INNOVATIVE SOLUTION TO OPTIMIZE THE FORMULATION & THE CURING OF FUNCTIONAL FILMS, PAINTS AND COATINGS

Yassine Nagazi*, Giovanni Brambilla, Gérard Meunier

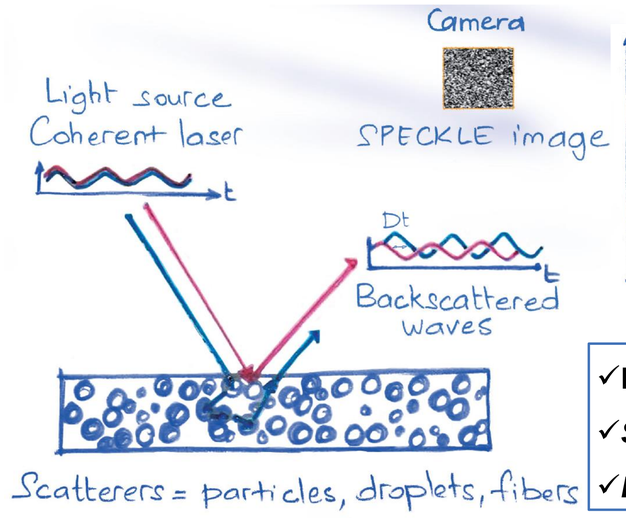
Introduction

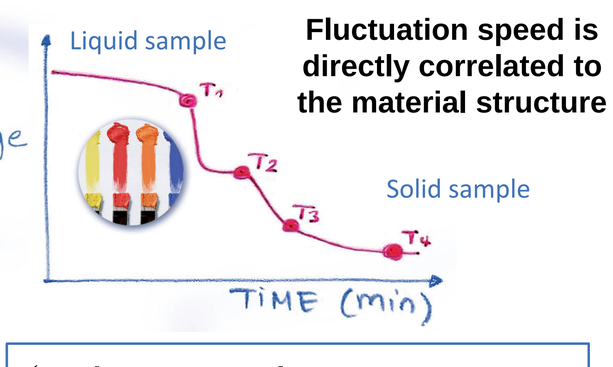
The characterization of the microscopic dynamics of functional films & coatings is an important step in every new development or quality control.
We use a dynamic light scattering technique to investigate the microstructure evolution (evaporation, packing, coalescence…) of a large panoply of materials at constant or in-creasing temperature (RT-250°C) and with humidity control. This technology allows to compare different formulation and to detect the characteristic steps (Drying/curing time, phase transition…) with a very handy sampling protocol, high sensitivity and on realistic conditions (temperature, humidity, substrate…)

The solution

- ✓***Objectivity and accuracy to monitor and compare the curing/drying (steps, times…) of different products***
- ✓**Possibility to analyse any sample and on any substrate**
- ✓**Realistic conditions: Temperature & humidity control**

How does it work [1]





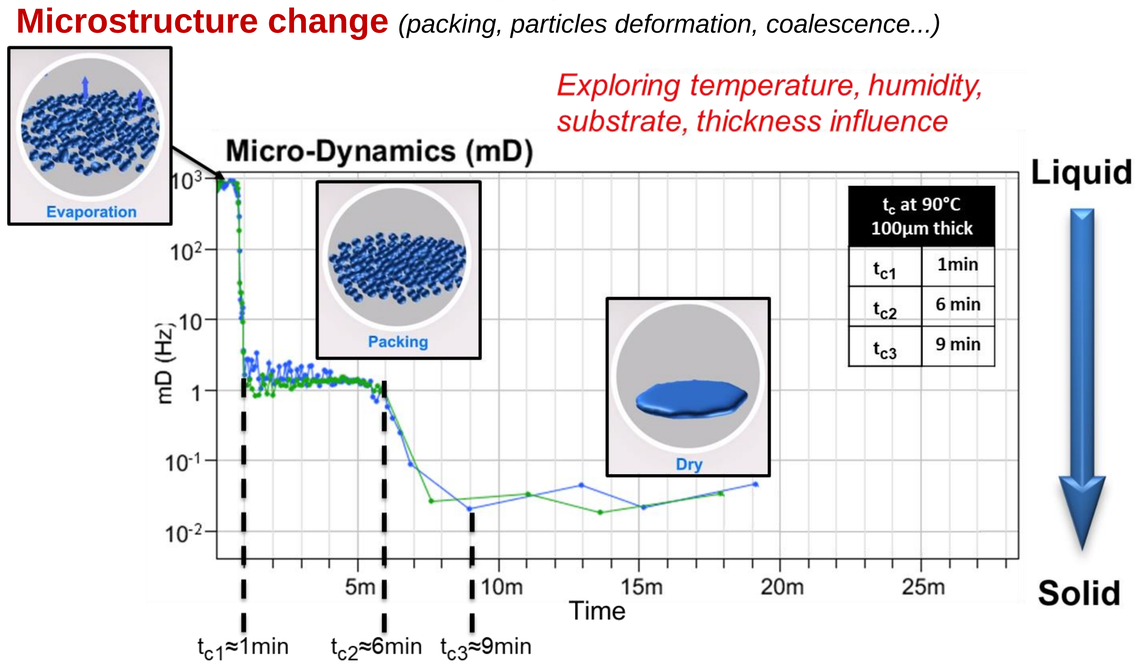
Fluctuation speed is directly correlated to the material structure

- ✓**In-situ & contactless measurement**
- ✓***Sensitive to nm mobility***
- ✓***Large range of drying/curing kinetics***

Coatings, Paints & Inks

Characteristic times of the drying *(Open-time, Surface dry, Dry-through…)*
Microstructure change *(packing, particles deformation, coalescence...)*

Exploring temperature, humidity, substrate, thickness influence

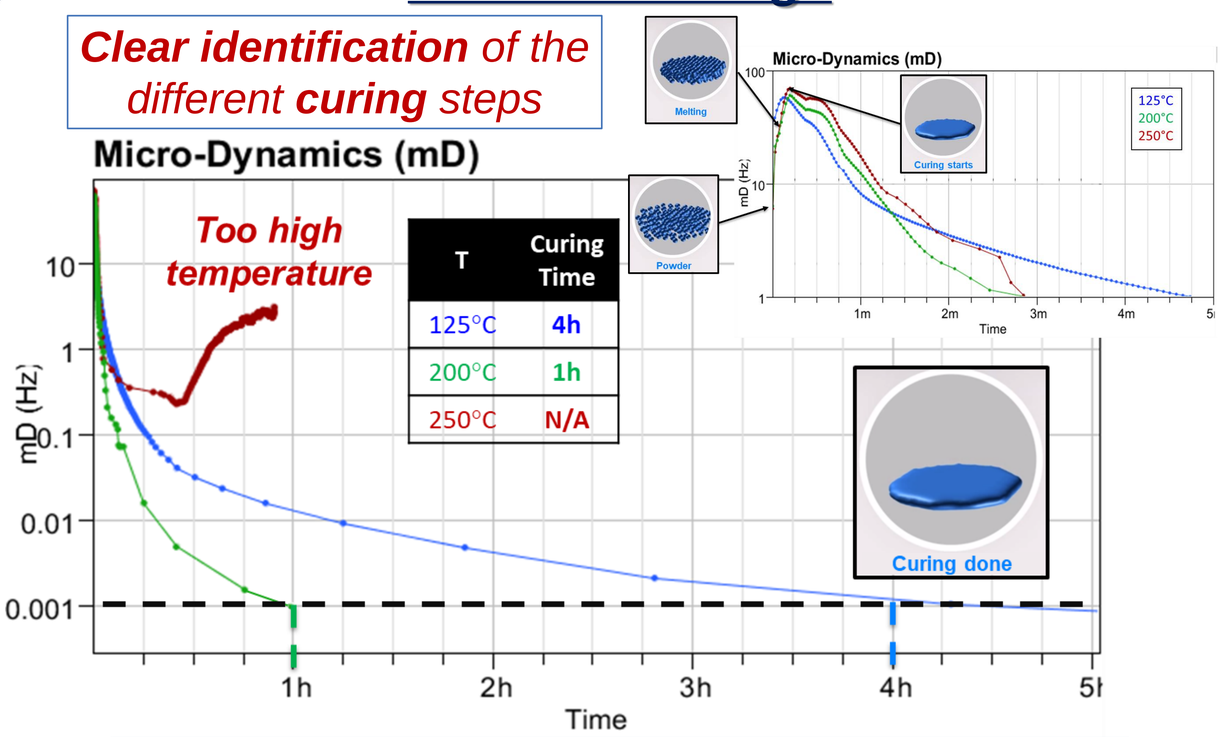


t_c at 90°C 100µm thick	
t_{c1}	1min
t_{c2}	6 min
t_{c3}	9 min

***Clear identification** of the different **drying** steps*

Powder Coatings

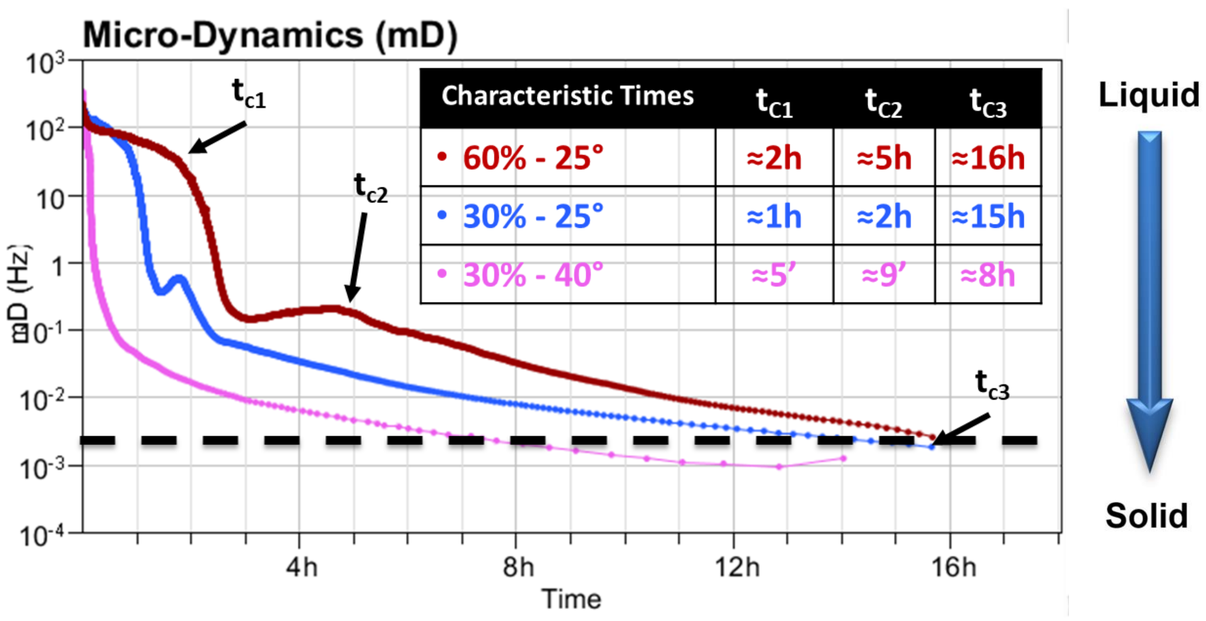
***Clear identification** of the different **curing** steps*



T	Curing Time
125°C	4h
200°C	1h
250°C	N/A

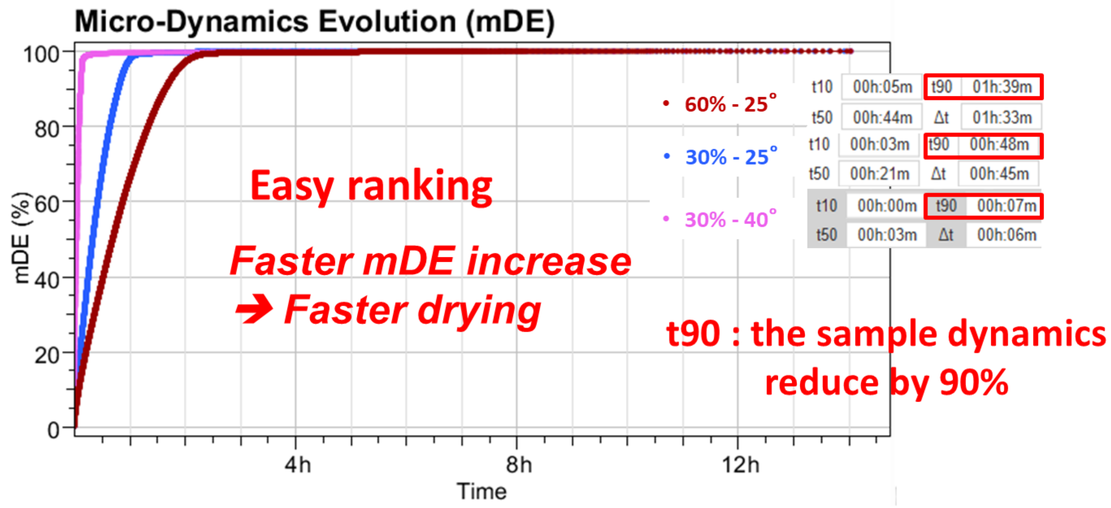
Determination** of the **optimal curing protocol

Functional Film



Characteristic Times	t_{C1}	t_{C2}	t_{C3}
• 60% - 25°	≈2h	≈5h	≈16h
• 30% - 25°	≈1h	≈2h	≈15h
• 30% - 40°	≈5'	≈9'	≈8h

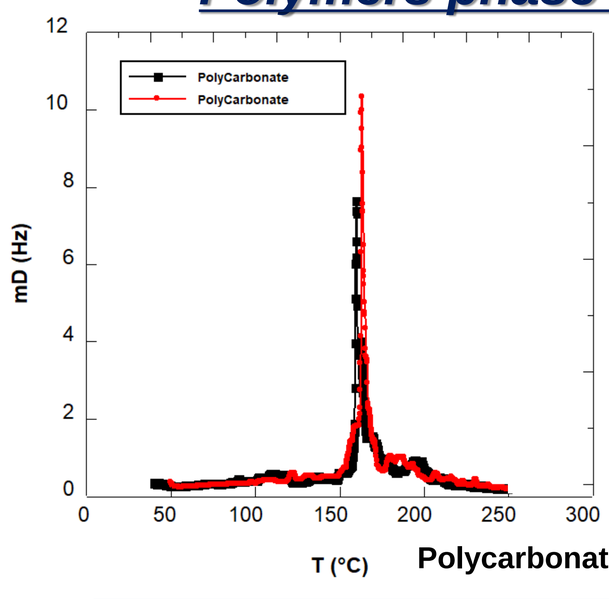
Clear temperature and humidity influence
➔ Optimize the drying protocol & process

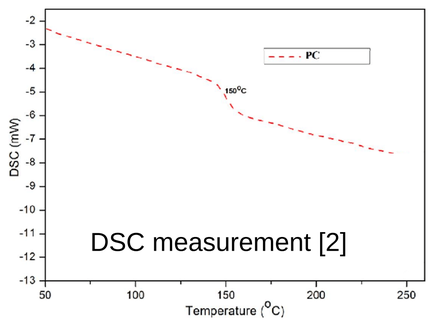


t10	00h:05m	t90	01h:39m
t50	00h:44m	Δt	01h:33m
t10	00h:03m	t90	00h:48m
t50	00h:21m	Δt	00h:45m
t10	00h:00m	t90	00h:07m
t50	00h:03m	Δt	00h:06m

Compare, rank and screen different formulations and drying conditions

Polymers phase transition





Good agreement with the literature

Polycarbonate example, T_R ⟶ 250° C

Detection of polymers phase transition

Conclusion

Innovative **in-situ, non-invasive and handy** method to better understand your different materials allowing to:

- ✓**Monitor** and **know** precisely the **curing** and **drying kinetics**
- ✓**Determine the characteristic times** of the curing process
- ✓Analyse from **RT up to 250°C** with **humidity control**
- ✓Evaluate the **impact of the formulation**, the temperature or the substrate
- ✓**Optimize** the manufacturing protocol

References

[1] D. J. Pine, D.A.W., J. X. Zhu and E. Herbolzheimer, Diffusing-wave spectroscopy: dynamic light scattering in the multiple scattering limit. Journal de physique, 1990.
[2] Charde, S. J., Sonawane, S. S., Sonawane, S. H., & Shimpi, N. G. (2018). Degradation Kinetics of Polycarbonate Composites: Kinetic Parameters and Artificial Neural Network. Chemical and biochemical engineering quarterly, 32(2), 151-165.