EMULSION OPTIMIZATION

SURFACTANT CONCENTRATION SCREENING

Introduction

In the formulation process, once the surfactant is selected, the concentration corresponding to the minimum cost /efficiency ratio still needs to be adjusted. The TURBISCAN is the leading technology in direct stability measurement and thus can be a perfect solution to rapidly define the optimum concentration that preserves the highest efficiency with low cost and ensures long shelf life. With its new capabilities to measure particle size with no dilution, online directly in the measurement cell, the TURBISCAN becomes a full characterization tool for rapid formulation optimization without user intervention during analysis. This application paper shows how the TURBISCAN DNS with circulation function (T-LOOP), helps select the right surfactant concentration by reaching the required size and stability properties.

How it works

The TURBISCAN technology, based on Static Multiple light scattering (SMLS), consists of illuminating a sample with an infrared light source and acquiring backscattered (BS) and Transmitted (T) signals.

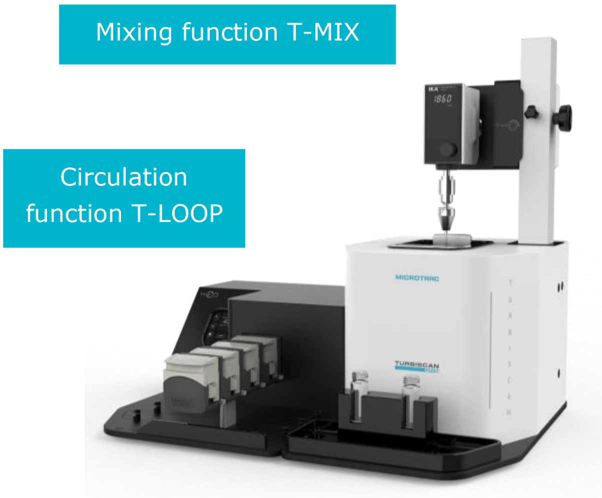
$$BS \text{ and } T = f(\varphi, d, np, nf)$$

The signal is directly linked to the particle's concentration (φ) and size (d) according to the Mie Theory, with refractive index of continuous (n_f) and dispersed phase (n_p) being fixed parameters. The measurement of the BS and T can be performed either in scanning mode, to provide homogeneity and stability measurement, or with very high frequency for fast time-resolved and online measurement.

The measurements are done without any dilution & on native samples.

Additionally, the TURBISCAN DNS associates 2 functions for online characterization of the dispersion state and the dispersibility:

- **Mixing function (T-MIX)** for automated fast formulation screening with a stirring bar directly inside the measurement cell.
- **Circulation function (T-LOOP)** for online measurement, scale-up, and process optimization.



Experiment and method setup

Aim of the work: Study the impact of Tween 20 concentration on the emulsification properties and stability of a 20% O/W emulsion.

The emulsion type: 20% O/W emulsion stabilized with Tween 20 at different concentrations from 0.25% to 1.5%.

Sample preparation: A Pre-Mix of water and surfactant is prepared under magnetic stirring for a couple of minutes. The oil is then added to the Pre-Mix under agitation and Sonication for 10 minutes.

Sample analysis: Particle size measurement is done via SMLS and directly during agitation, using the **circulation function T-LOOP** to monitor the online emulsification process (the kinetics of droplet size reduction). The measurement frequency is set at 10 measurements per second.

After 10 minutes, the samples are placed in the 20 mL vial and placed in the TURBISCAN set in **scan mode** for stability measurement.

Results

1. Emulsification efficiency in function of surfactant concentration

Figure 1 represents the kinetics of mean diameter dSMLS versus emulsification time.

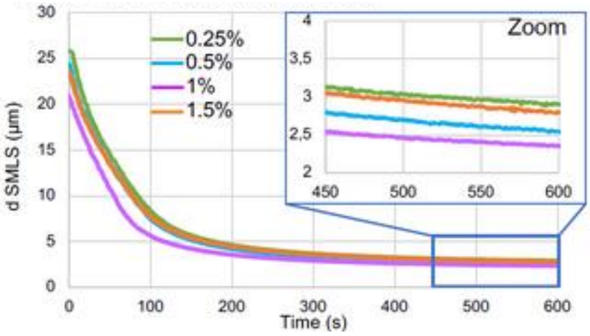


Figure 1. Mean diameter dSMLS as the function of emulsification time at a different surfactant concentration

From the figure 1 and thanks to online measurement of the particle size, we can conclude:

- The concentration of Tween 20 has little impact on the kinetics of the size reduction: the optimum droplet size is obtained after 300 - 400 seconds
- On the other hand, the surfactant concentration impacts the final particle size. Surprisingly, the finest emulsion is obtained at 1% of Tween 20 with a final particle size of 2.2µm

2. Stability of the emulsion in function of the surfactant concentration

Figure 2 represents the Turbiscan Stability Index* (TSI) for the different surfactant concentrations.

The TSI is a fully automatic calculation representing the cumulative sum of all the differences between scans, hence,* ***the higher the TSI, the lower the stability*

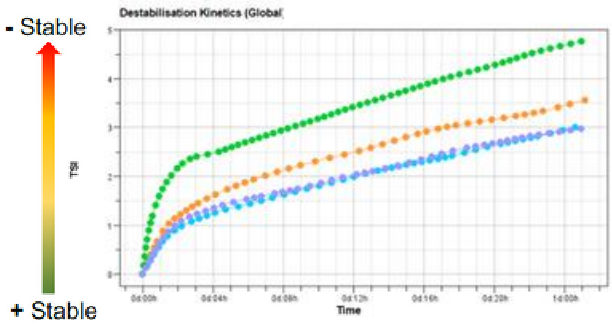


Figure 2. Turbiscan stability index in function of time for the different concentrations of Tween20

The graph below summarizes the data obtained.

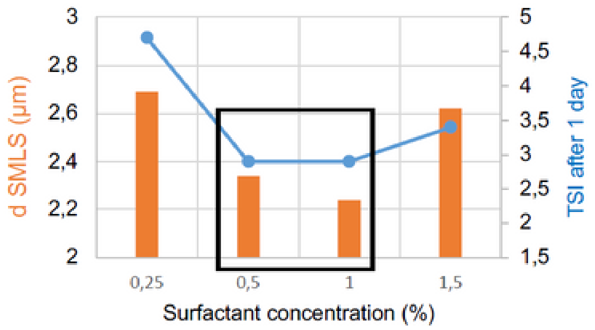


Figure 3. Correlation between mean diameter and TSI extracted from the figure 1's data

- The optimum concentration is between 0.5 and 1% of Tween 20 as it assures the lowest particle size and best stability.
- At lower surfactant concentration: not enough surfactant to stabilize the emulsion, hence higher droplet size and bad stability.
- At higher surfactant concentrations, particle size, and stability get worse, caused by depletion phenomena.

It is also interesting to note that this conclusion could be obtained after only a couple of hours, while a visual observation cannot provide such conclusions on the stability differences after a **few days**.

Conclusion

Particle size and dispersion stability are key parameters to study when optimizing formulations. The TURBISCAN is a unique type of analyzer that allows one to measure both parameters in a single setup and directly on a native sample. In addition, it provides a complete understanding of the stabilizer's role in emulsifying and stabilizing thanks to the:

- **Online** measurement of the surfactant efficiency thanks to the T-LOOP module
- **Ultra-fast stability** measurement via the scan mode of the TURBISCAN.

References:

Luis M. Pérez-Mosqueda & al., Formulation and optimization by experimental design of eco-friendly emulsions based on d-limonene, Colloids and Surfaces B: Biointerfaces 128 (2015) 127–131