1. Final publishable summary report

Phase separation and crystallization

Concentrated protein mixtures are ubiquitous in nature and widespread in many fields of technology. For example, living cells contain up to 300 mg ml^{-1} of thousands of different proteins in their intracellular fluid. An interesting new development in the food sciences concerns “high protein foods”. These products contain large amounts of proteins and are thought to aid in the fight against obesitas and perhaps sarcopenia. While each organism or application may require a specific set of components and circumstances to function properly, perform optimally, or taste exquisitely, they certainly share one common requirement: stability. It is one of the biggest challenges in the field, as concentrated protein mixtures are prone to undergo many different types of phase transitions, such as crystallization, liquid-liquid phase separation, and complex coacervation (Figure 1).

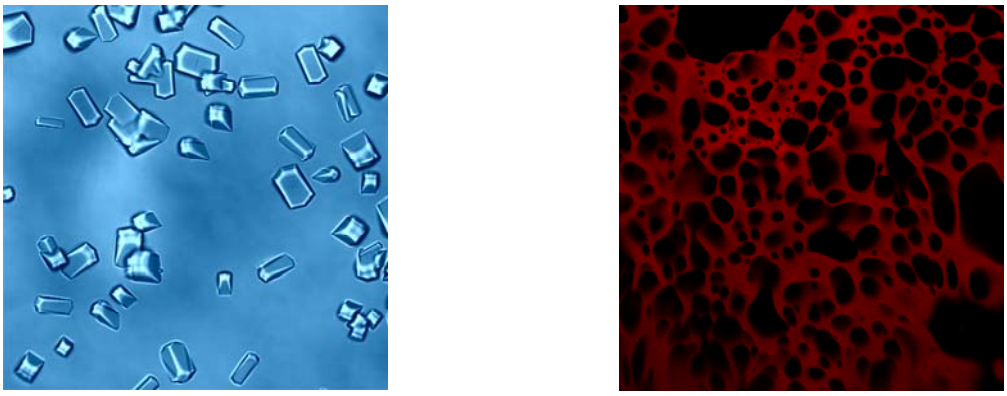

Figure 1. (left) Lysozyme crystals and (right) arrested associative phase separation in concentrated mixtures of lysozyme and α-lactalbumin visualized under a confocal laser scanning microscope.

The physico-chemical approach

Within the framework of PROMIX, we have used a combination of experimental methods, including UV-Vis spectroscopy, confocal laser scanning microscopy, X-ray scattering, and optical microscopy to systematically investigate the phase behaviour of several concentrated binary protein mixtures. Our experiments revealed how the salt concentration, p*H*, and protein composition essentially dictate the phase state (liquid, solid, order, disorder) of the system. Furthermore, our findings strongly suggest that stability in more complex protein mixtures, such as intracellular fluids (also known as the cytosol), is governed by counter-ion entropy and partial protein volume fractions rather than by protein specific properties. This opens new pathways for a thermodynamic description of protein mixtures that may account for their extraordinary stability encountered in nature. We therefore hope to connect our experimental results in the near future to a theoretical framework to further enhance our understanding of the physics behind the rich and fascinating phase behaviour of concentrated protein mixtures.