Adsorption study of molecules with surface-active properties on the interface of milk fat globules: application to high pressure homogenization process

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High pressure homogenization processes are often used in the dairy industry in order to achieve homogeneous and stable dispersion of the fat in the formulated milk product. These operations, consisting of splitting the milk fat globules into smaller units, lead to an area increase of the interface between lipidic and aqueous phases which is progressively covered by surface-active molecules and a significant reorganization of the fat globule interface. The fat globule size and interface can then modify the textural and sensory properties of the dairy products in which it is dispersed.
The general aim of this work is to better understand and model the structuring of the milk fat interface by the homogenization process. Modelling is combined with two complementary levels of experimentations. On the one hand, tensiometry experiments are carried out in order to simulate the adsorption of the various surfactants naturally present in milk (phospholipids, whey proteins, caseins) on a single fat droplet (anhydrous milk fat). On the other hand, high pressure homogenization experiments (HPH) are carried out on model milks of varying composition after which granulometry and interfacial charges are measured.
From the tensiometry experiments, through modelling by the Ward-Torday approach, the diffusion and adsorption characteristics (saturation surface excess, critical concentration at which half of the surface is covered by the surfactant, diffusivity) were determined assuming Langmuir model for adsorption isotherm. Then, using these parameters, a multi-component diffusion-adsorption model was developed to simulate the main phenomena occurring during HPH treatment. In a first approach, some simplification assumptions were made (e.g. fragmentation occurs very rapidly compared to diffusion, diffusion occurs trough a non-turbulent sub-layer)
This communication presents the general modeling approach, an example of parameter estimation from tensiometry measurements and an example of simulation of fragmentation/diffusion/adsorption in the HPH process. It illustrates not only the phenomena of individual adsorption of surface-active molecules but also competition and synergy phenomena during homogenization process.
This work initiates an approach to better understand the impact of homogenization processes and more broadly the interfacial phenomena and thus how to modulate the formulation and the process in order to obtain optimal properties.