Study of the gelling of an emulsion

Done in collaboration with

Application

Cosmetics

Objective

Characterization of the kinetics and the stability of an emulsion by aggregation

Device

TURBISCAN® LAB

INTRODUCTION

Gelling can be obtained through two main mechanisms: creation of a network due to a reticulation of polymers (it is the case for gelatin) or aggregation of particles (it is the case in yogurt). In the cosmetics industry it is commonly used to get various textures (Figure 1).

For a given system, adhesive interaction between the drops of emulsions depends on the temperature, the size of the drops, the concentration of salt and the volume fraction of the emulsion. The objective of the formulator can be to identify the interaction at the origin of the aggregation in the emulsion, to characterize the experimental conditions under which it arises or to characterize the gel and the kinetics of its formation, the conditions of its existence, of its stability, etc. We present a few results obtained on a model system.

METHOD

We studied a hexadecane emulsion stabilized with SDS at the CMC. The average drop size is of the order of 1 µm.

In an initial series of experiments (a, b, c), we studied the influence of the salt concentration in the continuous phase. The emulsions are heated to 40°C and placed in the Turbiscan LAB.

In a second set of experiments, we studied the influence of the dispersed phase volume fraction (d, e, f). The intial emulsion is the same as before. Emulsions are heated to 60°C before being characterized by the Turbiscan LAB.

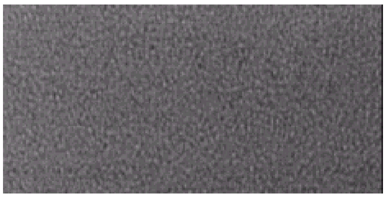
RESULTS

1. Salt Concentration

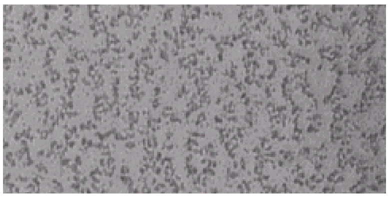
We present the results obtained with short cycles corresponding to the appearance of the adhesive interaction upon return to ambient temperature.

Upon return to ambient temperature, we observe a decrease in the homogeneous backscattering intensity in the sample (Figure 2). For sample b, this decrease is slow (20 min) and moderate (-6%) while for c, it is fast (10 min) and pronounced (-17%). For longer cycles, apart from a creaming phenomenon, the backscattering intensity at the core of the sample does not vary.

We can see the aggregation of the drops in the emulsion due to aggregation. When the salt concentration is low (b), small flocs form in the emulsion (with a slight lowering of backscattering). When the salt concentration increases, the aggregation between the drops becomes stronger and leads to the formation of aggregates of greater characteristic size (greater lowering of backscattering).

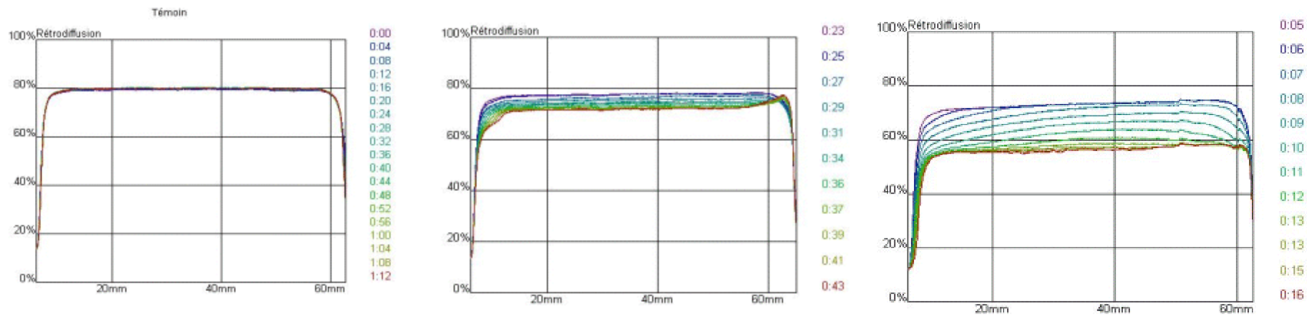


Initial emulsion



Same emulsion forming a gel

Figure 1. Optical microscopy snapshots of samples a and c at ambient temperature (lens 40).

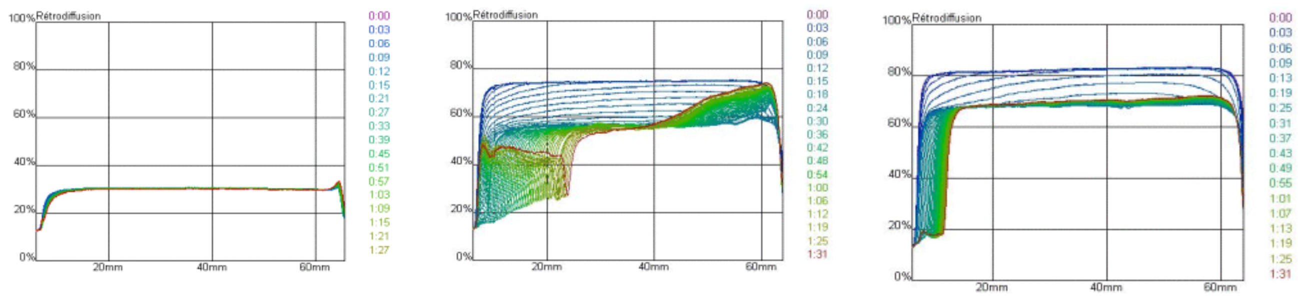


a – [NaCl] = 0 M, Φ = 10%. *b - [NaCl] = 0.38M, Φ = 10%.* *c - [NaCl] = 0.45M, Φ = 10%.*

Figure 2. Effect of salt concentration on emulsion flocculation

2. <u>Volume fraction</u>

Figure 3, we do not observe any noticeable variation of backscattering for the emulsion d (Φ = 1%). On the other hand, for emulsions e and f, backscattered intensity decreases significantly for short cycles, but proportionately less according to the concentration of the emulsion (-19% and -14% respectively, for Φ = 10 and 20%). These decreases in intensity correspond to increases in characteristic sizes in the emulsions. The Turbiscan LAB highlights a decrease of the characteristic gel size with the increase of the volume fraction of the emulsion. The gel formed by the adhesion of the drops is, in effect, more dense when the volume fraction of drops is greater.
Another aspect revealed in longer cycles is the kinetics of contraction of the gel formed. We represent the speed of clarification on the right. These curves show that only the emulsion at Φ = 30% forms a gel that is stable over time, which contraction is completed after about one hour. The other emulsions cream greatly without stabilizing.



d - [NaCl] = 0.45M, Φ = 1%. *e - [NaCl] = 0.45M, Φ = 10%.* *f - [NaCl] = 0.45M, Φ = 20%.*

Figure 3. Effect of salt concentration of emulsion flocculation

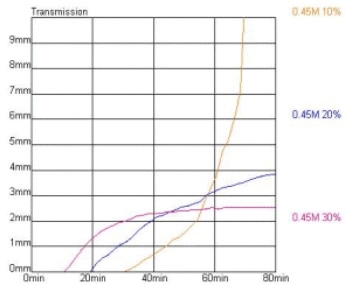


Figure 4. Speed of clarification of the aggregated emulsions

SUMMARY

The adhesive interactions between drops of emulsion in presence of salt and as a function of temperature confer new properties to the initial emulsion. The Turbiscan LAB is a tool that is both sensitive and quantitative. It makes it therefore possible to optimize formulations and to characterize the new materials thus produced.

