Droplets-based millifluidic for the establishment of protein-polysaccharide phase diagrams

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Texture, structure, taste as well as stability of food products are strongly related to its constituent’s interactions. The understanding of these interactions is still a challenge in food-processing. Besides lipids or flavour, proteins and polysaccharides are widely used in food products. It is already well known that under specific conditions protein-polysaccharide mixture can lead to liquid-liquid phase separation, of segregative or associative type. To highlight the conditions of phase separation, a phase diagram is established. However, such a study, generally performed in bulk is time and raw material consuming. Therefore alternative strategies for rapid phase diagram determination using microfluidics recently emerged. Microfluidic enables a large reduction of engaged volume, a precise control over experimental conditions and mixed systems composition as well as an acceleration of reaction time. Nevertheless, to the best of our knowledge, these techniques were only described for segregative phase separated systems [1], [2].

In the present work we developed a droplets-based millifluidic device for rapid phase diagram building of associative phase separated system. Binodal curve was determined by turbidity measurements within the droplets using grey balance analysis. Cloud points, corresponding to the onset of phase separation, were defined as the composition corresponding to a 10% increase in turbidity compared to the original reference solution. The first part of the study was dedicated to the proof of concept using a colloidal suspension of titan dioxide (TiO₂). We evidenced proportionality between the turbidity measured in bulk using spectrophotometer and the one determined within the droplet by grey balance analysis. The second part of the study was devoted to establish the phase diagram of an associative phase separated system: β-lactoglobulin (BLG) / Gum Arabic (GA), first in bulk and then using the more innovative droplets-based millifluidic approach where the composition and total concentration were finely tuned by flow rates variation (Figure 1). Considering the high similarities obtained at both scales, we now plan to extend the technic to several protein-polysaccharide mixtures.

Figure 1: Biopolymers droplets at various protein-polysaccharide ratio (1% total concentration) obtained by millifluidic approach (a) and observed using (b) magnifying glass (c) phase contrast optical microscopy