industrial and biomedical applications. Due to the nanoscopic size and the minuteness of materials contained within bulk volumes of solvent, even the slightest amounts of impurities pose serious challenges on reliable analysis of the content composition, casting doubts on the very existence of stable nano-bubbles under the conditions previously conjectured. The authors caution that, in most cases, emulsified nano-scale particles, particularly under surfactant free conditions, are nano-particles or nano-droplets—although the transient existence of nano-bubbles may play some role. The review points to the crucial role of experimental measurements in discerning the existence and molecular composition of nano-sized structures within surfactant-free emulsions.

The original research article by Moleiro et al. reports experimental findings of the interaction between β-aescin (i.e., escin), a naturally occurring biosurfactant, with the model lipid DMPC (1,2-dimyristoyl-sn-glycero-3-phosphocholine). The study focuses on the insertion of escin into DMPC lipid bilayers, either by transversal adsorption or longitudinal integration, and measuring the structural phase behavior and the mechanical properties of the hybrid escin/phospholipid membranes. The observed properties include soft glassy rheological behavior reminiscent of liquid-crystalline ordered phases that manifest fluidlike viscoelasticity, resembling disordered phases at physiological temperatures. The authors offer a physicochemical perspective relevant to pharmacological designs, exploiting the dual mechanical impact of escin as modulable by composition and temperature changes in biological membranes. As a commonly used biosurfactant in the saponins category, the detailed structure and mechanical properties characterized in this study offer context to the therapeutic efficacy of escin in treating chronic venous insufficiency (CVI), hemorrhoids, and post-operative oedema (Sirtori, 2001). Further studies are needed, however, to gain insights on what molecular mechanisms specifically account for the various medicinal benefits that have been clinically demonstrated.

Cryopreservation is a century-old practice that has critical applications in biomedical technology such as assisted reproduction, stem cell therapy, blood banking, and species preservation. Only recently has the subject seen renewed interest with studies at the nexus of soft matter research. A wide range of synthetic and natural compounds are discussed, from the most widely used permeable cryoprotectants (CPAs), such as glycerol and dimethyl-sulfoxide (DMSO), to naturally produced, intracellular CPAs, such as sucrose and trehalose. Through a comprehensive discussion of these, the review addresses the need for new, permeating, less toxic CPAs. The review published in this anniversary collection focuses on the discussion of several soft matter techniques with special emphasis on those that have been traditionally practiced by a relatively small community of physical chemists who find their effort integrated into the broader soft matter field. The techniques discussed in this review include optical imaging, X-ray and neutron reflectivity spectroscopy, infra-red (IR) and Fourier transform infra-red (FTIR) spectroscopy, electron microscopy (EM), and atomic force microscopy (AFM). In connection with these techniques, the review also describes in some detail a couple of specific methods, such as shrink-swell experiments and Langmuir trough measurements. With broad-ranged experimentation and unlimited human ingenuity, perhaps one day the species on Earth can indeed be cryo-preserved and revitalized to cope with distant space exploration and exoplanetary travel.

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