Smart stratifying powder coatings

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FPL FORSCHUNGSGESELLSCHAFT FÜR PIGMENTE UND LACKE E.V.

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Gefördert durch:

Bundesministerium für Wirtschaft und Energie

aufgrund eines Beschlusses des Deutschen Bundestages

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The motivation to investigate stratification effects for powder coatings

- Multilayer coatings with three to four separate layers are state of the art for today's high quality protective coatings systems.
- The general trend in the coating industry can be described by the replacement of thick multilayer coatings with thinner, less layer containing coatings systems.
- Good adhesion and corrosion protection properties of epoxy coatings predestine these coating materials to be excellent primers but polymers on the base of acrylics or polyurethanes must be used as top coats.
- To bridge the gap between the coating market demands for cost efficient and highly durable, protective coatings, it is therefore obvious, that an urgent need for new smart and efficient powder coating systems exists.

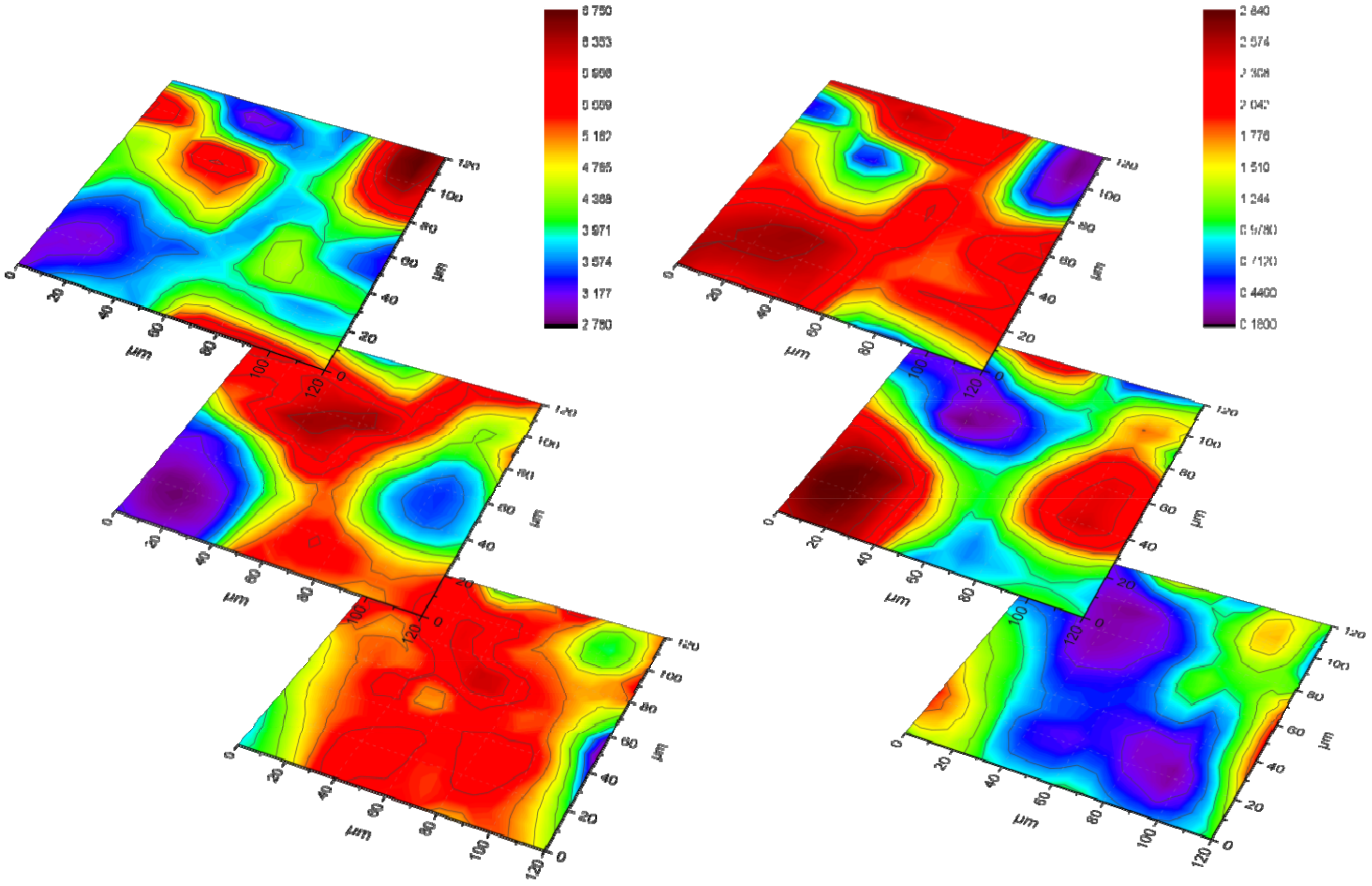
- **In the presented study, an innovative concept for smart powder coatings is proposed, which is based on stratification effects in epoxy-polyester Dry-Blend powder coating formulations.**

Stratification effects could be observed under certain conditions for epoxy/polyester Dry-Blends

RAMAN microscope results for a Dry-Blend of epoxy/polyester (EPOX/PES) 3:1

Surface

Substrate



EPOX-fraction **PES-fraction**

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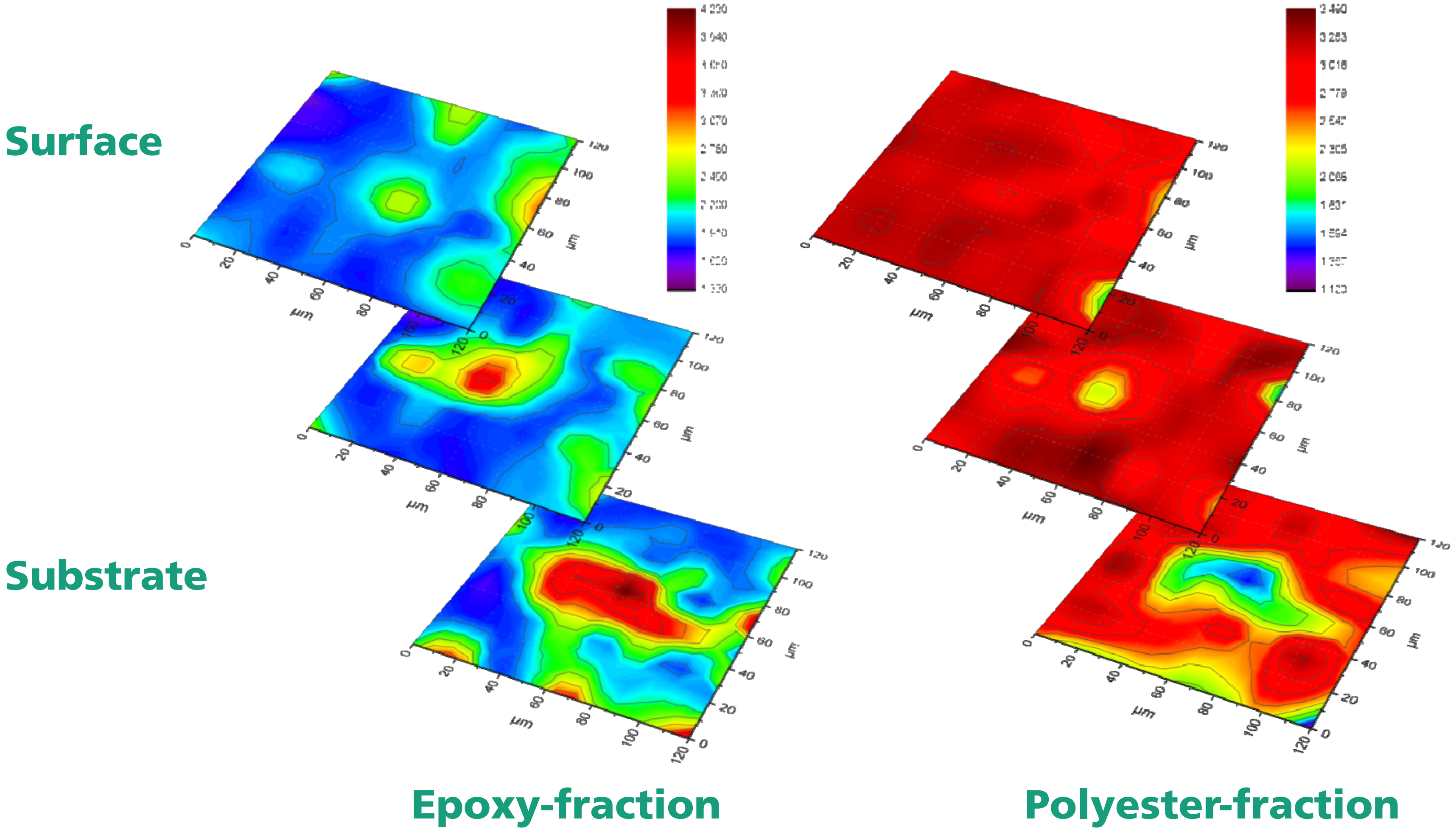
RAMAN microscope results for a Dry-Blend epoxy/polyester (EPOX/PES) 1:3



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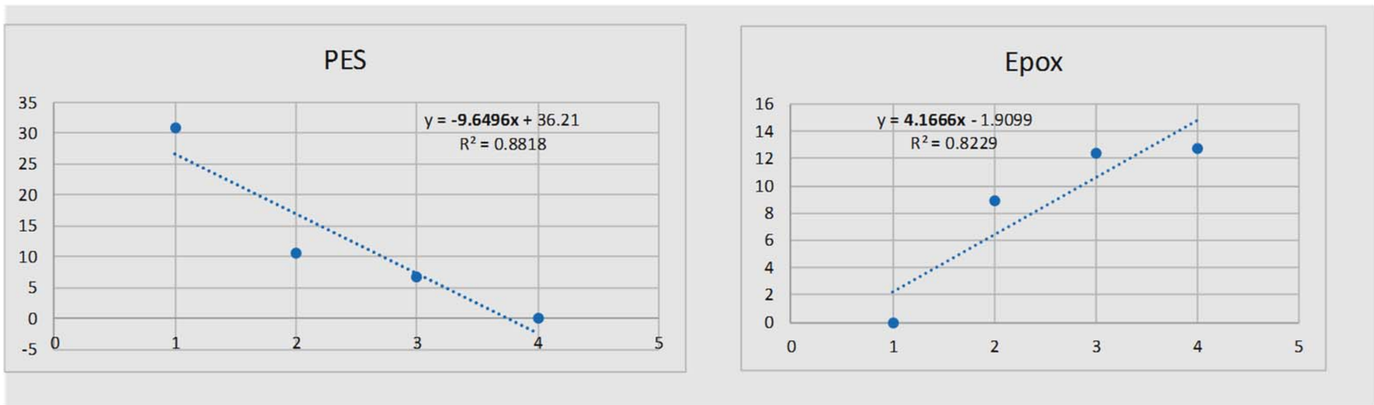
Trials to differentiate the observed stratification effects

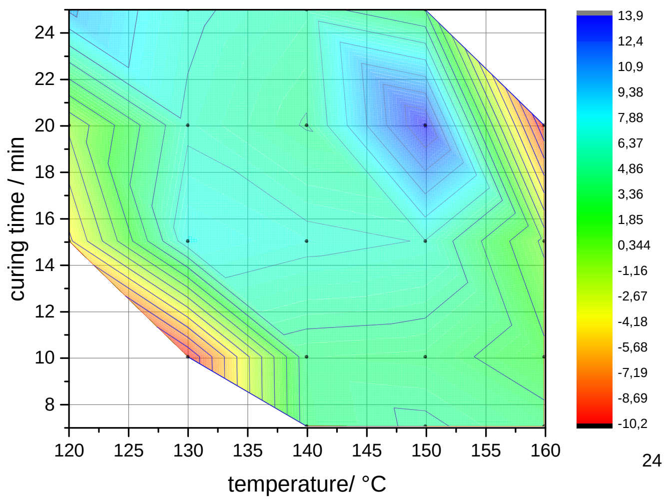
Quantification of stratification effects through calculation of gradients using data from confocal RAMAN microscope maps

- RAMAN mapping was performed in four different plains, from surface to substrate, with sixteen spectra each.
- An average value for the strength of RAMAN frequencies for epoxy-/polyester with respect to alkyl groups as internal standard were taken as a measure for stratification effects.
- For each plain an average value was calculated and a linear regression analysis was performed.
- A gradient for polyester and epoxy components could be obtained and the sum of both gradients was taken as stratification gradient of the Dry Blend powder coating.

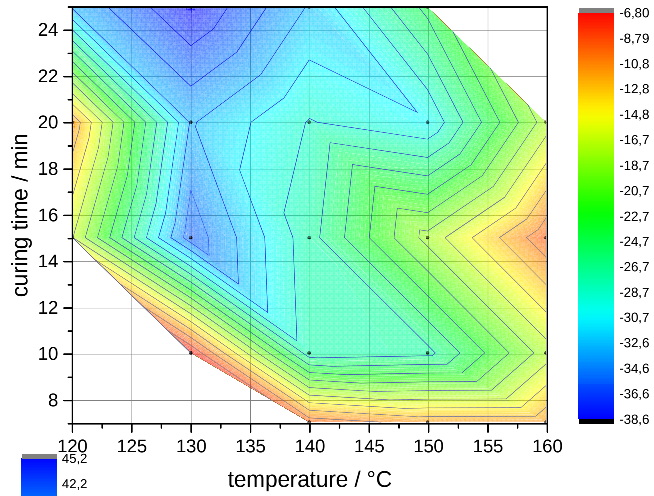


Stratification-gradients versus temperature (°C) and duration (min) for a Dry-Blend of epoxy/polyester (EPOX/PES) 3:1

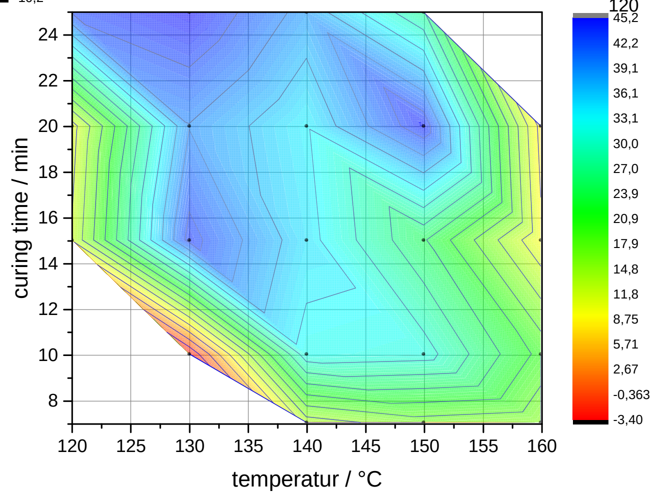
Stratification gradient -> Epoxide



Stratification gradient -> PES



Stratification gradient -> Σ (PES + Epoxide)



- Dry-Blends of epoxy/polyester show stratification effects depending on the curing conditions (time/temperature regime)

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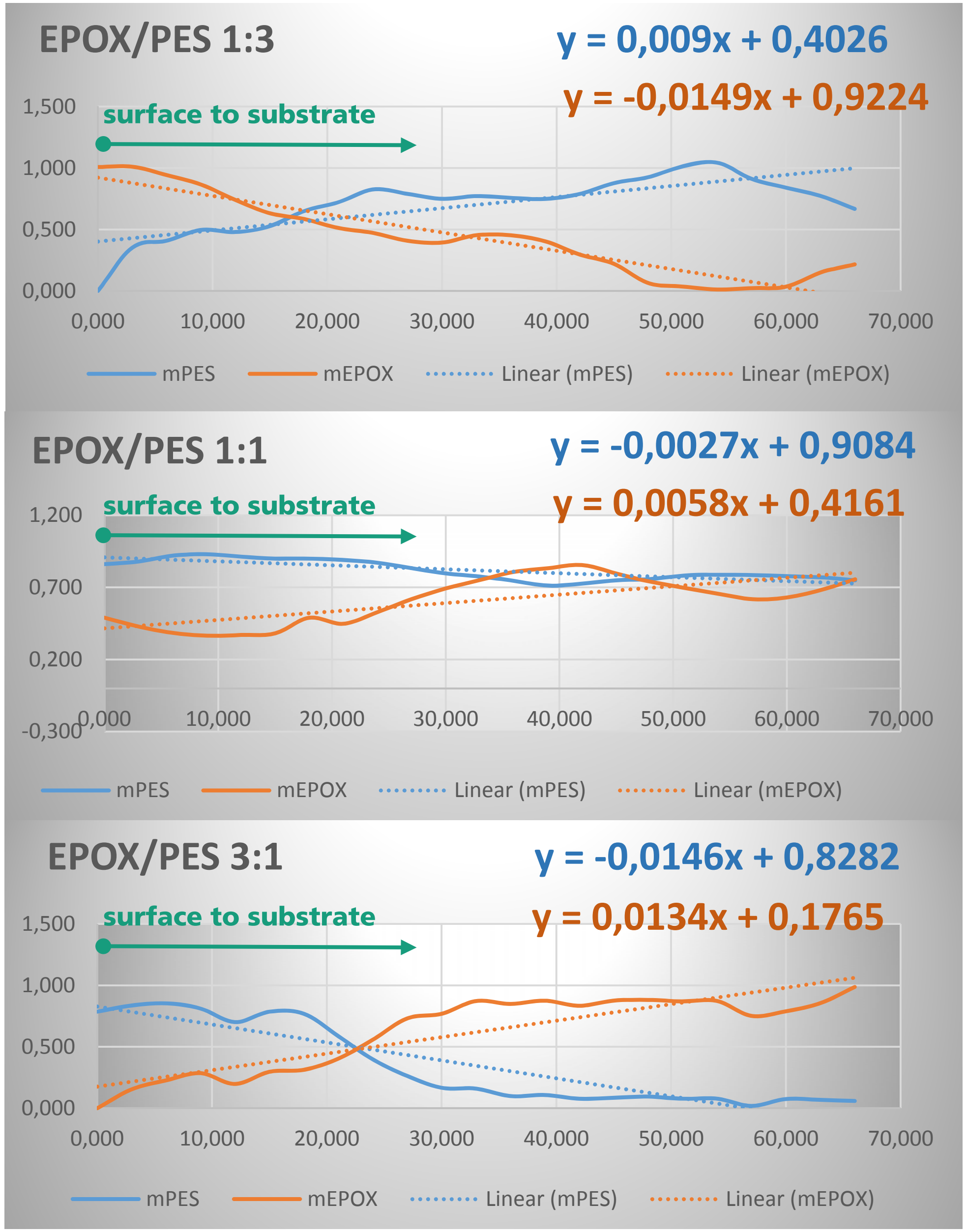

Stratification behavior of dry blend epoxy-/polyester powder coatings at 150 °C/20 min

Epoxy/polyester Dry Blends show clear stratification effects

- For epoxy-/polyester 3:1 Dry-Blends, the epoxy component gets enriched in direction from surface to substrate.
- For epoxy-/polyester 1:3 Dry-Blends, the inverse behavior could be observed so the epoxy component gets enriched near the surface.
- For epoxy-/polyester 1:1 Dry-blends, the epoxy component gets enriched only near the surface.

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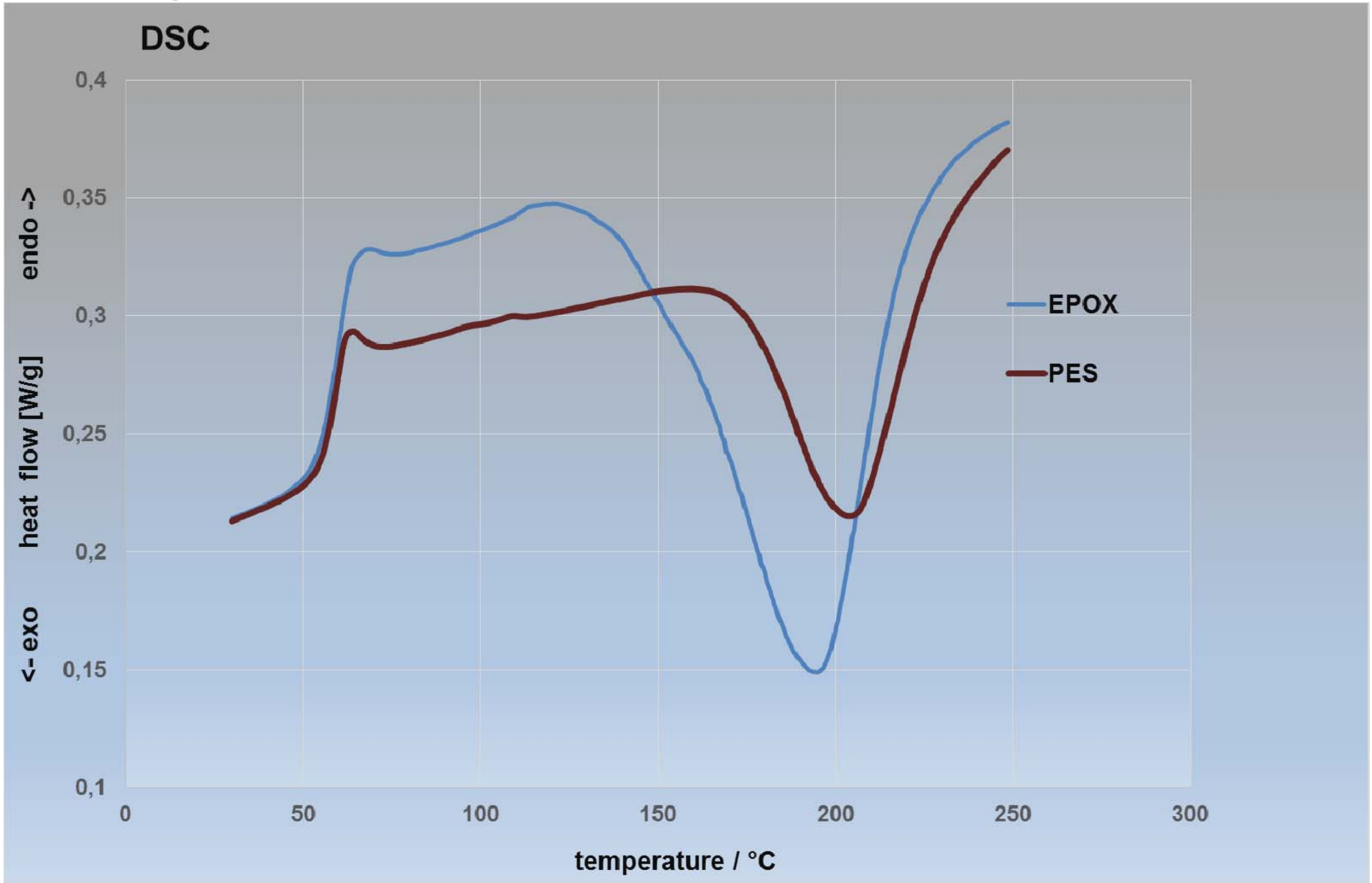
What are the driving forces behind the stratification effects?

What is the driving force behind the stratification – does stratification depend on glass transition (TG) behaviour ?



- For the epoxy-component more distinctive glass-transition behaviour and crosslinking reactivity could be observed.

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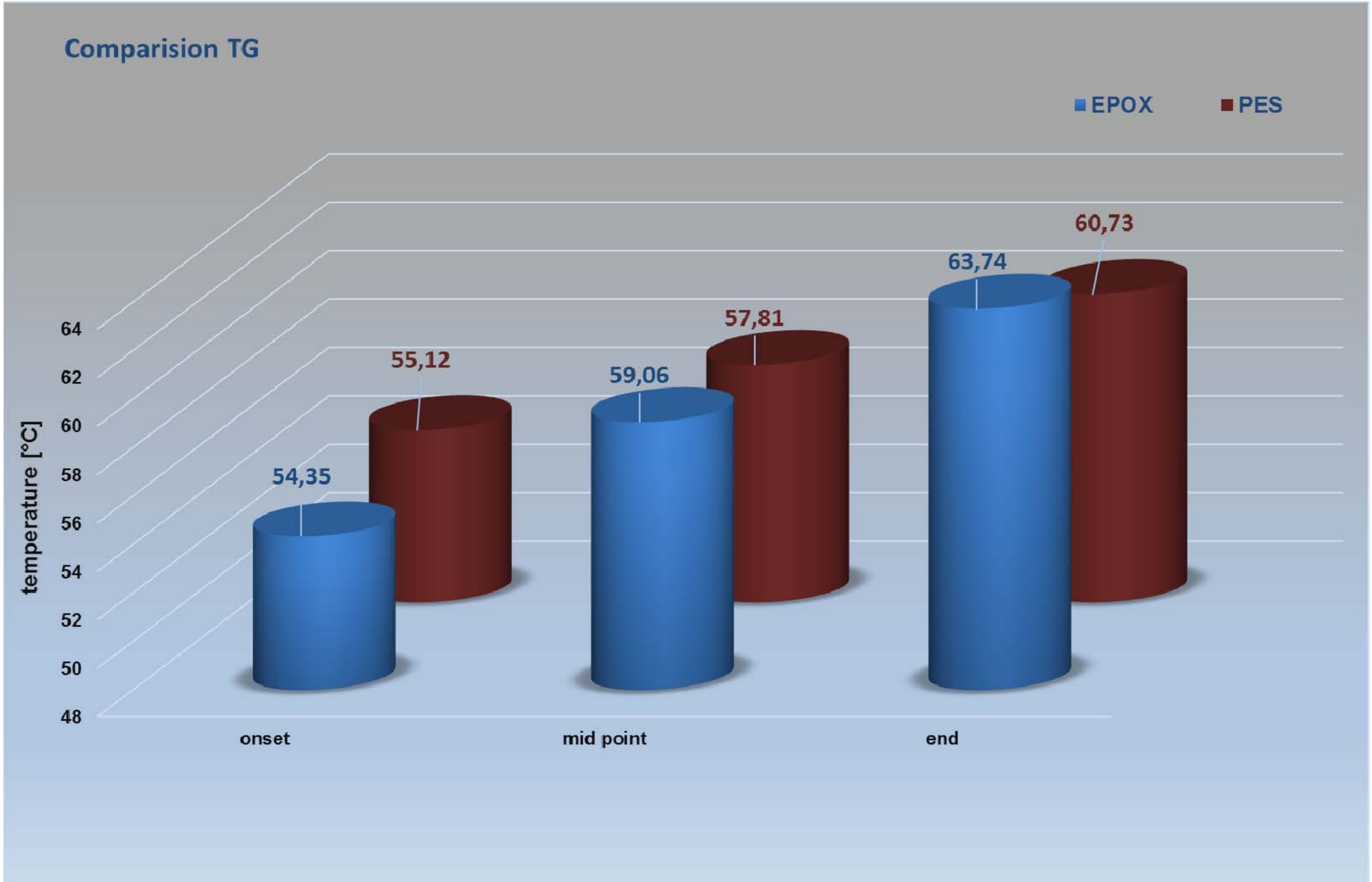

- For the epoxy and polyester component similar onset and end temperatures for the glass transition could be determined.

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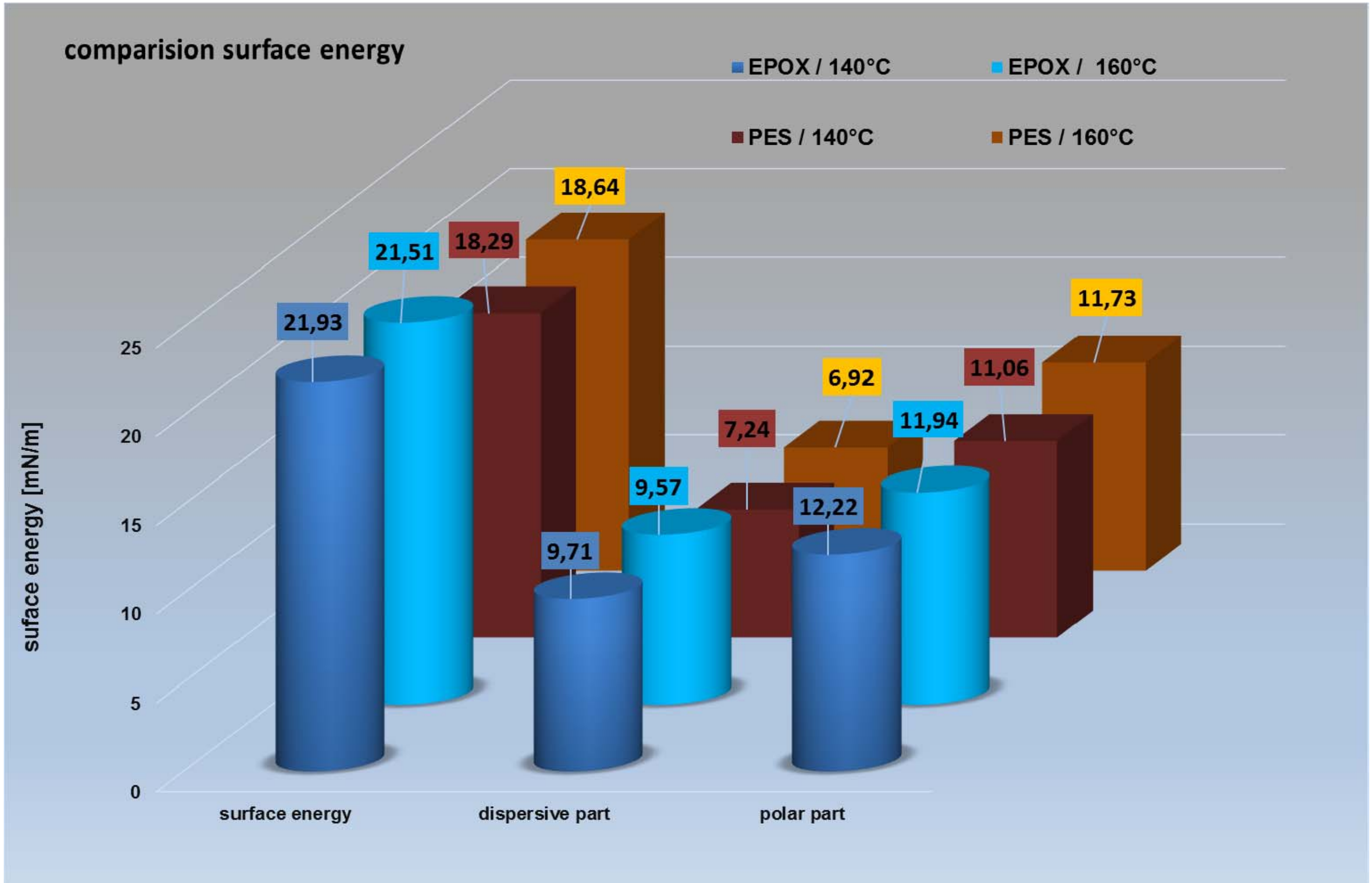
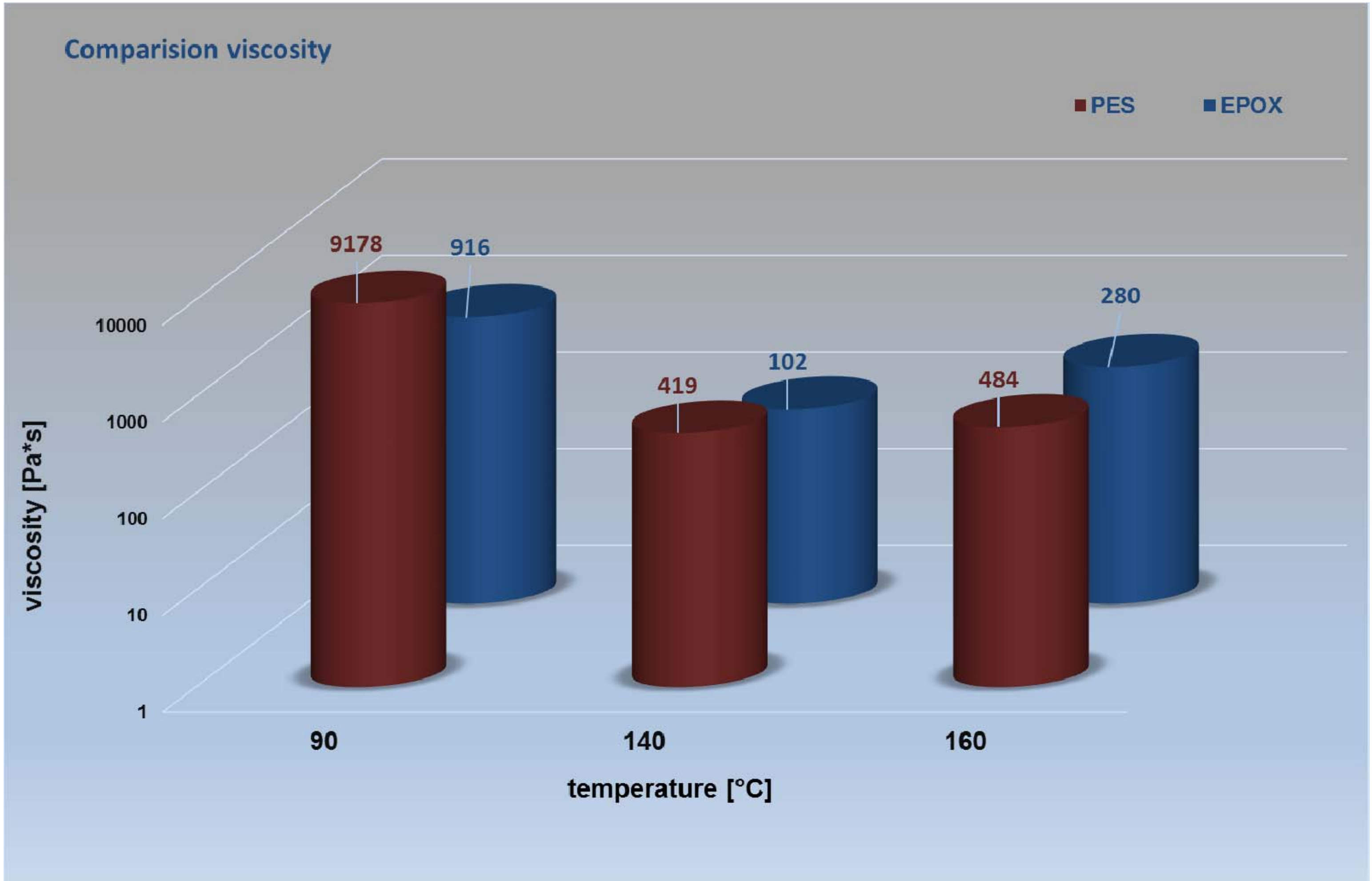
What is the driving force behind the stratification – does stratification depend on surface energy effects?



- For the epoxy component at different curing temperatures, a slightly increased surface energy with higher values for the dispersive parts could be determined.

What is the driving force behind the stratification – does stratification depend on viscosity effects?



- For the epoxy component a significant lower viscosity in the regarded temperature range could be observed.

Summary and Conclusions

- Stratification effects could be observed and quantified under certain conditions for epoxy/polyester Dry-Blends.
- A gradient for polyester and epoxy components could be obtained and the sum of both gradients was taken as a measure for stratification effects in powder coatings.
- Dry-Blends of epoxy/polyester show stratification effects depending on ratio of the components as well on the curing conditions (time/temperature regime):
  - For epoxy-/polyester 3:1 Dry-Blends, the epoxy component gets enriched in direction from surface to substrate.
  - For epoxy-/polyester 1:3 Dry-Blends, the inverse behavior could be observed, so that the epoxy component gets enriched near the surface.
  - For epoxy-/polyester 1:1 Dry-blends, the epoxy component gets enriched only near the surface.

- ***As possible driving forces for the observed enrichment of the epoxy component at higher concentrations, a slightly increased surface energy with higher values of the dispersive parts, as well as a significant lower viscosity could be determined.***

Thank you for your attention!

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