Smart Non-Aqueous Foams From Lipid based Oleogel

Anne-Laure Fameau\textsuperscript{1*}, Stephanie Lam\textsuperscript{2}, Orlin Velev\textsuperscript{2} and Arnaud Saint-Jalmes\textsuperscript{3}

\textsuperscript{1}Biopolymères Interactions Assemblages INRA Nantes, France.
\textsuperscript{2}Department Chemical & Biomolecular Engineering, North Carolina State University, USA
\textsuperscript{3}Institut Physique de Rennes, Université Rennes 1, France.
*anne-laure.fameau@nantes.inra.fr

Recently, responsive aqueous foams, which can be manipulated using external fields, have been obtained from various systems such as surfactants, particles or polymers [1]. Contrary to aqueous foams, few studies have been devoted to the understanding of oil foam, despite their great potential in diverse fields [2]. The production of oil foams is difficult to achieve due to the inefficiency of surfactant adsorption at oil-air interfaces. We report a simple way to produce oil foams from oleogels, whose liquid phase is a mixture of sunflower oil and fatty alcohols crystals [3].

We show that the oil foams could be easily produced by incorporating gas during the fatty alcohol crystallisation process. The platelet crystals coat the air bubbles in the foam and mediate the gelification of the continuous phase, giving rise to ultrastable oil foams (Figure 1). The quantity of foam produced is directly linked to the quantity of crystal particles present to stabilize air bubbles. Foam stability increases with increasing hydrocarbon chain length and fatty alcohol concentration, both of which affect the formation and melting of the crystal particles. Below the melting temperature of the crystals, oleogel foams are stable for months. Upon heating, these ultrastable foams collapse within a few minutes due to the melting of the crystal particles. The transition between crystal formation and melting is completely reversible, leading to thermo-responsive non-aqueous foams (Figure 1). The reversible switching between ultrastable and unstable foam depends solely on the temperature of the system. We demonstrate that these oleogel foams can be made to be photoresponsive by using internal heat sources such as carbon black particles, which can absorb UV light and dissipate the absorbed energy as heat.

To our knowledge, such foams obtained from oleogel are the first example of multi-responsive non-aqueous foams [3]. This simple approach for the formulation of responsive oil foams can be easily extended to other oleogel systems and can find a broad range of applications due to the availability of the components in large quantities and at low cost.

\textbf{Figure 1}: Photographs showing the stabilization/destabilization phenomena with temperature for an oleogel foam stabilized by lipid crystals. The lipid melting ($T_m$) and crystallization ($T_c$) temperatures are 48.3 and 31.7°C, respectively. (a) Stable foam at 20°C. (b) At $T > T_m$, foam destabilization starts occurring in less than one minute. (c) By decreasing the temperature back to $T < T_c$, the foam becomes stable again. (d) Upon increasing $T > T_m$, after 2 minutes at 50°C, the foam is completely destroyed.