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# *Aging behavior of polymeric absorber materials for solar thermal collectors*

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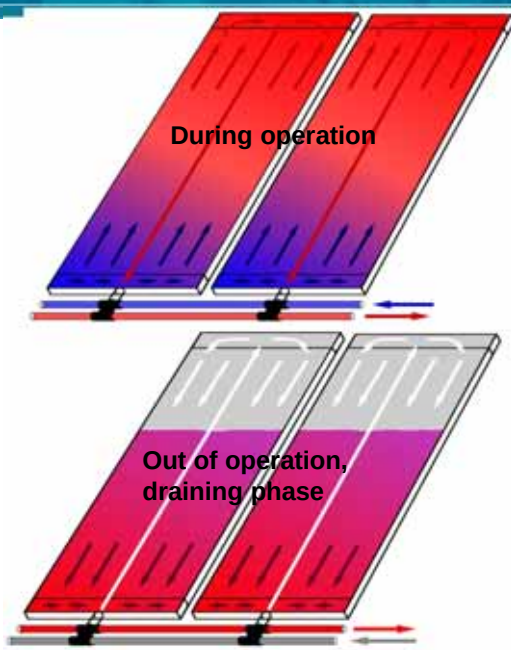
## *Introduction – Plastics based collectors 2*




**Application in Northern Europe**

System conditions:

- operation - water at 80 °C
- stagnation - air at 140 °C

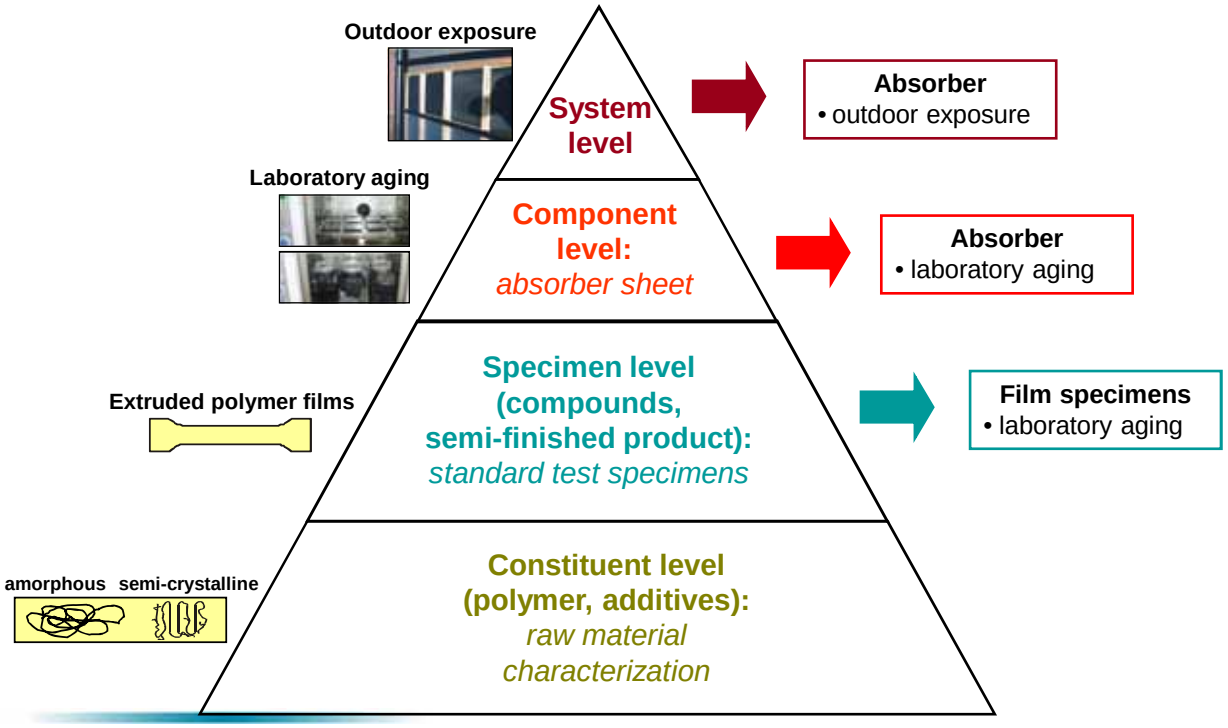
→only few comparable systems with plastics available

- No comprehnsive and scientifically founded understanding of the aging behavior and the long-term stability of plastics for solar thermal absorber applicatons

# Methodology – Testing pyramid

## Structure-property-performance pyramid

**Various levels of material state** | **3 levels of characterization/testing**






# Methodology – Materials and exposure conditions

| Designation | Polymer type | Commercial designation | Material supplier |
|---|---|---|---|
| PPE+PS | Polyphenylene ether polystyrene blend | Noryl EN 150SP | Sabic Innovative Plastics |
| PC | Polycarbonate | Makrolon 3103 | Bayer Material Science |
| PA12 | Polyamide 12 | Grilamid L25H, Grilamid L25ANZ | EMS-CHEMIE |
| PP | Polypropylene random copolymer | Beta-PPR RA7050, RA130E-8427 | Borealis Polyolefine |

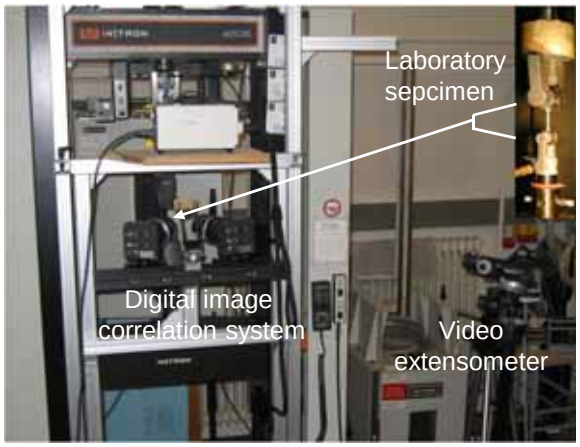
*System level:*
Outdoor exposure under stagnation (northern climate):
1 winter, ½ summer, 1 summer, 1 year, 2 years

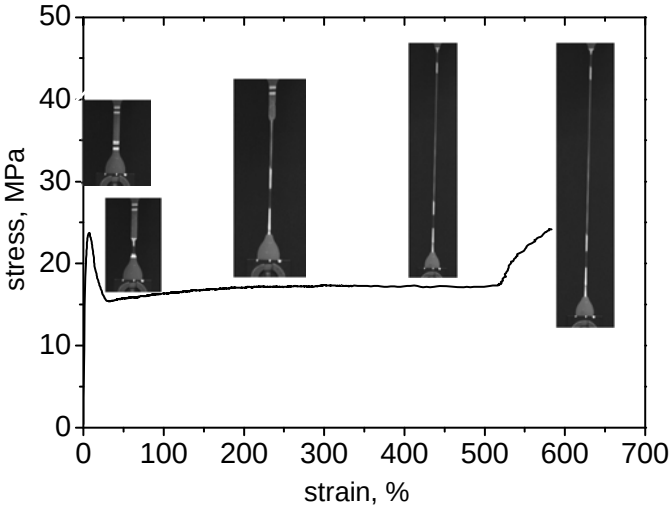
*Specimen and component level:*
Laboratory aging: - in air at 140 °C up to 500 h
(northern climate) - in water at 80 °C up to 16000 h

# Methodology – Characterization and Testing 1

Specimen level

## Tensile Testing




## DSC and SEC analysis

→ **Characteristic parameter for aging: strain-to-break ($\varepsilon_B$)**

→ **Morphology and thermal properties (e.g., crystallinity, $T_m$, $T_g$, $T_{ox}$)**

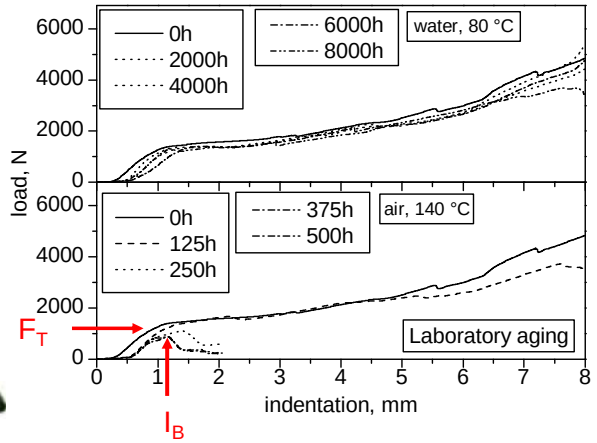
→ **Weight average molecular mass**



# Methodology – Characterization and Testing 2

Component level

## Indentation testing

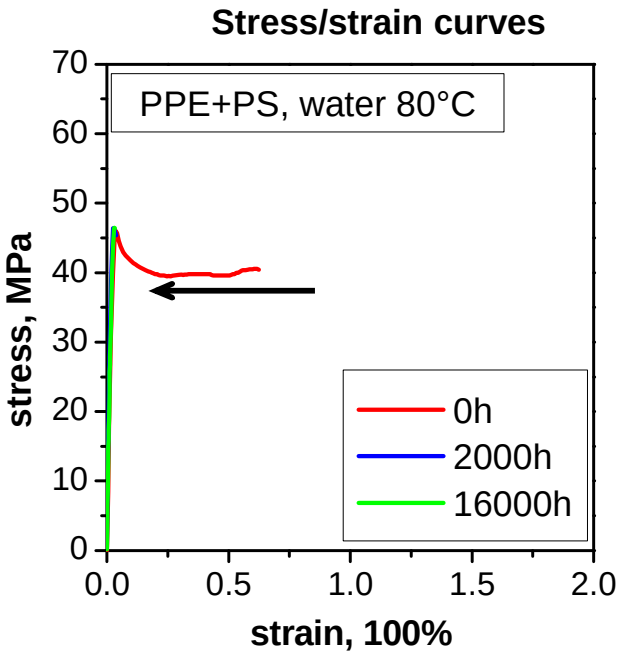



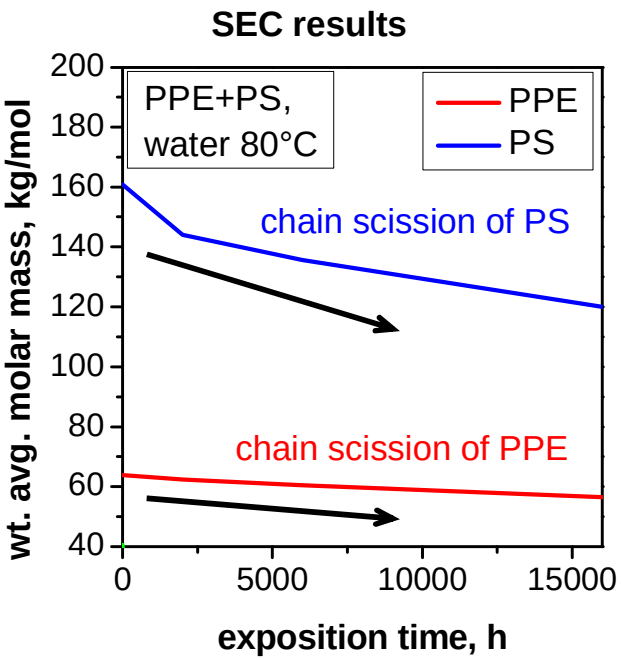

## DSC analysis

→ **Characteristic parameter for aging: indentation at break ($I_B$)**

→ **Morphology and thermal properties (e.g., endothermic and exothermic effects, $T_g$, $T_{ox}$)**

## PPE+PS - Effect of exposure to hot water at 80°C



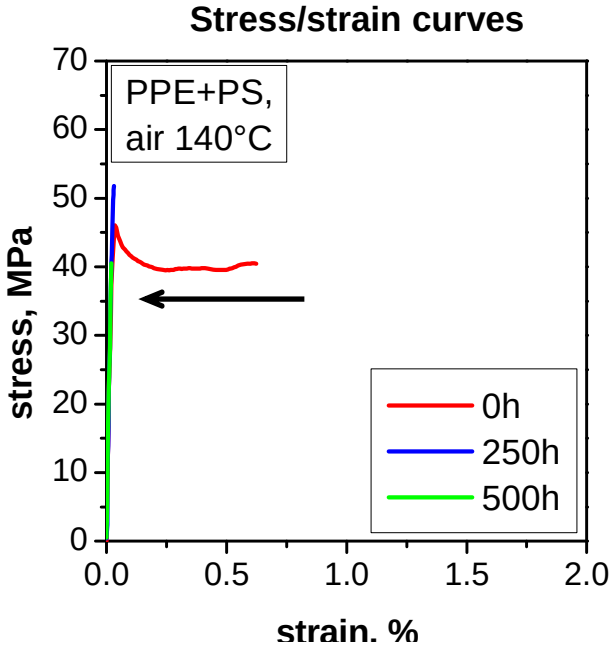



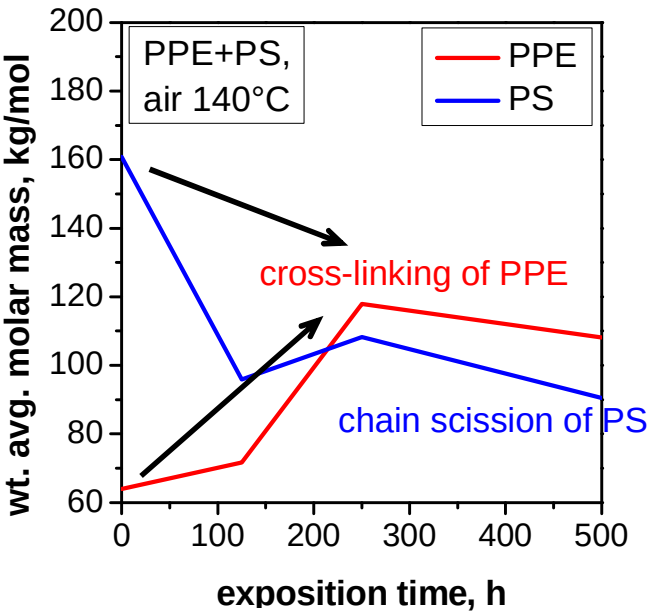

- DSC: no physical aging detected





## PPE+PS - Effect of exposure to hot air at 140°C

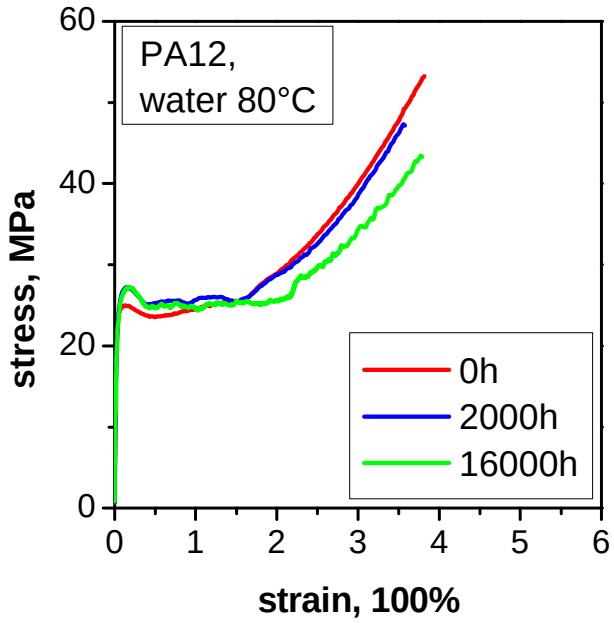


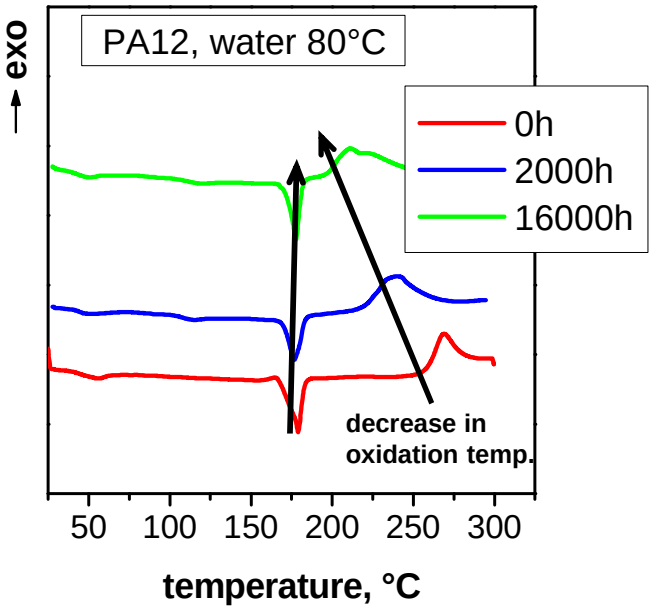

- DSC: physical aging (enthalpy relaxation) detected

## PA12 - Effect of exposure to hot water at 80°C

Stress/strain curves




DSC thermograms



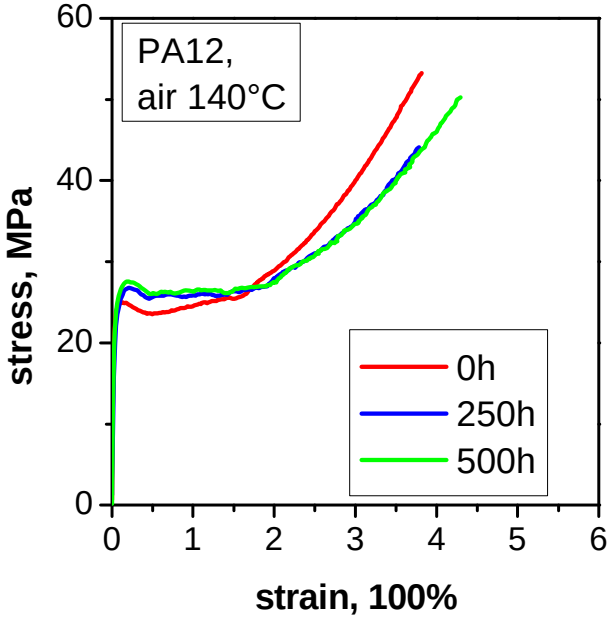

- SEC: slight decrease in weight average molecular mass



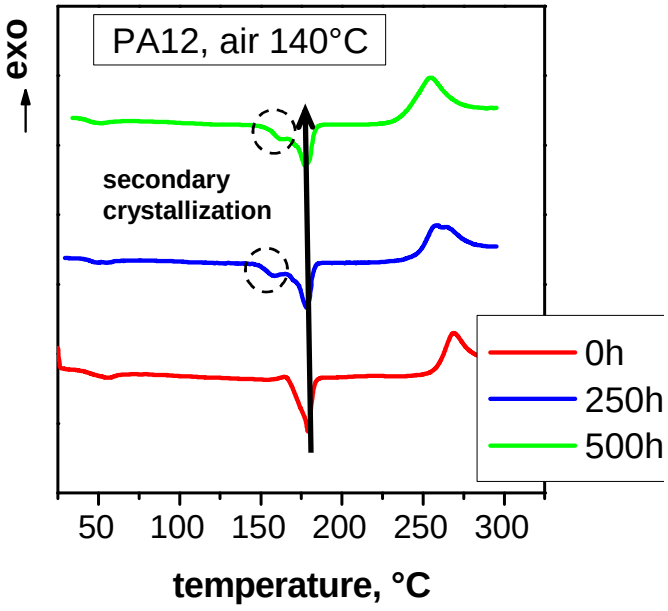


## PA12 - Effect of exposure to hot air at 140°C

Stress/strain curves



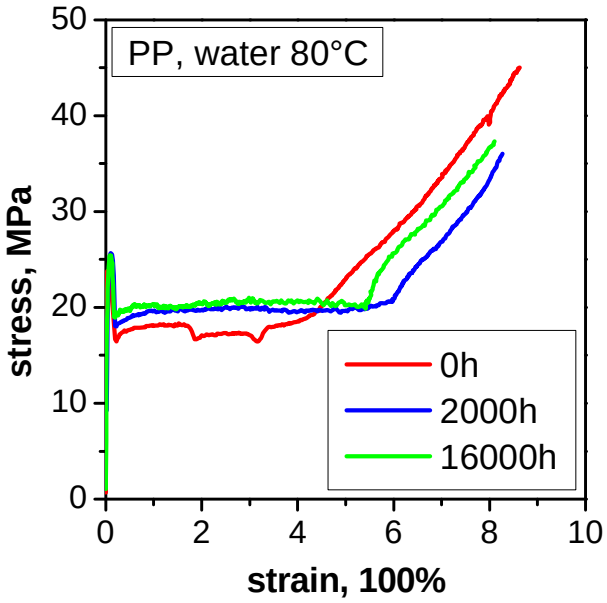

DSC thermograms



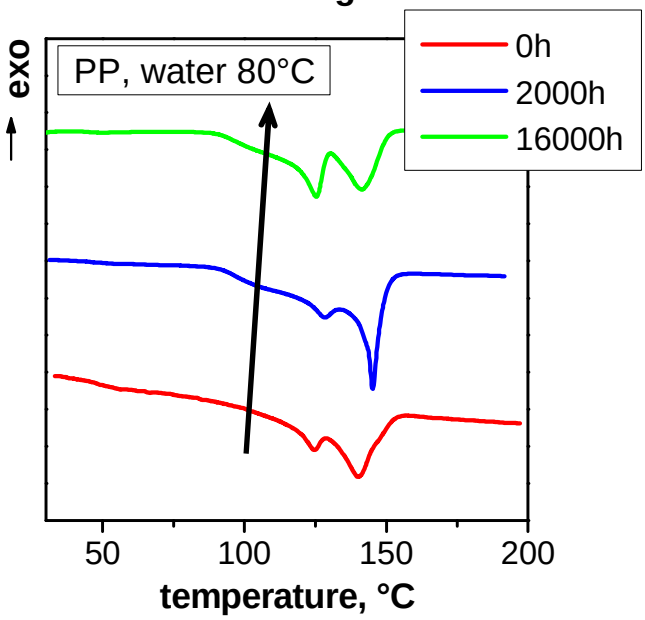

- SEC: slight increase in weight average molecular mass initially

## PP - Effect of exposure to hot water at 80°C

Stress/strain curves




DSC thermograms



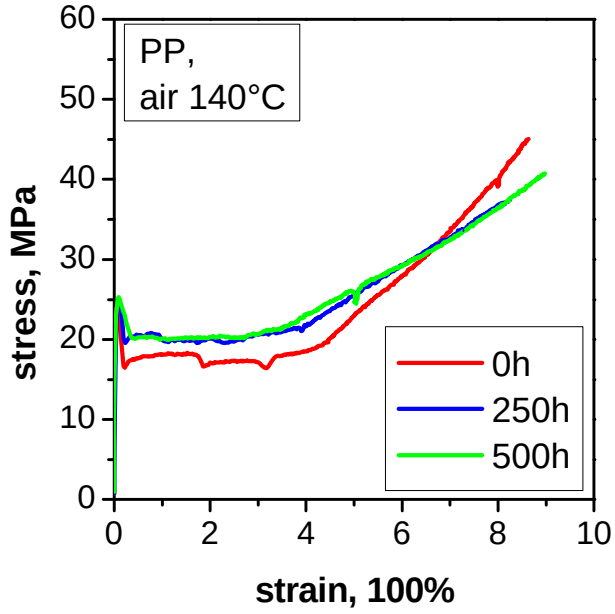

➢ SEC: no significant change in weight average molecular mass



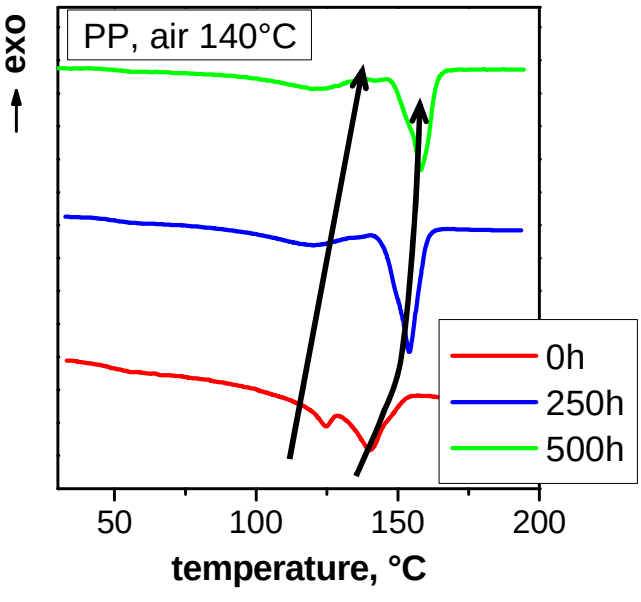


## PP - Effect of exposure to hot air at 140°C

Stress/strain curves

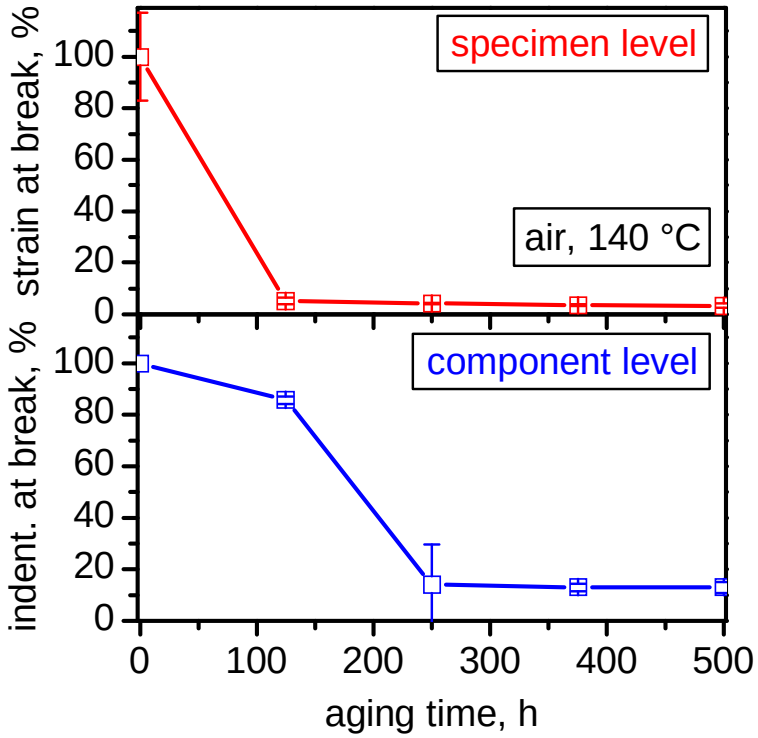



DSC thermograms



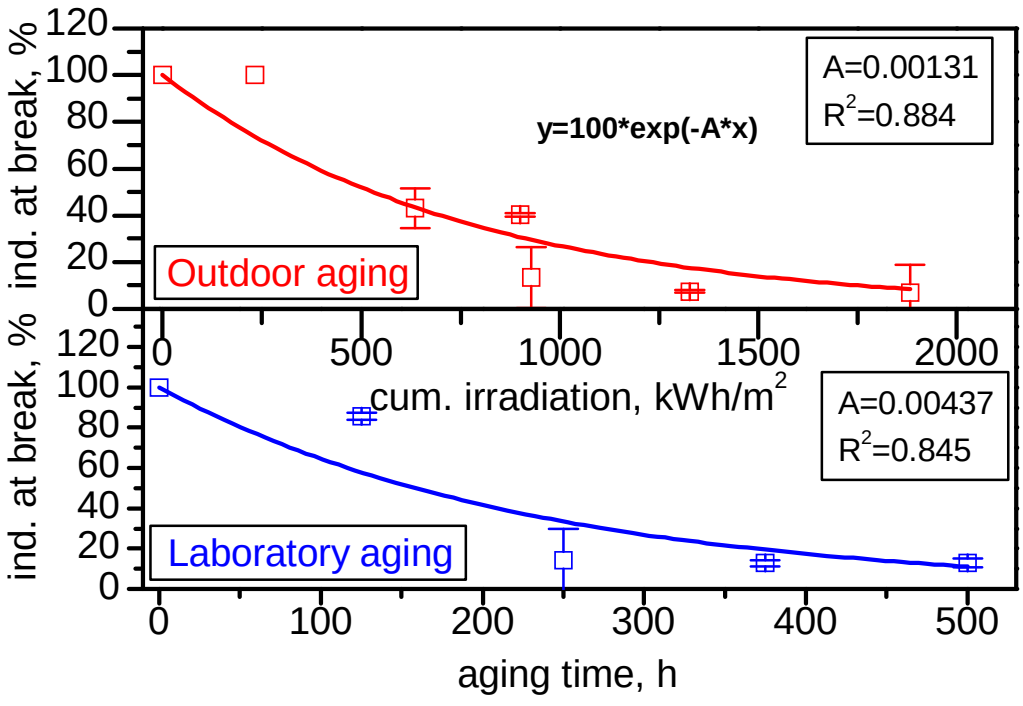

➢ SEC: no significant change in weight average molecular mass

## Results – Specimen vs. component level: PPE+PS






## Results – System level vs. Component level: PPE+PS




System level

Component level

# Conclusions and Outlook

**Conclusions:**

- Scientific approach was corroborated – efficient material screening for solar-thermal absorbers is possible on **specimen level**
- β-PP and PA12 grades exhibited better long-term stability compared to the PPE+PS reference grade
- AVENTA (Oslo, N): PPS for absorber used

**Outlook:**

- Competition with conventional solar thermal collectors by the use of commodity plastics (e.g., PP, PE) modified to the exisiting application and/or filled with fillers (carbon, etc.)
- Modification of solar thermal system to reduce max. stagnation temperature by design or by overheating protection (e.g., functinal polymers)