Thermoplastic polyurethane (TPU) solutions providing outstanding long-term aging properties for cable applications

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Providence, 16.10.2018

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1	Requirements for automotive cables
2	Suitable TPU materials
3	Results for non-flame retardant TPU
4	Results for flame retardant TPU

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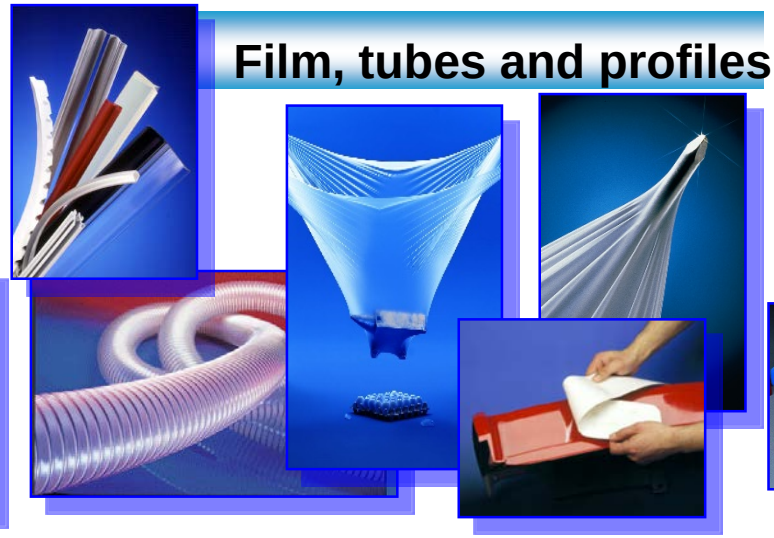
There are many commercial TPU materials available.

TPU in daily life

Automotive

Film, tubes and profiles



Miscellaneous

Electro

Shoe

Sports and leisure

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TPU for cable applications

- Flexibility over a wide temperature range (-40 to 125°C)
- High impact strength at low temperatures
- High elasticity/resilience
- Flexural fatigue strength
- High abrasion resistance
- High tear and tear propagation strength
- Resistance to microbes, UV radiation, ozone
- Good to very good resistance to atmospheric corrosion
- Good resistance to oil, grease and solvents
- Processing with standard machines
- Optional flame retardancy
- Halogen free, RohS, IMDS, Reach

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Automotive cable applications

Requirements for aging and hydrolytic stability

- **ISO 6722**

  "Dimensions, test methods and requirements for copper conductor cables."

- **LV 112**

  "Electrical cables for motor vehicles."

- **UL 1581**

  "Reference standard for electrical wires, cables, and flexible cords."

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ISO 6722

Temperature classes C and D

	125°C	150°C	175°C	200°C
3000h	Class C	Class D		
240h		Class C	Class D	
6h			Class C	Class D

After the aging – “Mandrel test” - wind a cable around a mandrel with roughly the diameter of the cable. No cracks or deformations, stickiness or excessive color changes allowed.

Requirement is equivalent to about 50% absolute elongation at break tested on standard test rods.

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LV 112

Hydrolytic resistance at 85°C@85% r.h.

Original: Damp heat at 85°C@85% r.h. for 1000h

Now: Damp heat at 85°C@85% r.h. for 3000h

After the storage in wet hot air – “Mandrel test” - wind a cable around a mandrel with roughly the diameter of the cable. No cracks or deformations, stickiness or excessive color changes allowed.

Requirement is equivalent to about 50% absolute elongation at break tested on standard test rods.

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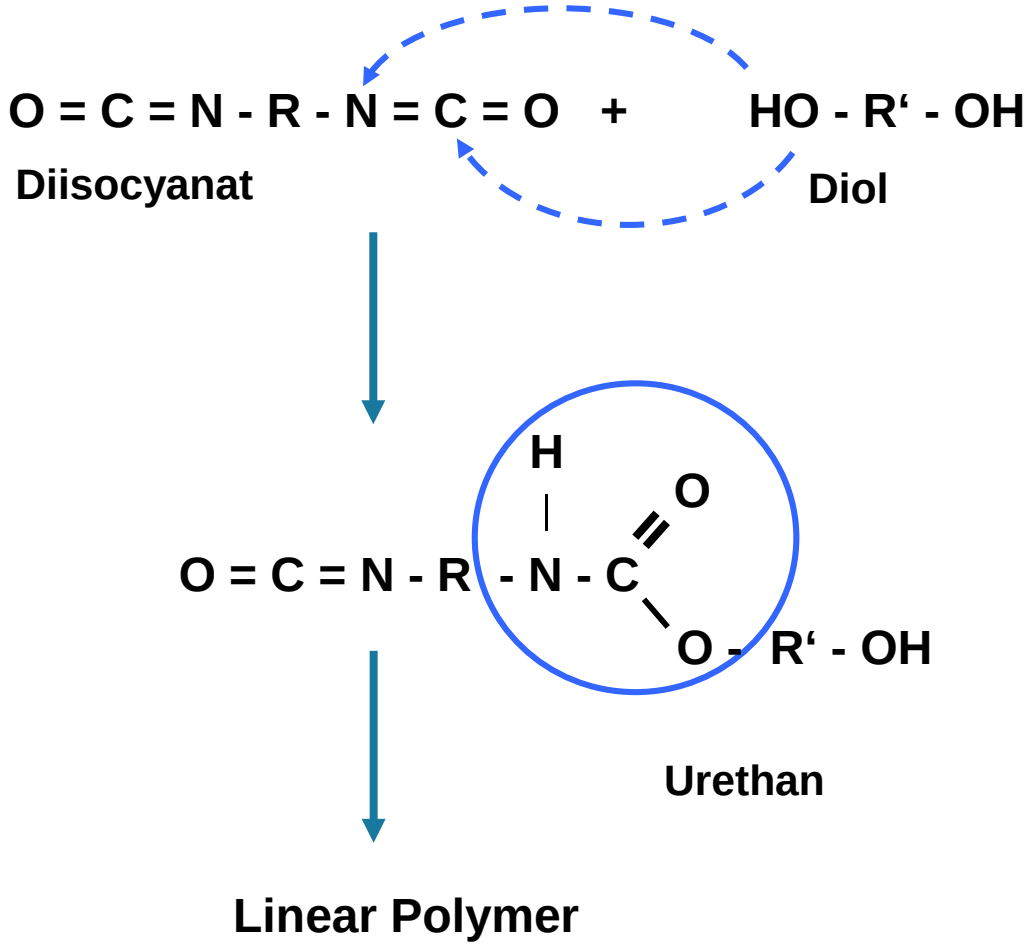
TPU chemistry



Addition reaction without byproducts.

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TPU building blocks

Chain extender

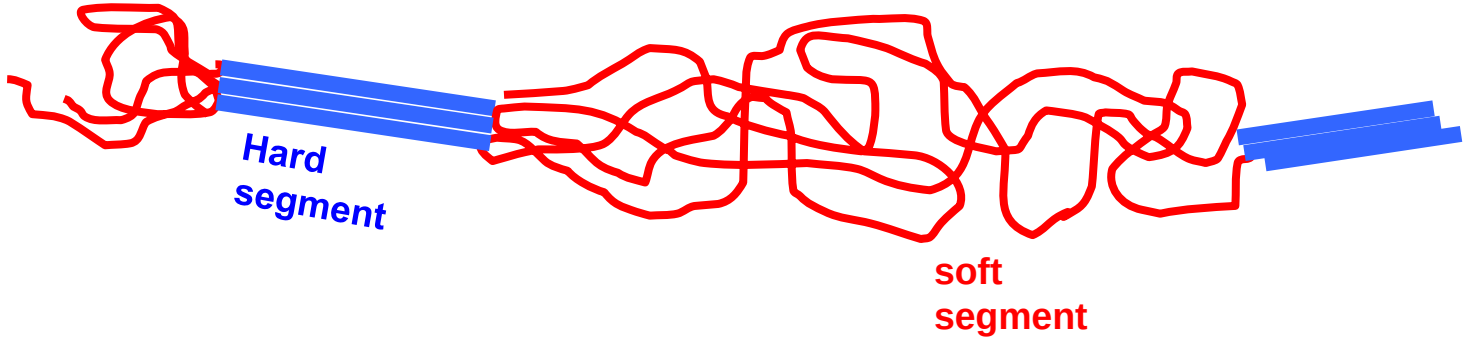
1,2-Ethylenglycol
1,4-Butandiol
HQEE
…

Isocyanate

HDI
MDI
H12MDI
...

Polyol

Polyether
Polyester
Polycarbonat
...



Many raw material combinations possible.

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Materials

TPU	Soft phase	Hard phase	FR package	ShoreA hardness
TPU B	polyether	MDI-B14		85
TPU D	new polyol*	MDI-B14		90
TPU A	new polyol*	new hard phase*		90
TPU A	new polyol*	new hard phase*	FR 1	95
TPU A	new polyol*	new hard phase*	FR 3	96

* Patent pending.

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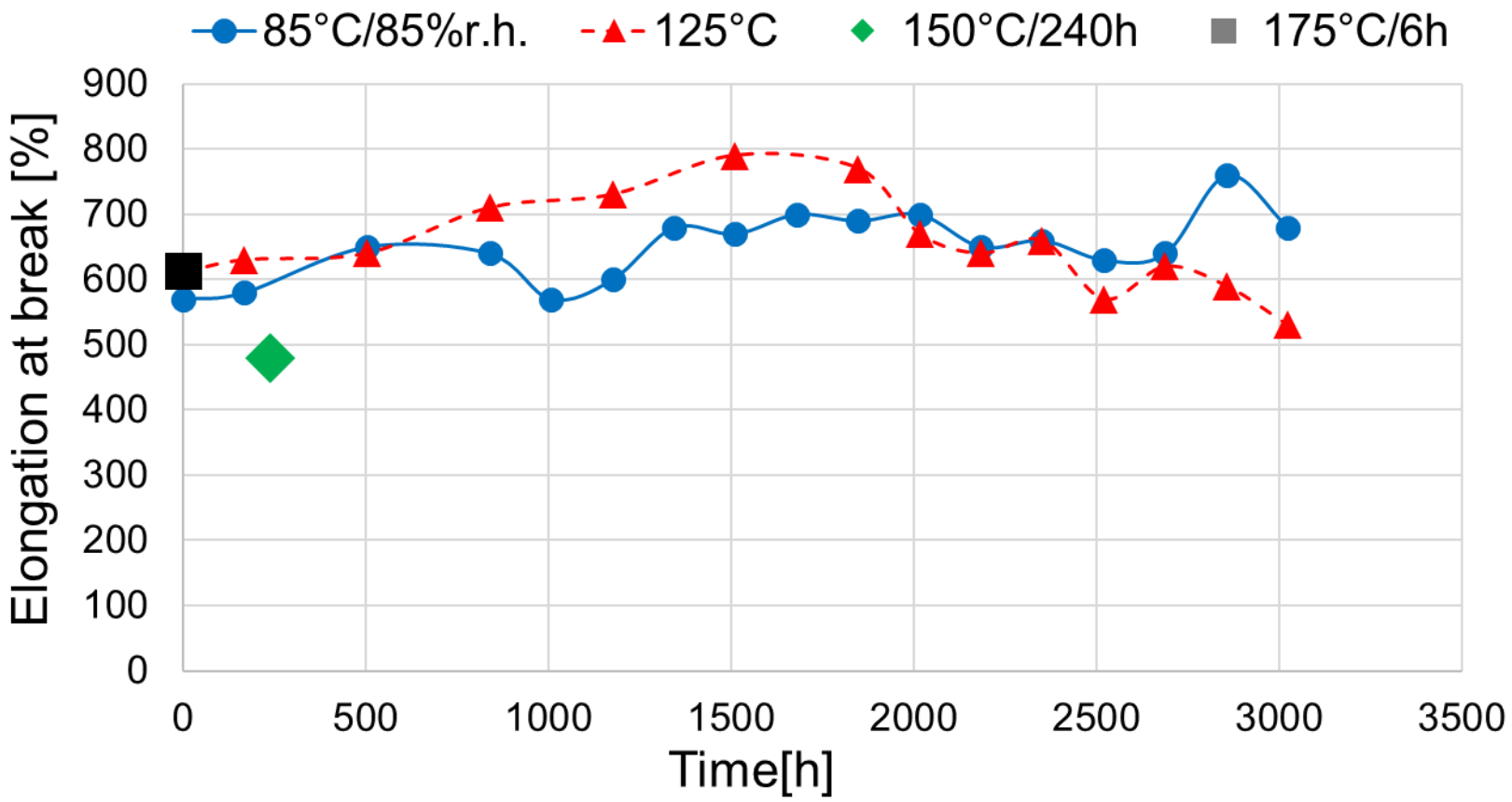
TPU B

Polyether based material – hard phase MDI/B14
Temperature class C



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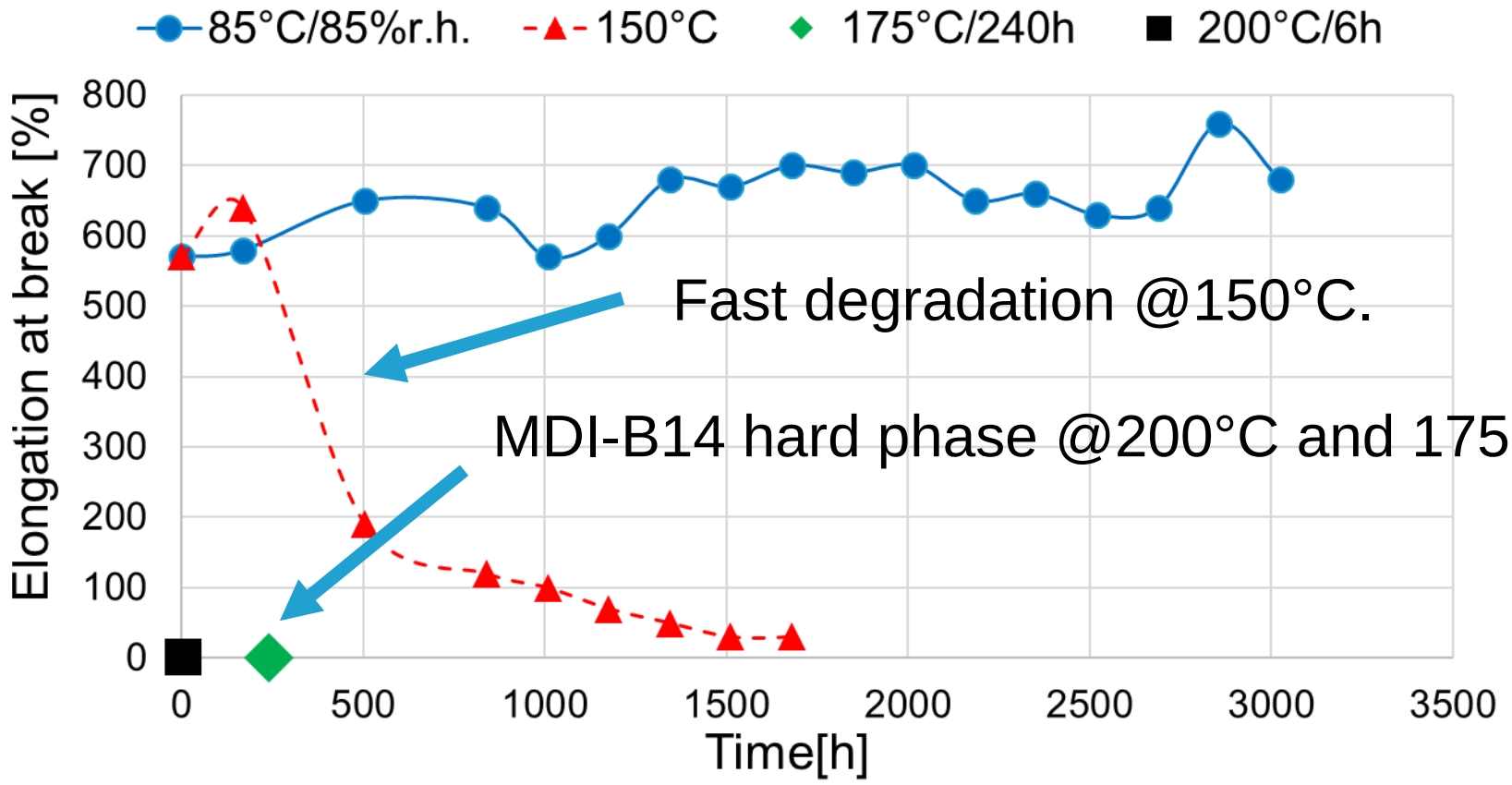
TPU B

Polyether based material – hard phase MDI/B14
Temperature class D



Fast degradation @150°C.

MDI-B14 hard phase @200°C and 175°C: creep and melting.

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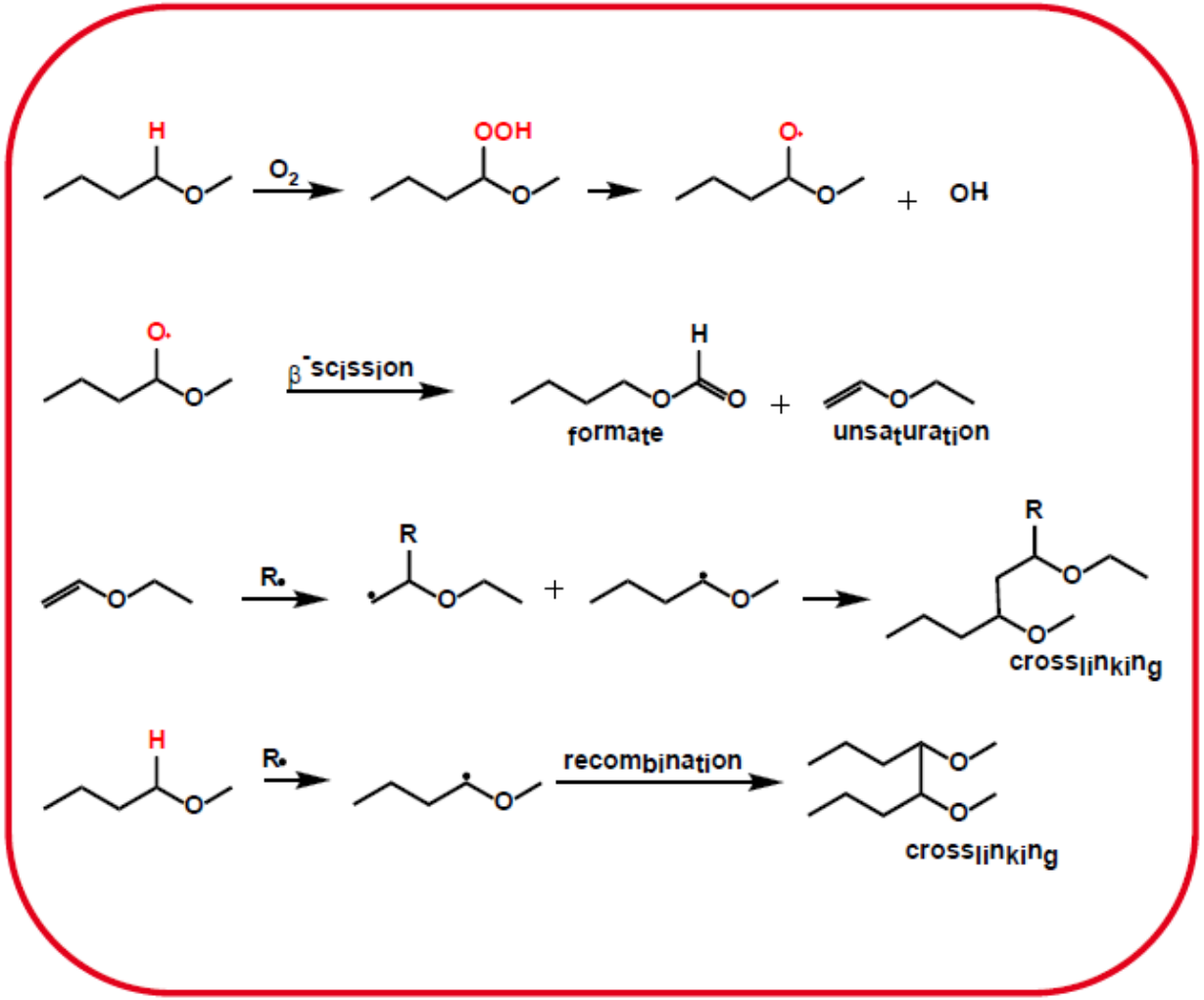
Oxidative stability

Oxidative degradation of the polyether.

Followed by cross-linking.



I. Schulz, University of Hamburg, BASF internal presentation Nov. 2016.
D. K. Chattopadhyay et al, Progress in Polymer Science, 34 (10).

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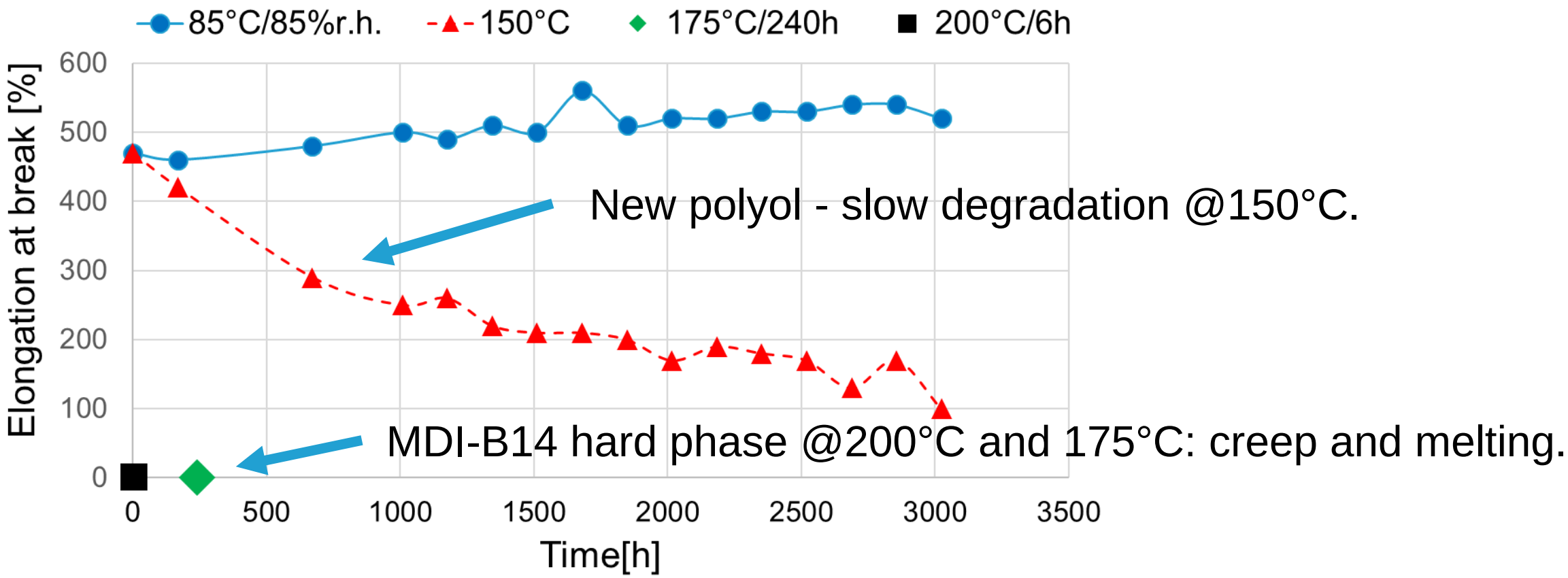
TPU D

New polyol – hard phase MDI/B14
Temperature class D



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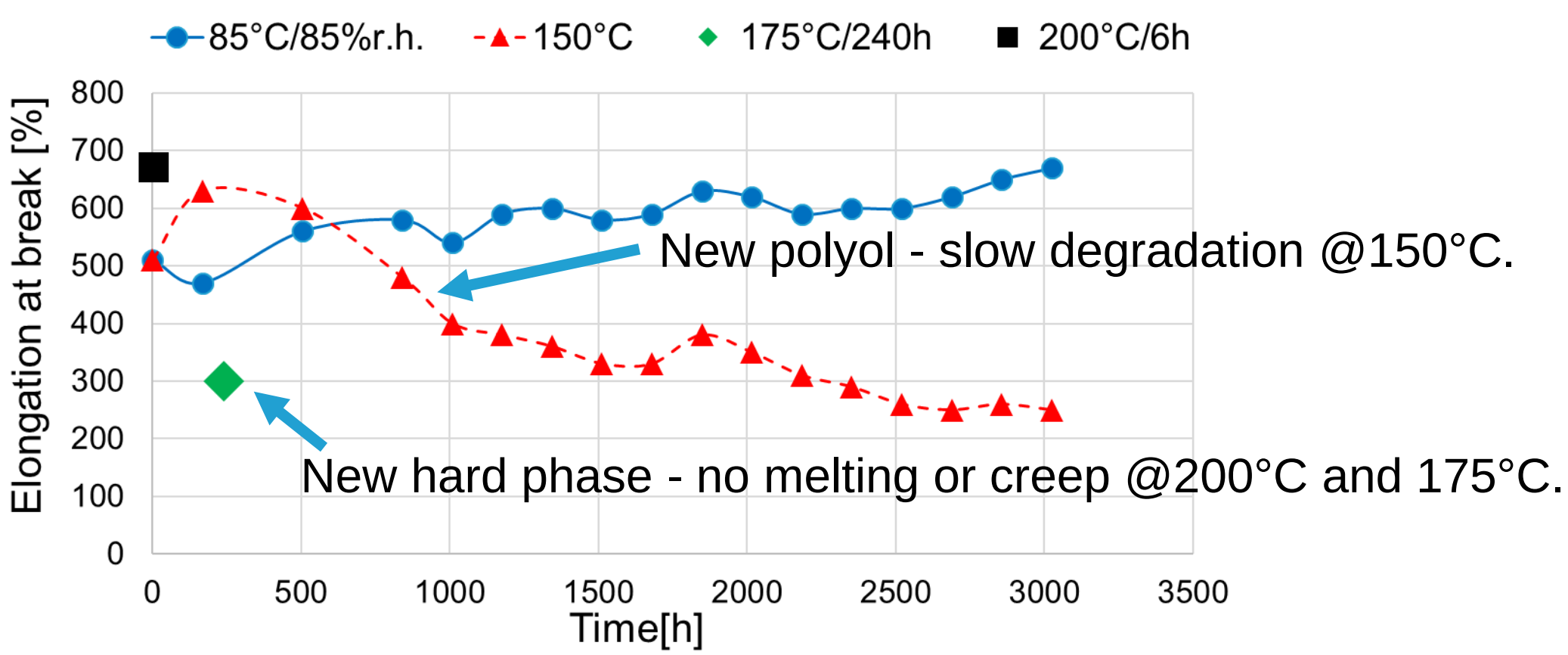
TPU A

New polyol and new hard phase
Temperature class D



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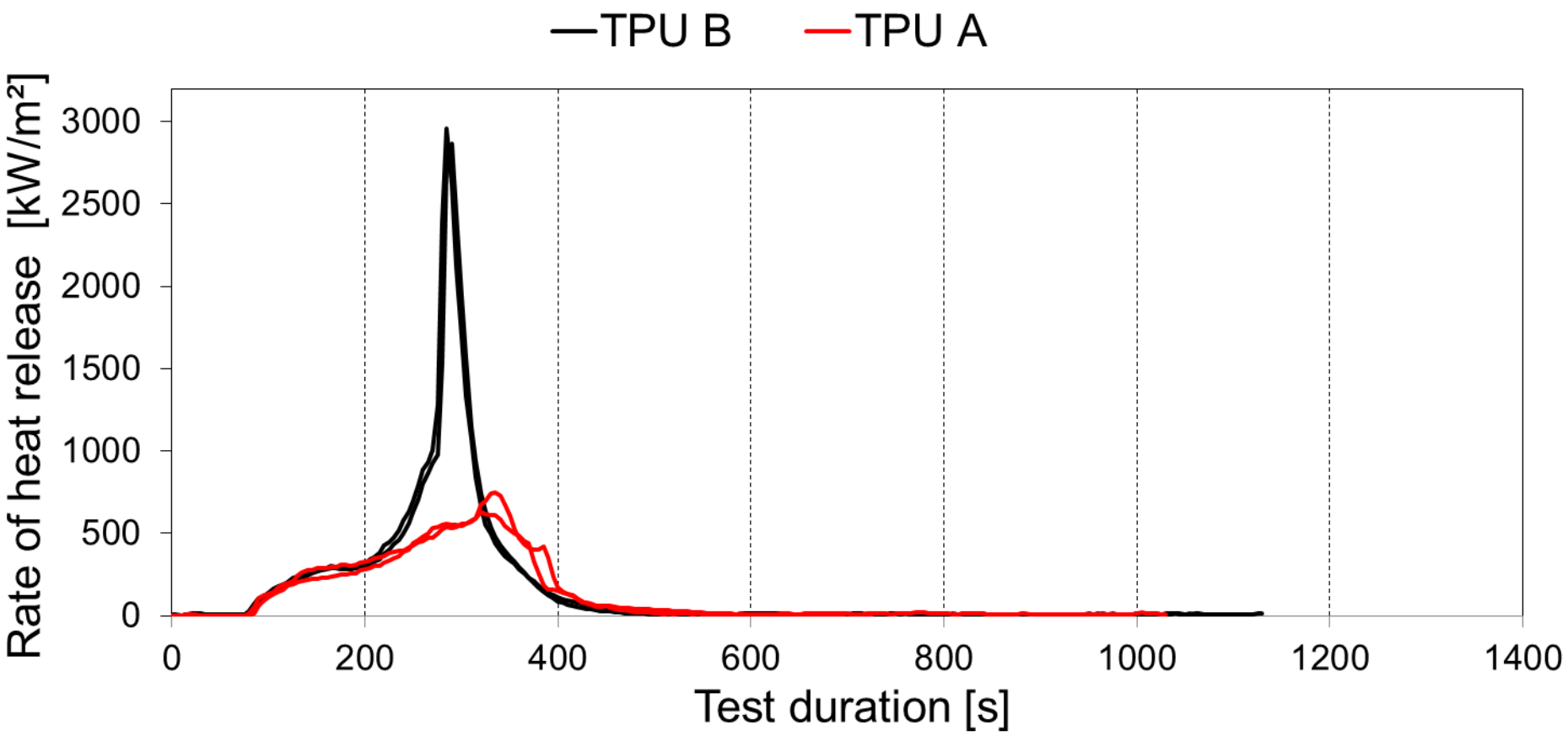
TPU A (new) and TPU B (polyether)

Rate of heat release



(ISO 5660-1, 100x100x5mm samples burned with 35kW/m²)

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TPU A, TPU A-FR1, and TPU A-FR3

Mechanical performance

		TPU	A-FR1	A-FR3	A
Tensile strength	DIN 53504-S2	[MPa]	24	30	49
Elongation at break	DIN 53504-S2	[%]	550	590	540
Density	DIN EN ISO 1183-1-A	[g/cm^3]	1,29	1,25	1,22
Tear strength	DIN ISO 34-1Bb	[N/mm]	96	97	97
Hardness	DIN 53505	[Shore A]	95	96	90
Abrasion	DIN ISO 4649-A	[mm^3]	60	52	48

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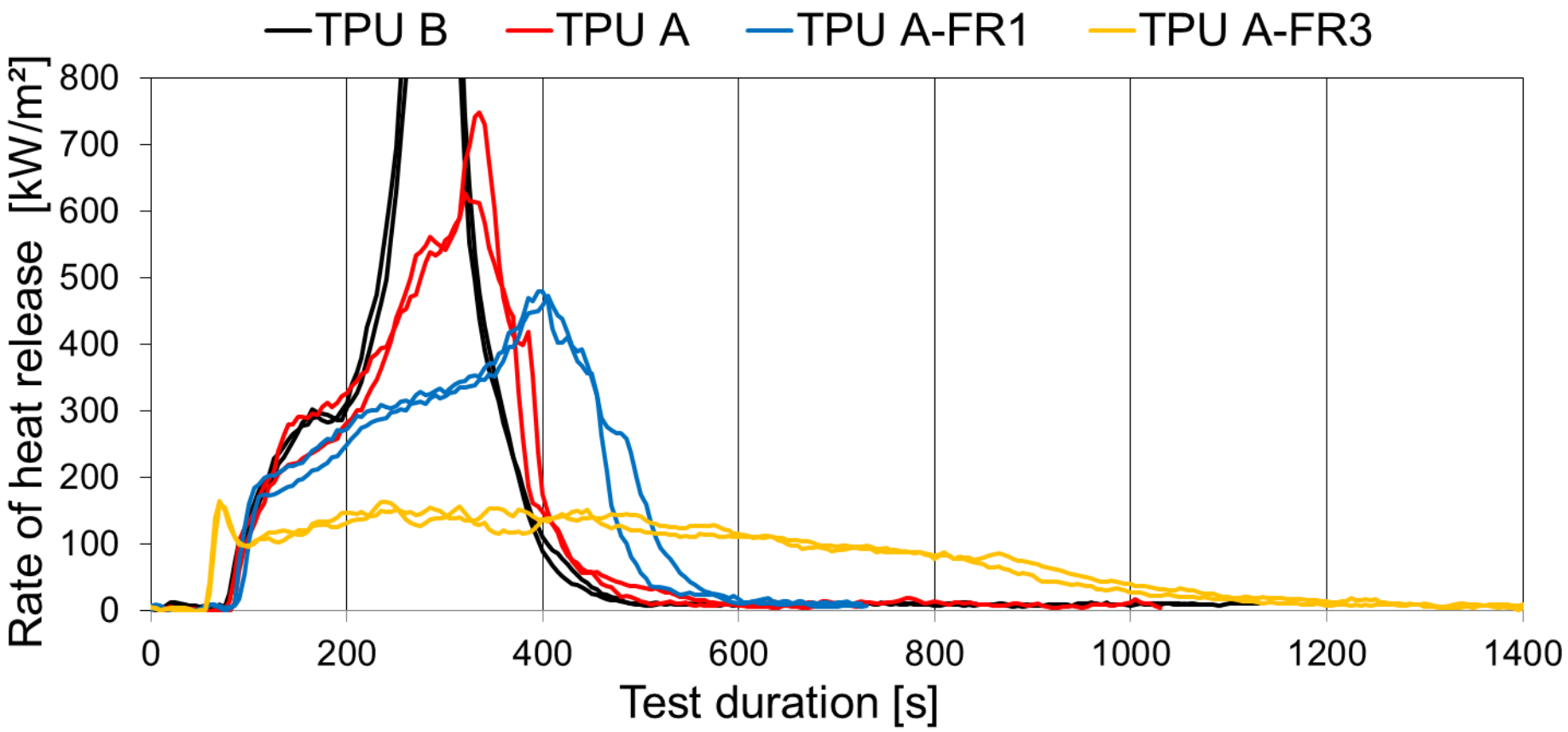
TPUB, TPU A, TPU A-FR1, and TPU A-FR3

Rate of heat release



(ISO 5660-1, 100x100x5mm samples burned with 35kW/m^2)

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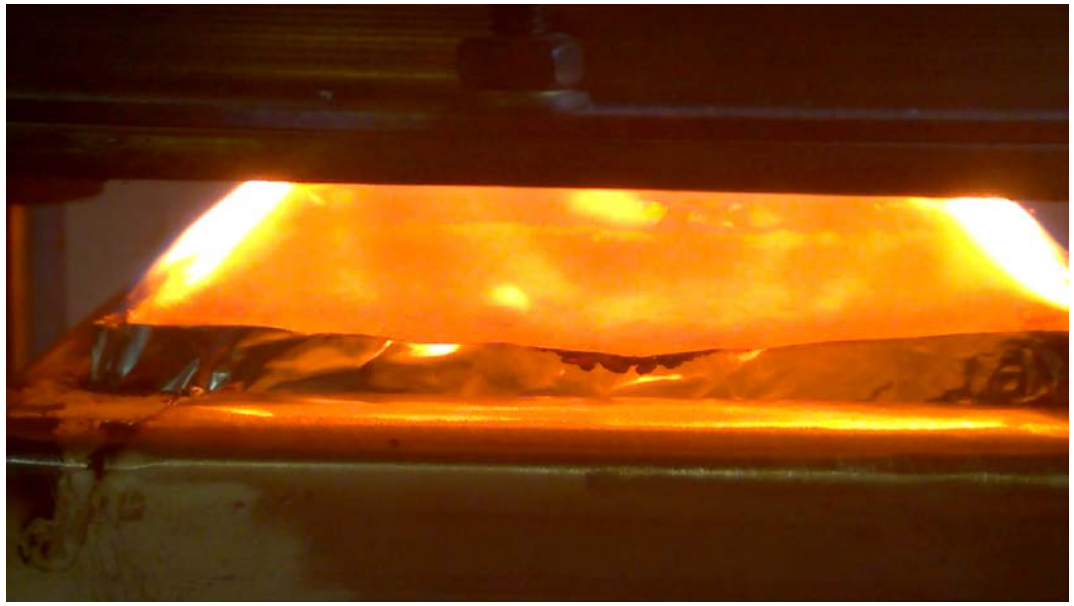
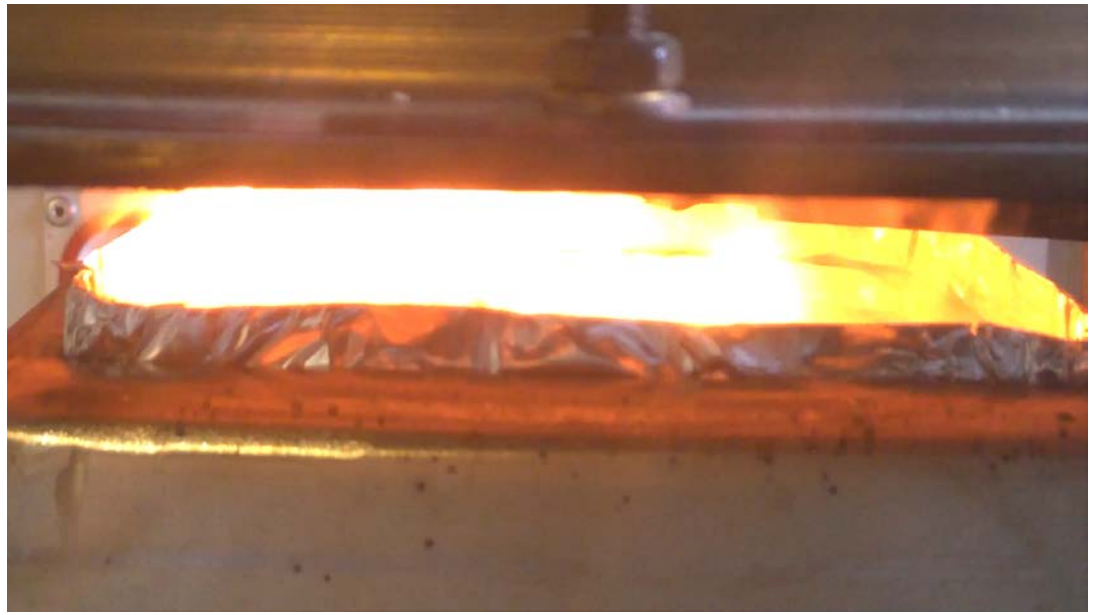
TPU A and TPU A-FR3

Video of cone test



TPU A



TPU A-FR3

(ISO 5660-1, 100x100x5mm samples burned with 35kW/m^2)

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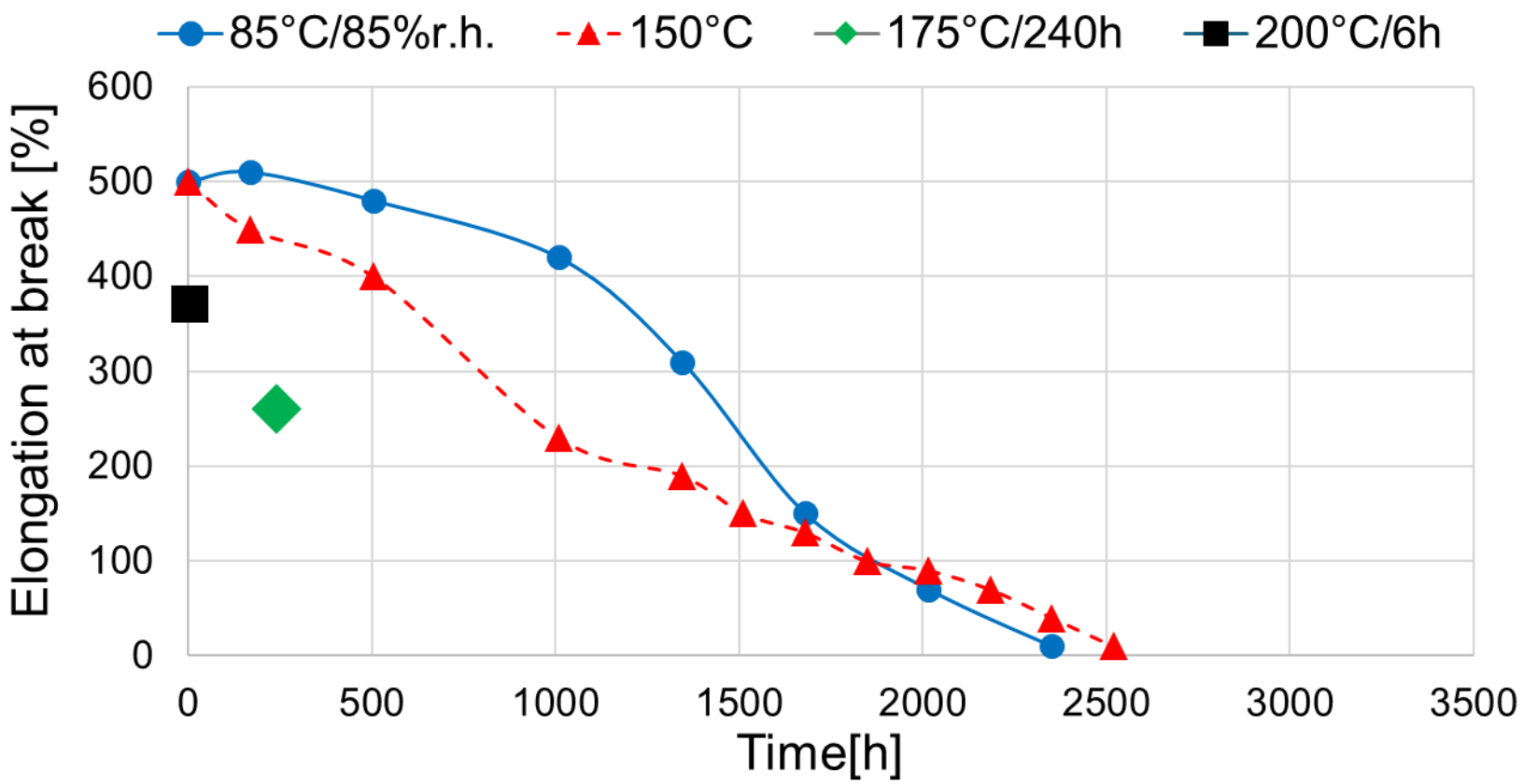
TPU A-FR3

New polyol - new hard phase – FR3 package
Temperature class D



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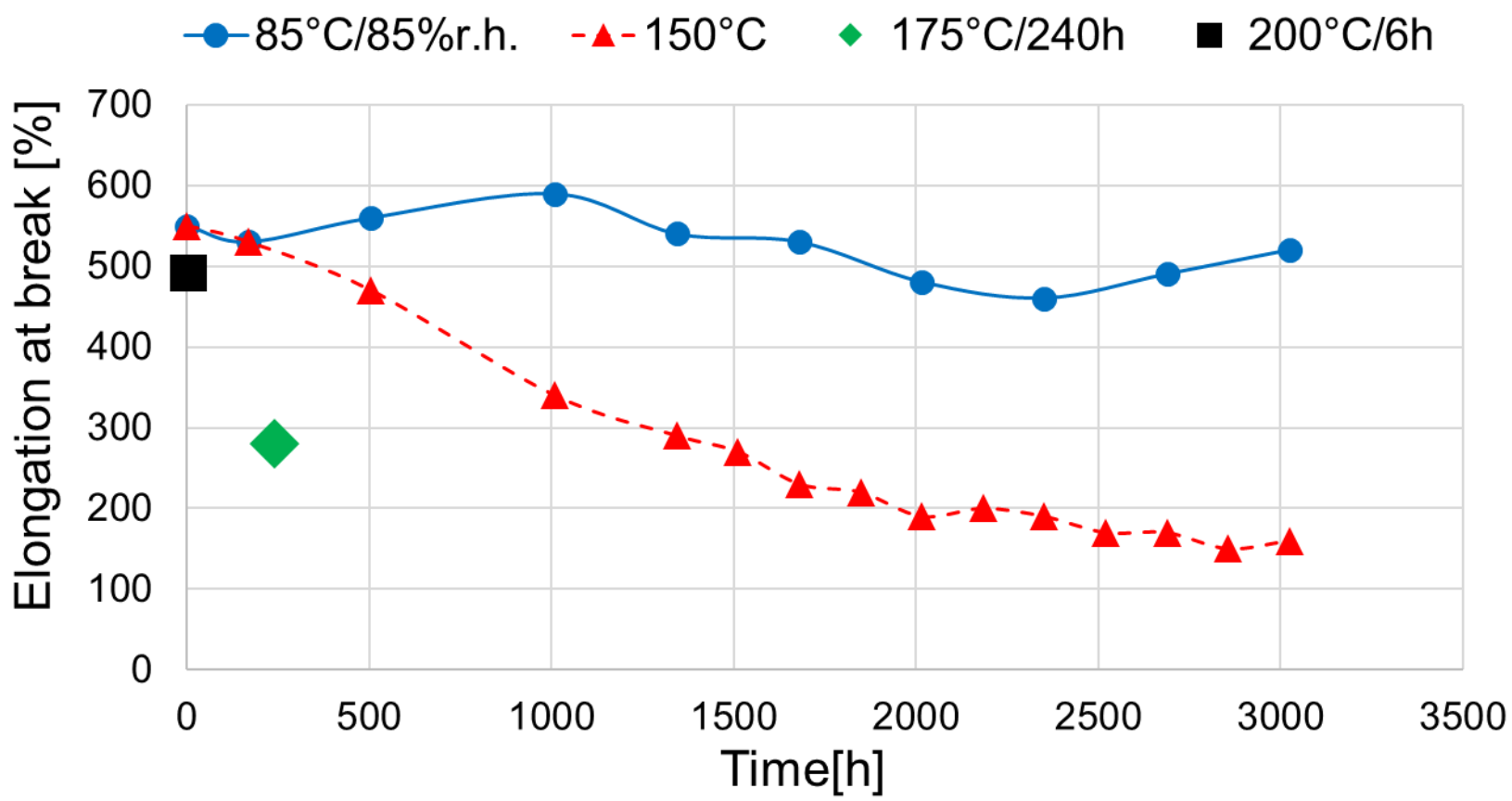
TPU A-FR1

New polyol - new hard phase – FR1 package
Temperature class D



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Summary

- Common polyether based TPU are suitable for temperature class C.
- New developed TPU materials are suitable for temperature class D.
- New flame-retardant TPU materials are suitable for temperature class D.

There are more results in the paper including the aging results according to UL 1581.

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