CURINSCAN Expert

Sunscreens: Compare and optimize their film formation

INTRODUCTION

Over the past years, sunscreens have become essential products in users' skincare routines. They provide high protection against DNA damage and photoaging thanks to anti-UVA/UVB mineral or chemical screens.
Consumers also switched to easy-to-use, multi-functional skincare products (sun protection is often completed with tint, glow, mattifying or moisturizing claims). Rising demand is noticed for greener, cleaner, organic cosmetic products. Hence, formulators are on the lookout for eco-friendly yet efficient components.
In this context, the characterization of new sunscreens is a key point, especially their film-forming abilities. Film-forming kinetics has a great impact on formulations' stability, appearance, and properties such as water resistance, tensor, and smoothing properties.

Sunscreens formulation | **Film-forming abilities** | **Formulation characterization**

HOW IT WORKS

CurinScan uses **Nanoscale Mobility Analysis (NMA)** and measures the particles' (polymers, aggregates, pigments...) Brownian motion, thanks to an optical method.

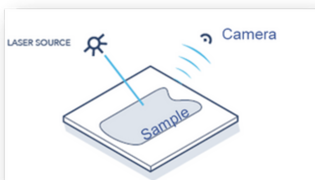

Figure 1: Measurement concept

During the film formation or curing process, the nanoscale mobility of particles changes due to the material properties' evolution, for example from liquid to solid.

When a material (coating, film, adhesive...) presents an important microscopic dynamics activity (liquid-like), the structures present an important Brownian motion directly correlated to the visco-elastic properties of the material.
Thanks to a dedicated image analysis algorithm, it is possible to determine a characteristic frequency, the **microscopic dynamics (µD or mD),** which directly correlates to the speckle image fluctuation on the camera.

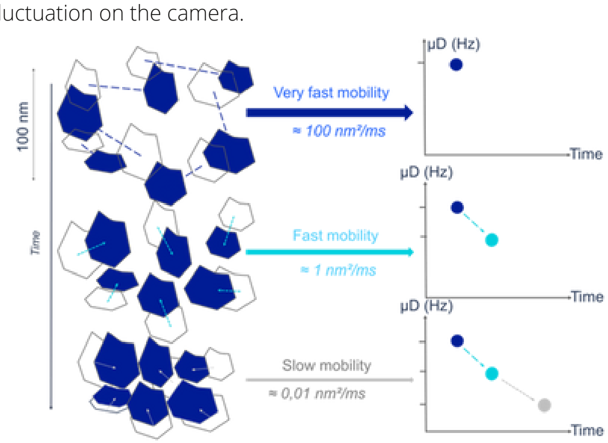

Figure 2 : Schematic representation of the mobility (µD) evolution during typical drying/curing process versus time

When the sample is liquid (early times), it presents a high level of mobility (µD). This mobility will be decreasing over time during the drying/curing process.

PROTOCOL & METHOD

The film formation capacity of three different sunscreens called A, B & C was analyzed. All these samples are characterized by a 50 Solar Protection Factor (SPF) but present different formulations and, thus, offer various properties such as water resistance.

For each of them, the sample is applied on a ceramic substrate using a blade applicator. The applied thickness is about 100µm.

To mimic conditions of use (skin temperature & humidity), each sunscreen formulation is analyzed at 35°C and 45%RH.

RESULTS

Determination of the different film formation steps and characteristic times

Figure 3 shows the microscopic dynamics (mD) versus time for a 100µm thick sunscreen sample at 35°C.

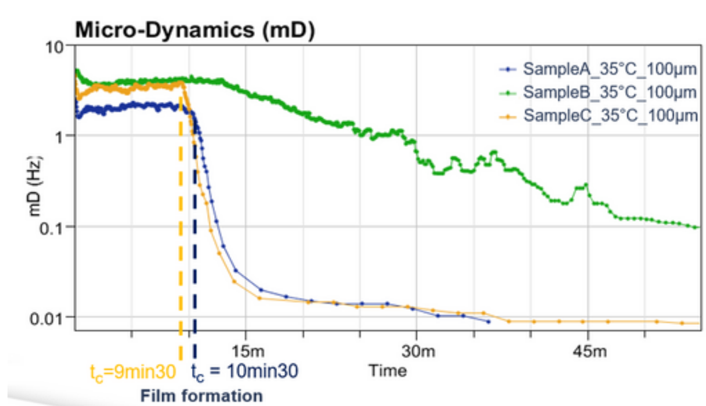

Figure 3: Micro-dynamics as a function of time for 3 sunscreens at 35°C

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Samples A and C form a homogeneous film and the graph allows us to determine characteristic times (film-forming time).
For sample A, the film formation time (10 minutes and 30 seconds) is longer than for sample C (9 minutes and 30 seconds).

On the other hand, sample B presents a different shape of curve: it doesn't form a film when applied in these conditions. Indeed, at a macroscopic scale, some droplets appeared on the ceramic substrate due to capillarity.

The instrument allows us **to determine of the different film-forming steps and characteristic times from RT and up to 250°C.**

Determination of temperature and humidity influence

It is also possible to explore the influence of different parameters (temperature, humidity, thickness, substrate porosity…) on the film formation kinetics between different formulations.
Figure 4 shows the film formation kinetics of 2 different sunscreens at different temperatures: 35°C and 24°C.

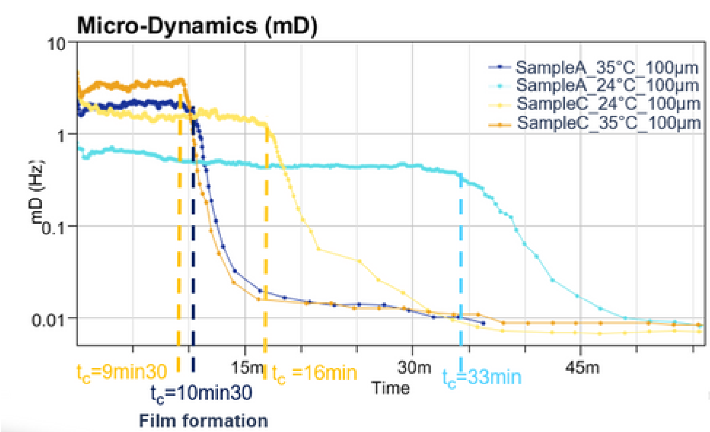

Figure 4: Micro-dynamics as a function of time for A&C sunscreens at 35°C and 24°C

Here, for sample A, at 35°C and 100µm thickness, the film forming time is around 9 minutes and 30 seconds whereas, at 24°C, it is around 16 minutes.
For both samples, in the same conditions, the film formation is faster at 35°C than at 24°C.

This technique allows formulators to **mimic realistic use conditions and optimize the film formation protocol & process**

The software's specific functionalities (mDE) allow us to easily rank the film formation kinetics of different formulations at various temperatures/ humidity/ thickness/ substrates…

As the evolution of the microscopic dynamics (mDE) increases, the film forms more rapidly.

Figure 5 shows the microscopic dynamics evolution (mDE) versus time for A&C sunscreens (discussed in figure 4) at different temperatures.

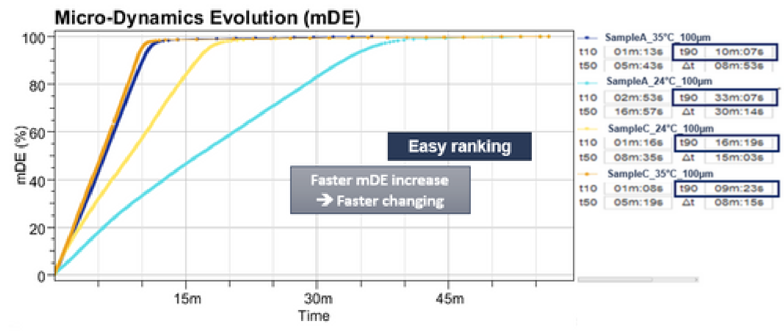

Figure 5: Micro-dynamics evolution as a function of time for A&C sunscreens at different temperatures

The orange curve (sample A at 35°C) presents a faster mDE increase than the yellow curve (sample A at 24°C). Also, the dark blue curve (sample C at 35°C) presents a faster mDE increase than the light blue curve (sample C at 24°C). So, for both sunscreens, drying is faster at 35°C.

The software also provides quantitative information, the time **'t90'** (in the red boxes, fig. 3). The **'t90'** corresponds to the time when the sample's microscopic mobility is reduced by 90%. The **'t90'** is of great interest for a wide range of applications where there is a need to optimize processes and determine when microscopic mobility reduces by 90%, so it is possible to start the next development step.
For those formulations, the **'t90'** is associated with the **"film formation time".**

Curinscan Expert allows formulators to **compare, rank and screen different formulations and film formation conditions.**

Here, the variable parameter is the temperature, but it is possible to vary humidity, formulation ingredients, the thickness of the sample or the substrate…

CONCLUSION

For sunscreens samples :

- **Monitor film formation kinetics under realistic conditions** *(skin temperature, humidity..)*
- **Determine characteristic times** of the film formation process
- **Evaluate the impact of formulation,** temperature, sample thickness, humidity, substrate…
- **Optimize** the manufacturing protocol