

Aging behavior of polymeric absorber materials for solar thermal collectors

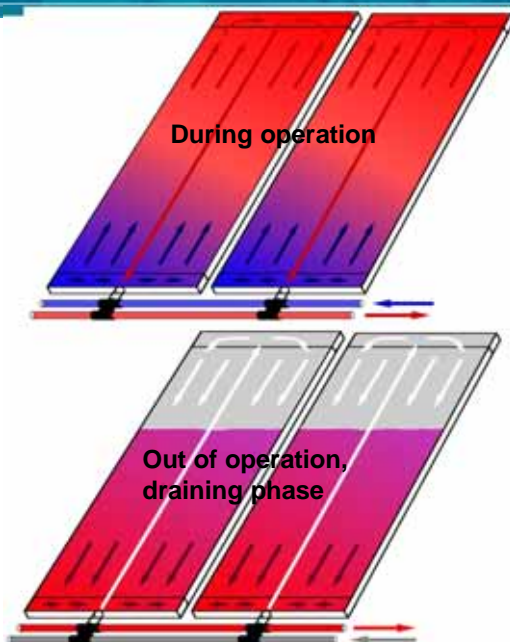


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Introduction – Plastics based collectors 2



Application in Northern Europe



System conditions:

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

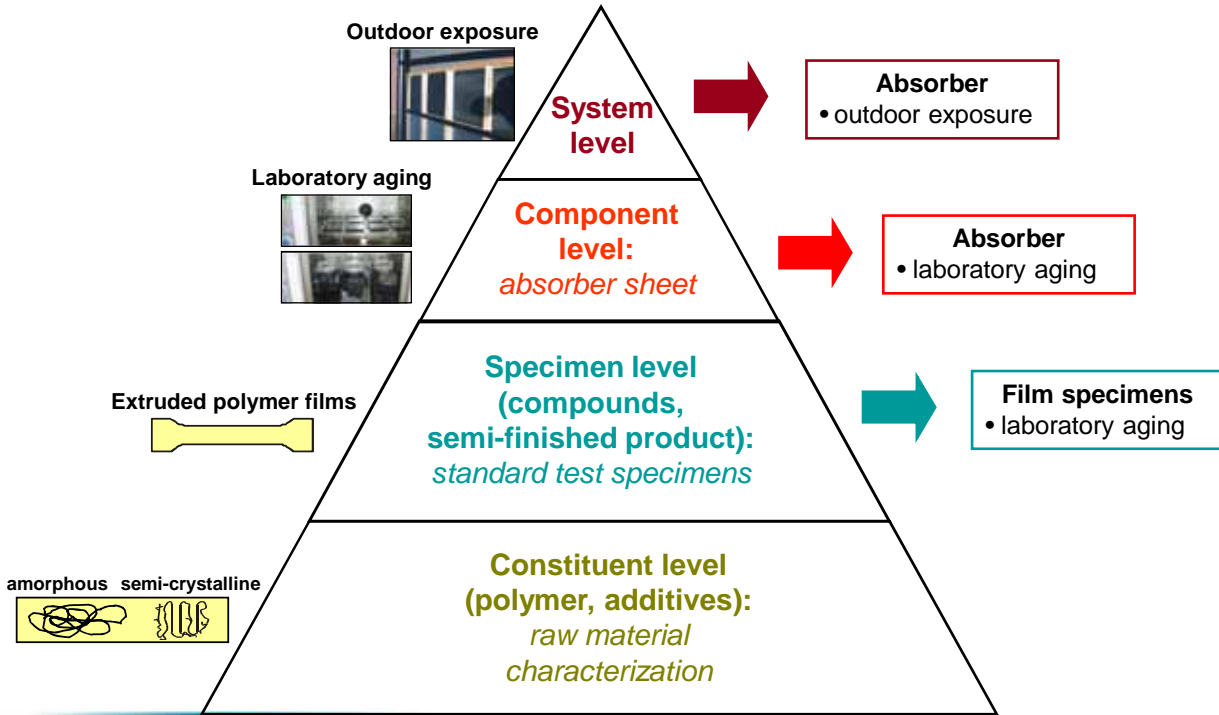
→ only few comparable systems with plastics available

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

Structure-property-performance pyramid

Various levels of material state

3 levels of characterization/testing



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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

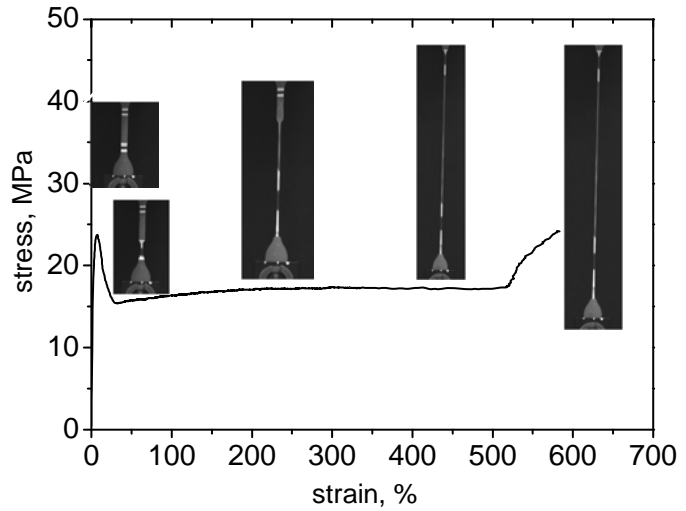
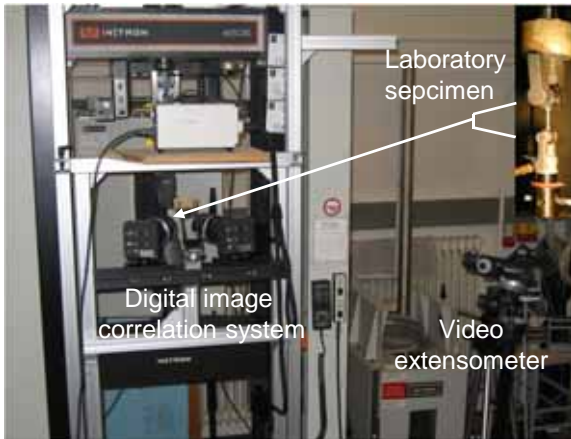
Specimen and component level:

Laboratory aging: - in air at 140 °C up to 500 h

(northern climate) - in water at 80 °C up to 16000 h

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Tensile Testing



DSC and SEC analysis



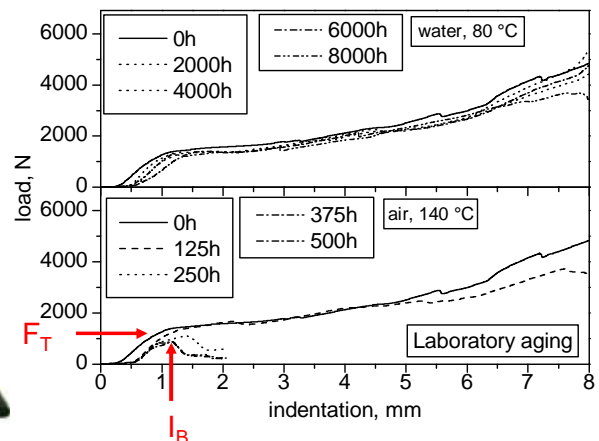
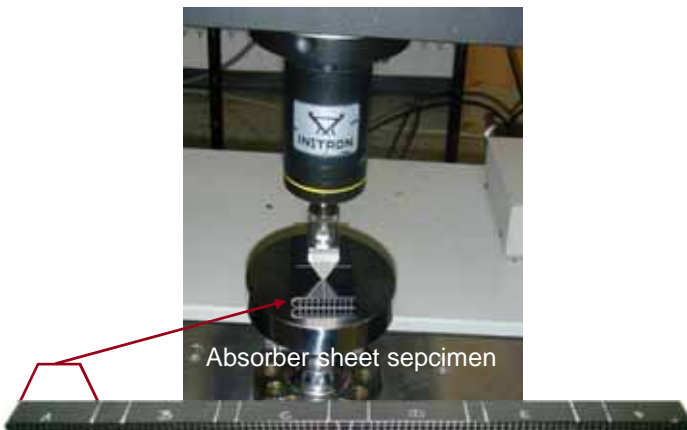
→ Characteristic parameter for aging: strain-to-break (ϵ_B)

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

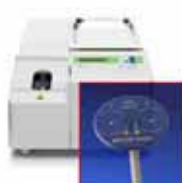
→ Weight average molecular mass

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Indentation testing



DSC analysis

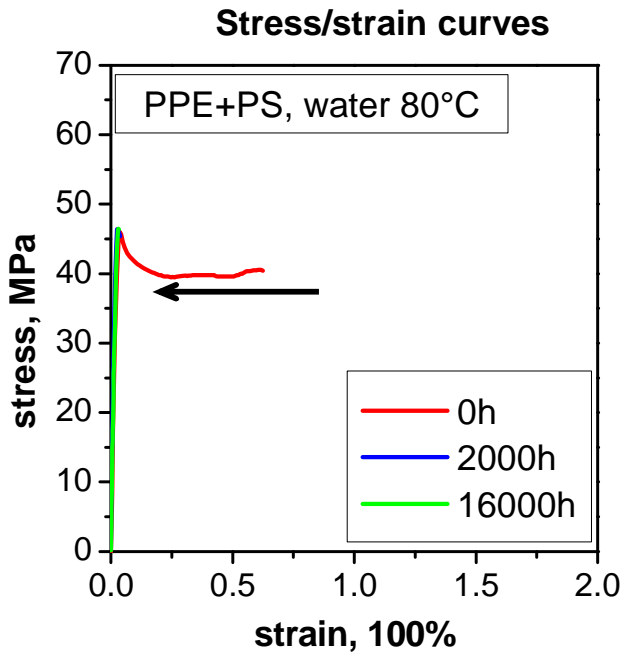


→ Characteristic parameter for aging: indentation at break (I_B)

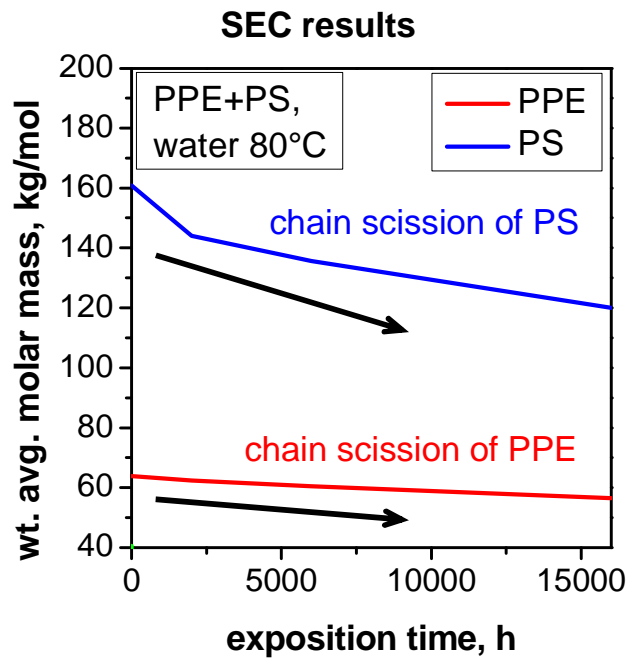
→ Morphology and thermal properties (e.g., endothermic and exothermic effects, T_g , T_{ox})

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

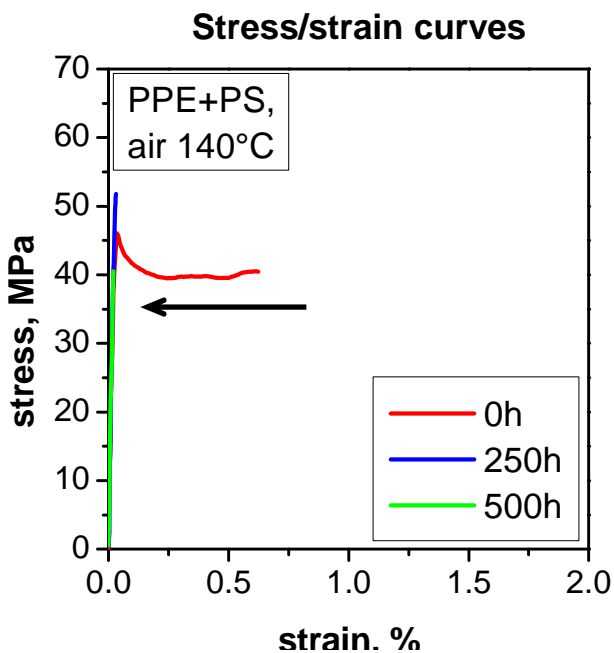


➤ DSC: no physical aging detected

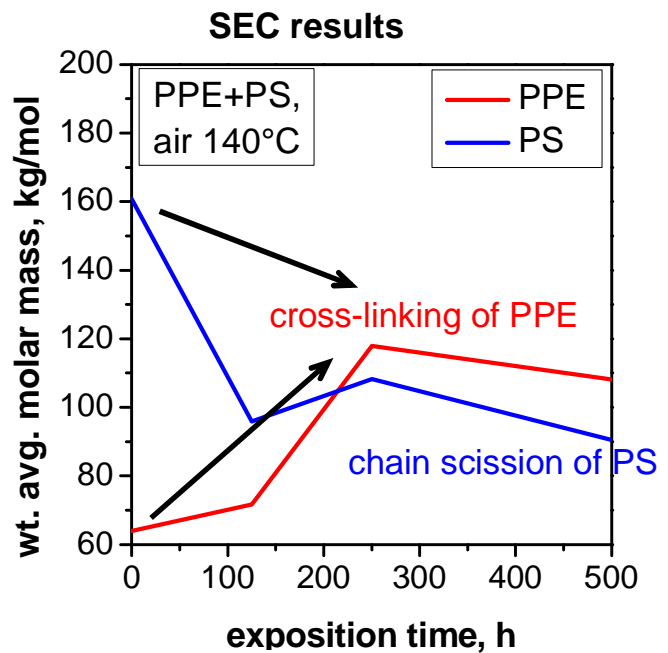


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PPE+PS - Effect of exposure to hot air at 140°C

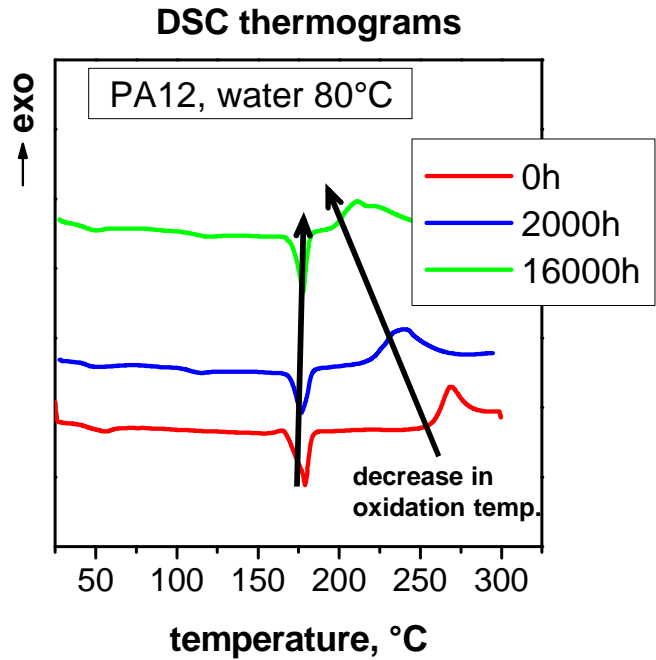
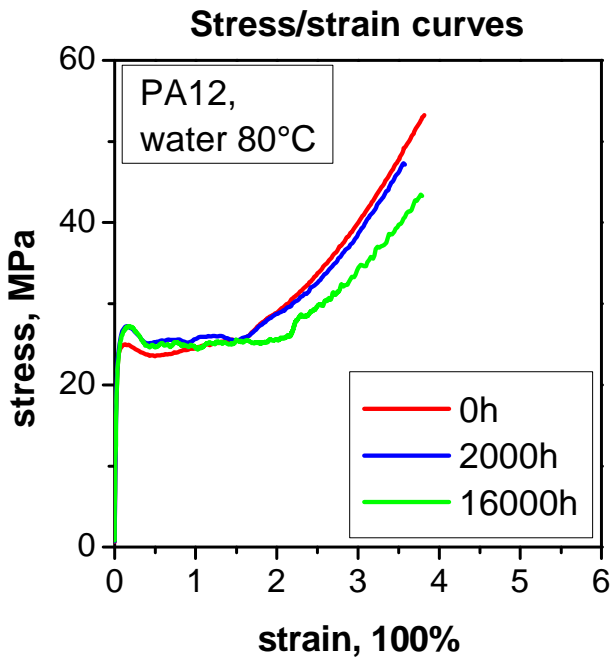


➤ DSC: physical aging (enthalpy relaxation) detected



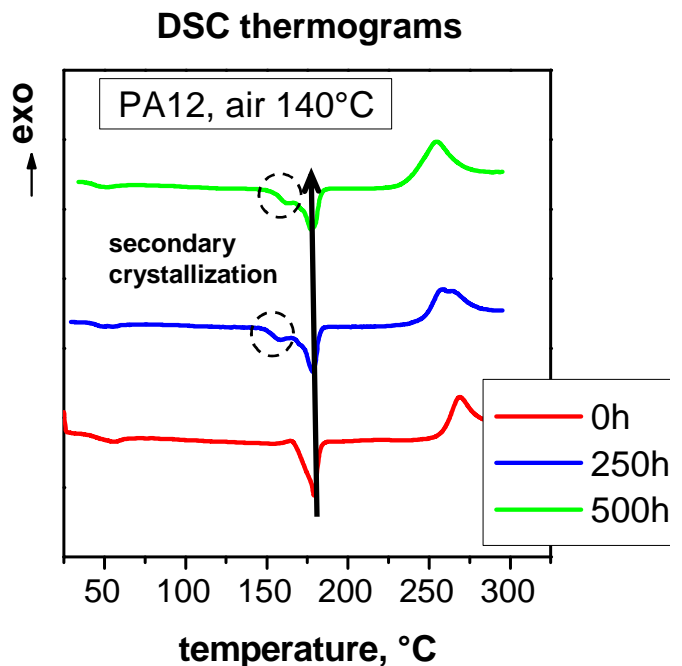
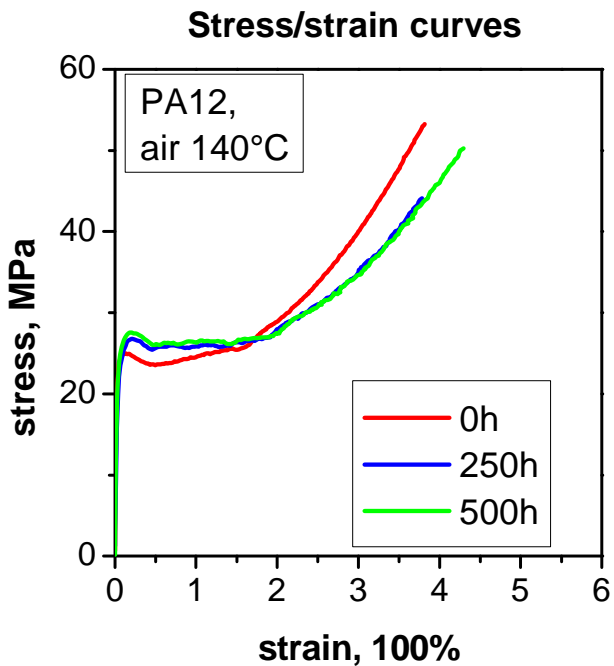
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PA12 - Effect of exposure to hot water at 80°C



➤ SEC: slight decrease in weight average molecular mass

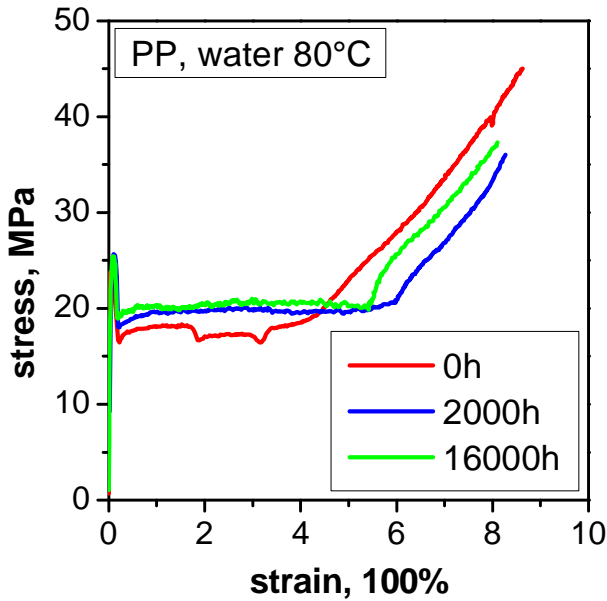
PA12 - Effect of exposure to hot air at 140°C



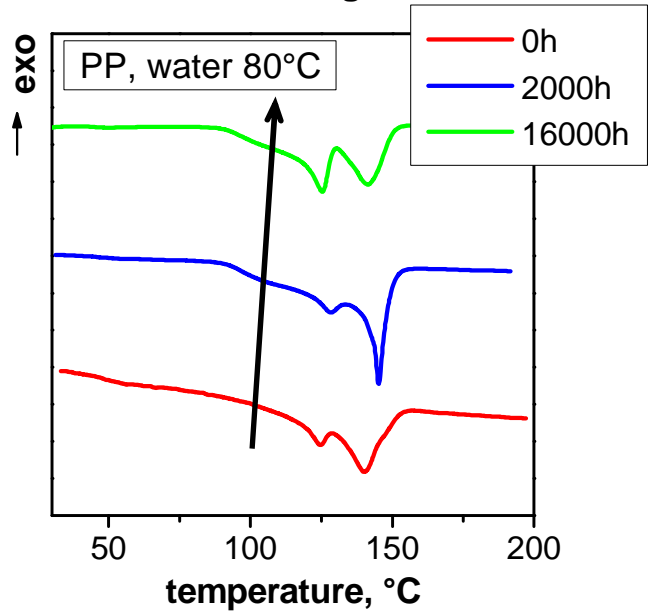
➤ SEC: slight increase in weight average molecular mass initially

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

Stress/strain curves



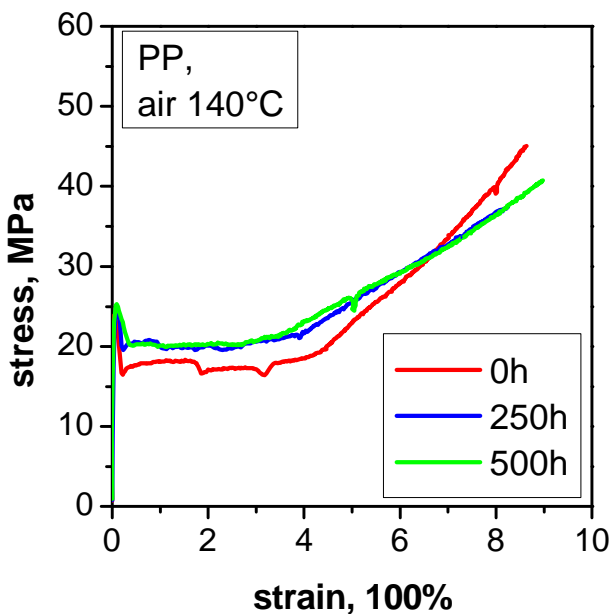
DSC thermograms



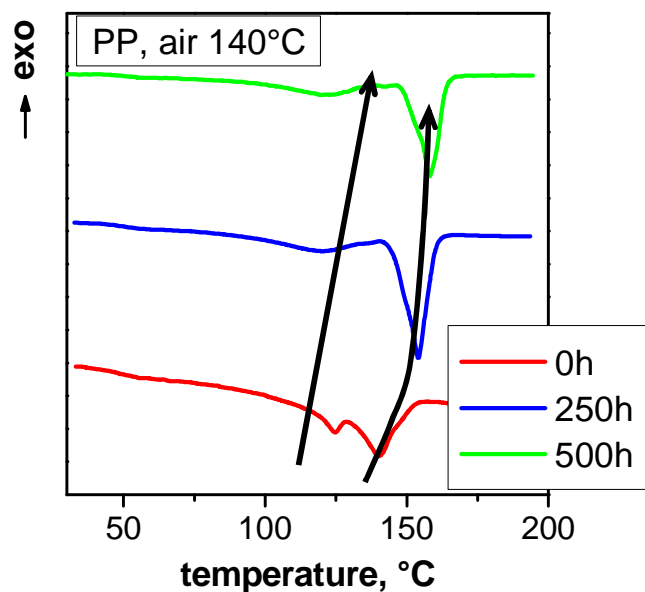
➤ SEC: no significant change in weight average molecular mass

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

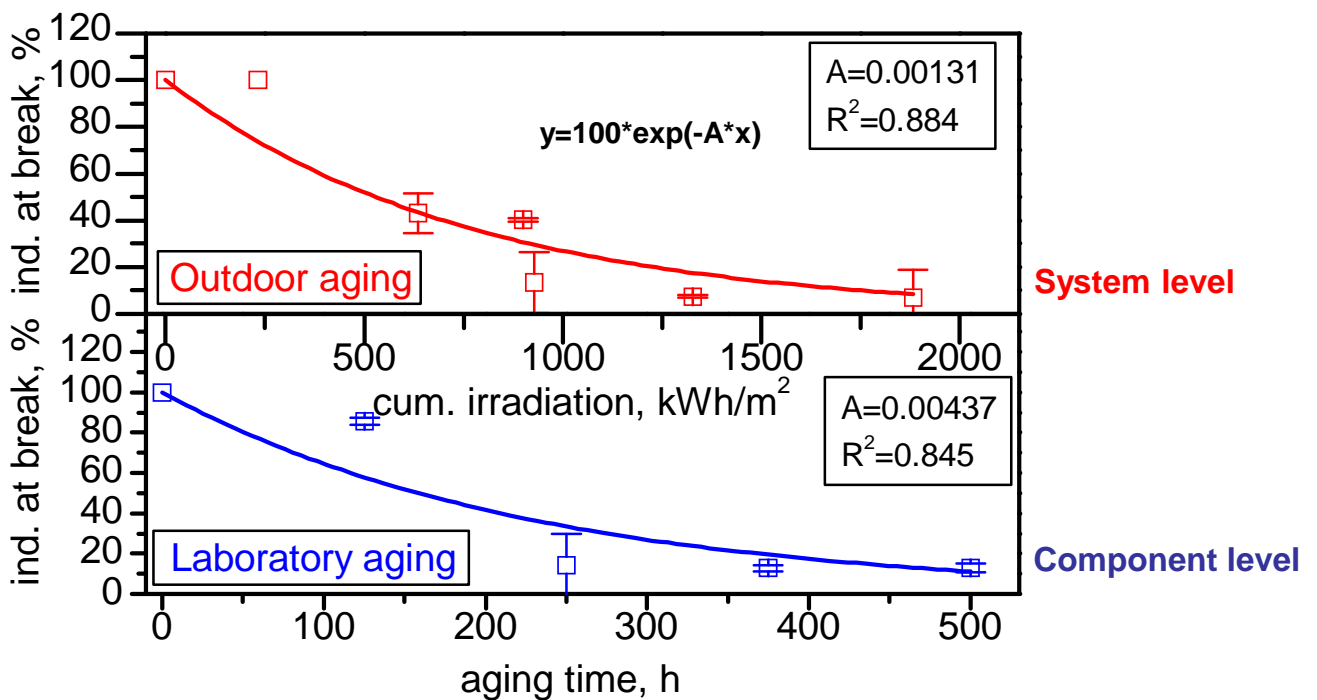
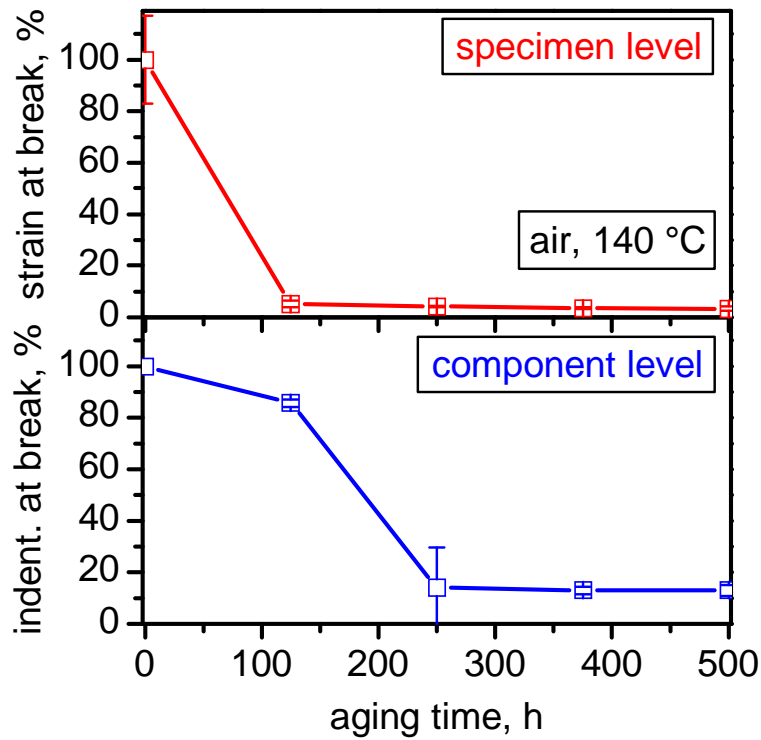
Stress/strain curves



DSC thermograms



➤ SEC: no significant change in weight average molecular mass



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 existing 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., functional polymers)