EFFECT OF RAW MATERIALS ON A SUNSCREEN FORMULATION

INTRODUCTION

In order to meet the specification requirement, cosmetics preparations are usually complex dispersion (suspension or emulsion). The addition of one raw material directly modifies the stability of the dispersion and so each formulation must be analyzed and validated. For example in sunscreen application, the choice of the sun blocker directly affects the final stability of the dispersion.

In this note, using the Turbiscan™ technology, the effect of two different sun blockers on the final stability was studied. Moreover, the mean diameter of the particles was measured directly in the final product without dilution.

PRINCIPLE

Measurement with Turbiscan®

Turbiscan™ instrument, based on Static Multiple Light Scattering, consists in sending a light source (880 nm) on a sample and acquiring backscattered and transmitted signal. Combining both detectors (BS & T) enables to reach wider concentration range. The backward reflected light comes from multiple scattering as the photons scatter several times on different particles (or drop).

This signal intensity is directly linked to the diameter (d), according to the Mie theory:

$$d = f(BS, \varphi, n_p, n_f)$$

More information

METHOD

To monitor the effect of different raw material on the final sample, we analyzed two sunscreens using the same process of formulation but with two different inorganic physical sun blockers:

- ZnO
- TiO_2

Samples are analyzed using the Turbiscan during 2 days at 40°C

RESULTS

By scanning the 3 samples according to the method described in the previous paragraph, the following results are obtained:

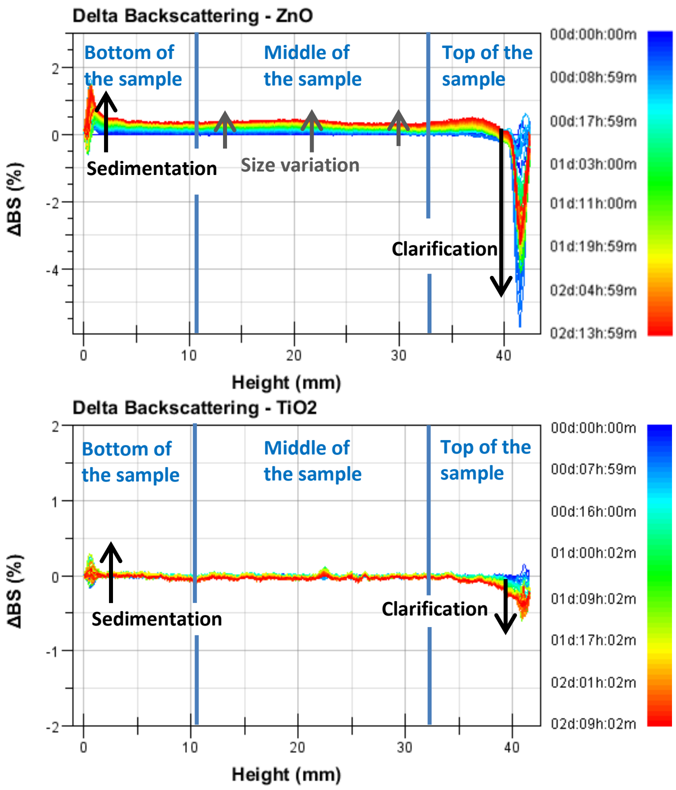

Figure 1: backscattering variaiton versus sample height for sample with ZnO (top) & TiO_2 (bottom)

From the graphs in Figure 1, we can observe the effect of the pigment on the emulsion stability. For the same emulsion, more destabilization is visualized for the pigment ZnO than the pigment TiO_2.

- At the top of the sample, due to the sedimentation of the pigment, a clarification appears and so a decrease of the intensity of the light is observed. Moreover, an increase of the light intensity is measured at the bottom meaning an increase of the concentration.
- All over the height of the sample, a global increase of the intensity of the light is observed meaning a particle size variation. The pigments tend to agglomerate.

To evaluate the impact of the type of pigment on the emulsion stability, the following parameters are measured:

- The global stability (TSI)
- The size variation (mean diameter)
- Migration rate

1- Global stability (TSI)

It is possible to monitor the destabilization kinetics in the samples versus ageing time, thanks to the **T**urbiscan **S**tability **I**ndex (TSI). It sums all the variations detected in the sample (creaming, size variation, …). At a given ageing time, the higher is the TSI, the worse is the stability of the sample.

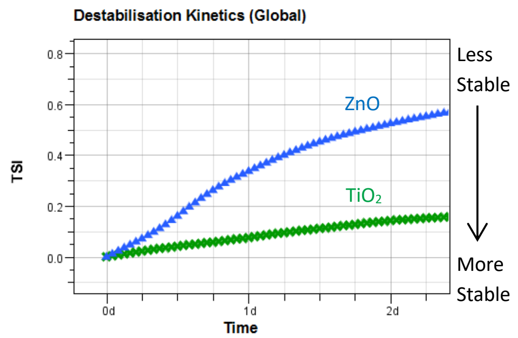

Figure 2: Turbiscan Stability Index for all samples

Sample	TSI (2 days)	Conclusion
ZnO	0.5	Less stable
TiO_2	0.1	More stable

Table 1: TSI values after 2 days of measurements

From Figure 2 and Table 1, we can conclude:

- The pigment titanium dioxide provide a better stability to the final product compare to zinc oxide
- In only 1 day at 40°C we can discriminate samples compare to several weeks with visual observation

2- Size variation

The Turbiscan technology allows us to measure the mean diameter of the particles in a concentrated media (no dilution). Using the Mie theory law and the parameters below, the mean diameter is automatically measure from the % of backscattering. In Figure 3, the mean diameter of the pigments with the following parameters

- Refractive index : ZnO np = 1.9
  TiO_2 np = 2.6
  Water nf = 1.33
- Volume fraction of the dispersed phase ϕ = 7 %

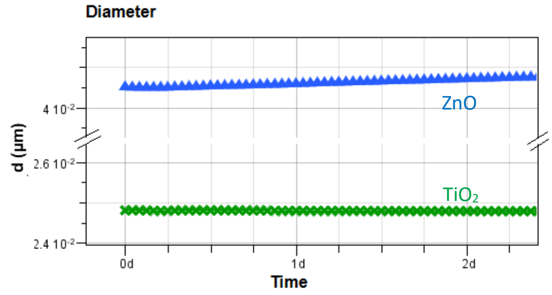

Figure 3: Mean diameter over time

Sample	Mean diameter (t=0)	Mean diameter (t=2d)
ZnO	40.5 nm	40.9nm
TiO_2	24.9 nm	24.9 nm

Table 2: Mean diameter of particles

We observe than ZnO particles are bigger than TiO_2 and ZnO particles tend to agglomerate compare to TiO_2.

3- Migration rate of the oil droplets

By measuring the thickness of the clear layer over the duration of the measurement (Figure 1), the migration rate of the sunblock can be computed.

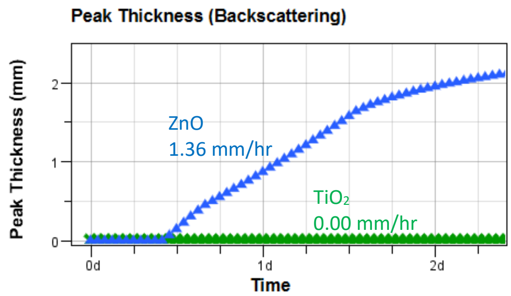

Figure 4: Thickness of clear layer over time

The Turbiscan is able to detect clarification at the top for both samples, however, for this application we consider than we have a clear layer if the percentage of change of backscattering is higher than 2%, Consequently, no clear layer are detected for TiO_2 and a sedimentation at 1.36 mm/hr is measure for ZnO.

Summary

This application note shows a quick and simple method to discriminate different raw material in only 2 days versus weeks with visual observation. We observe during this study that the sunblock TiO_2 give better properties in term of stability than ZnO. Finally, using the multiple light scattering, we were able to measure the mean diameter of the pigments without dilution.