Polyethylene, acid copolymer and ionomer sealants on aluminium foil - What really makes them different?

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Presented by:
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Structure

- ✧ Laminates for hot tack comparison
- ✧ Rheometer methods
  - ✧ Viscosity curves
  - ✧ Temperature sweeps
  - ✧ Temperature/melt tack measurements
- ✧ Advanced hot tack method
- ✧ Interfacial temperature during hot tack
- ✧ Correlation hot tack, real temperature and viscosity
- ✧ Summary

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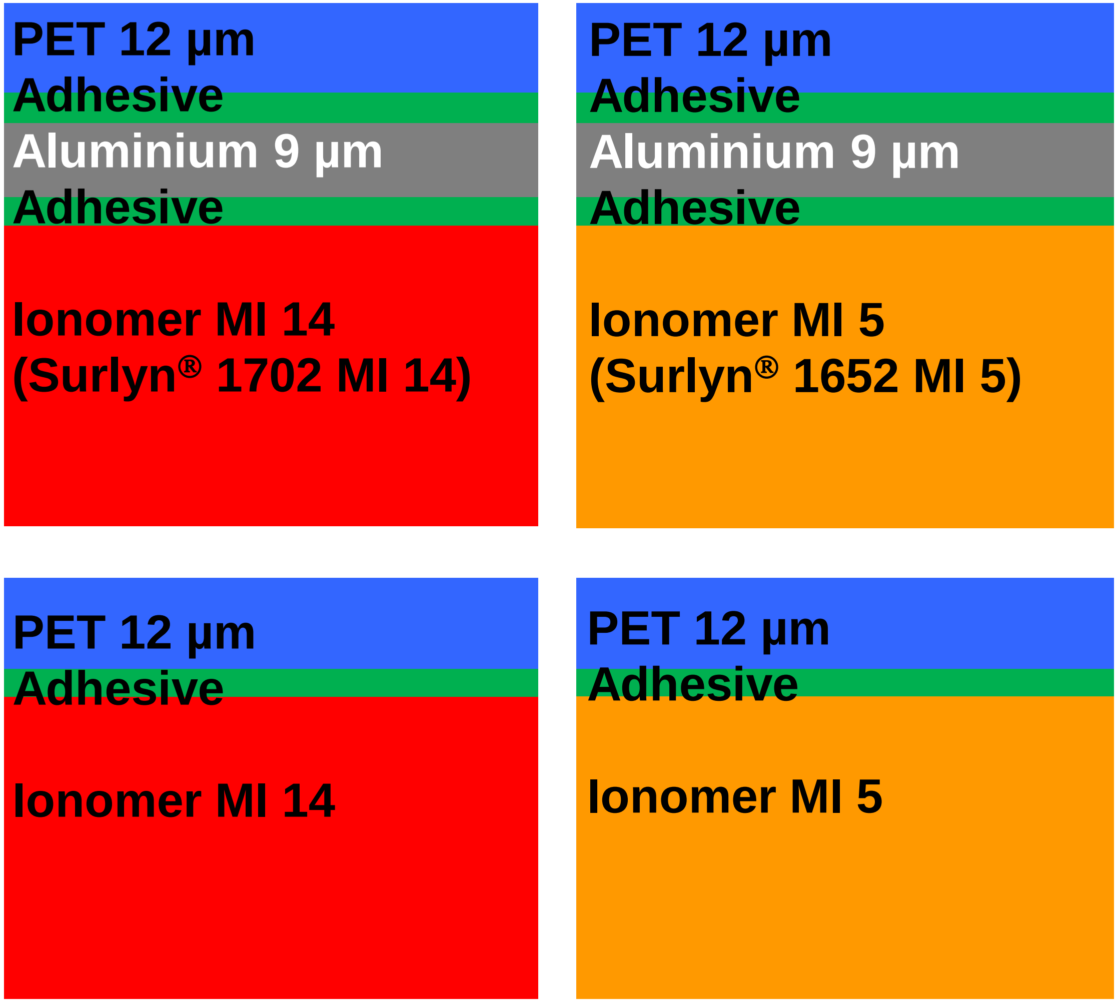
Compared laminates with ionomer sealants



Laminates with ionomer, PE and acid copolymer

PET 12 µm
Adhesive
Aluminium 9 µm
Adhesive
Ionomer MI 14 50 µm

PET 12 µm
Adhesive
Aluminium 9 µm
Adhesive
Ionomer MI 5 50 µm

PET 12 µm
Adhesive
Aluminium 9 µm
EMAA (8%) 5 g/m²
LDPE 1 40 g/m²
(LDPE 18R430 MI 14)

PET 12 µm
Adhesive
Aluminium 9 µm
EMAA (8%) 5 g/m²
LDPE 2 40 g/m²
(LDPE 23L430 MI 5)

PET 12 µm
Adhesive
Aluminium 9 µm
EMAA (8%) 5 g/m²
EMAA (8%) 40 g/m²
(EMAA 28M430 MI 8)

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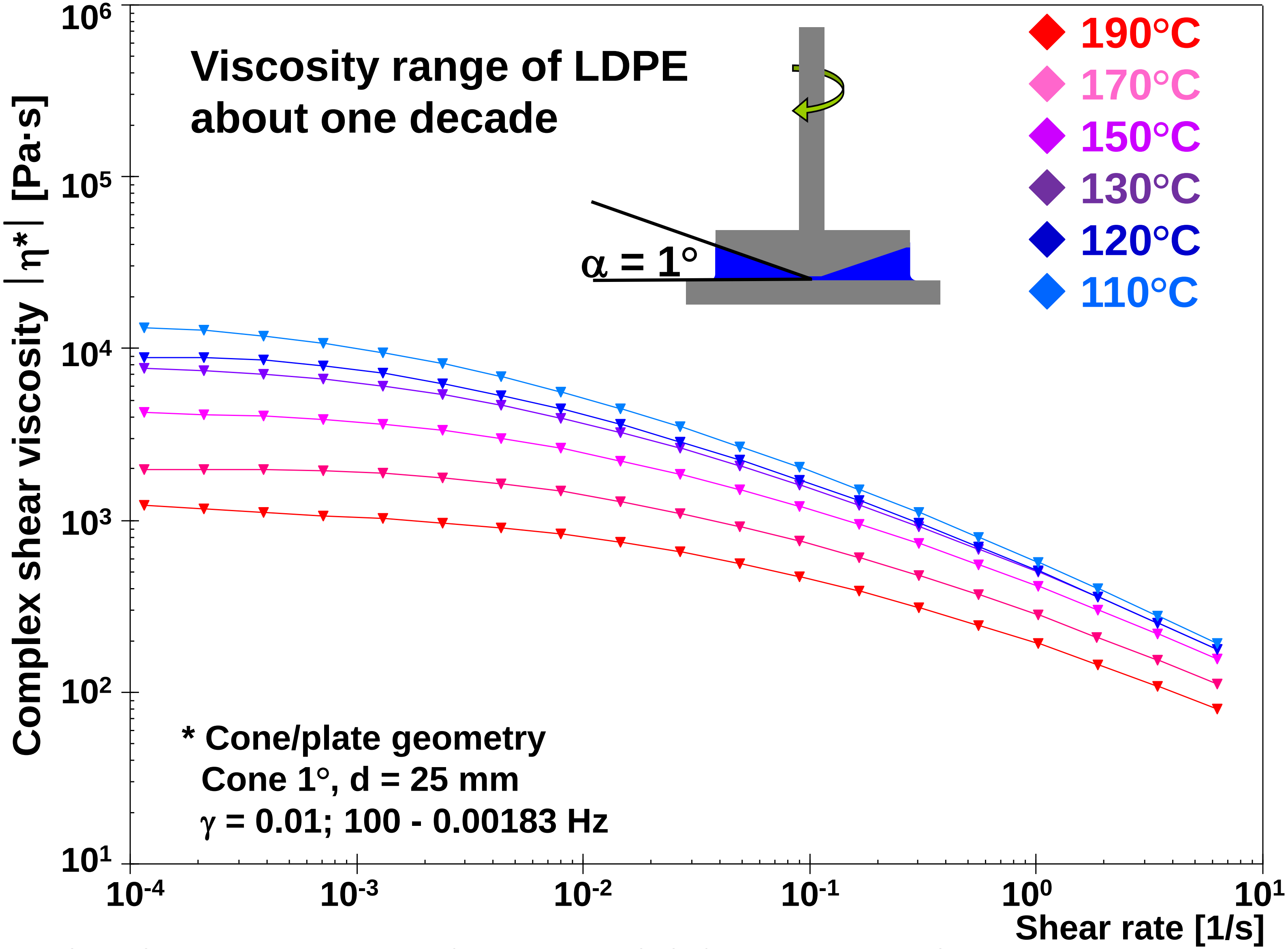
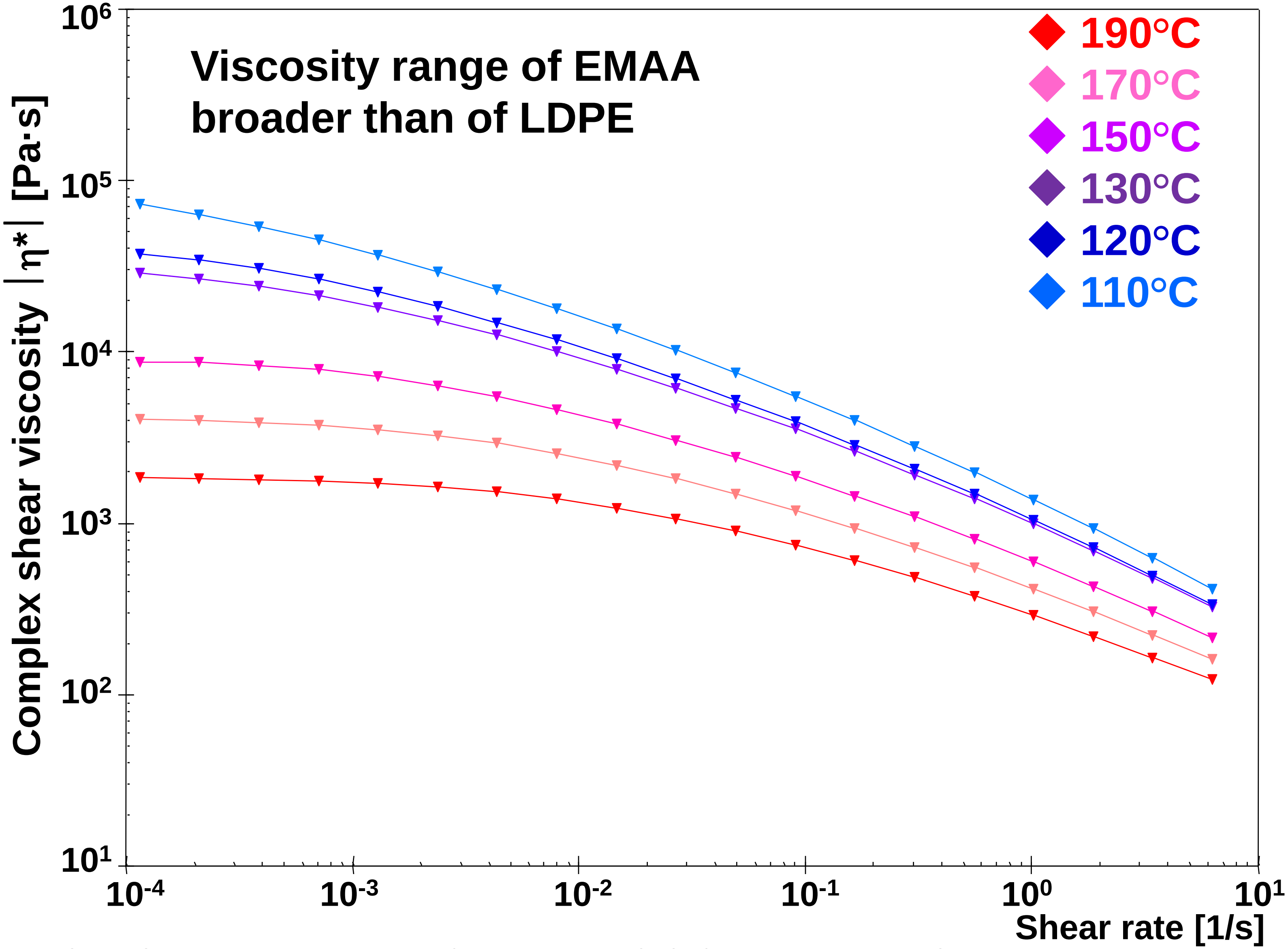
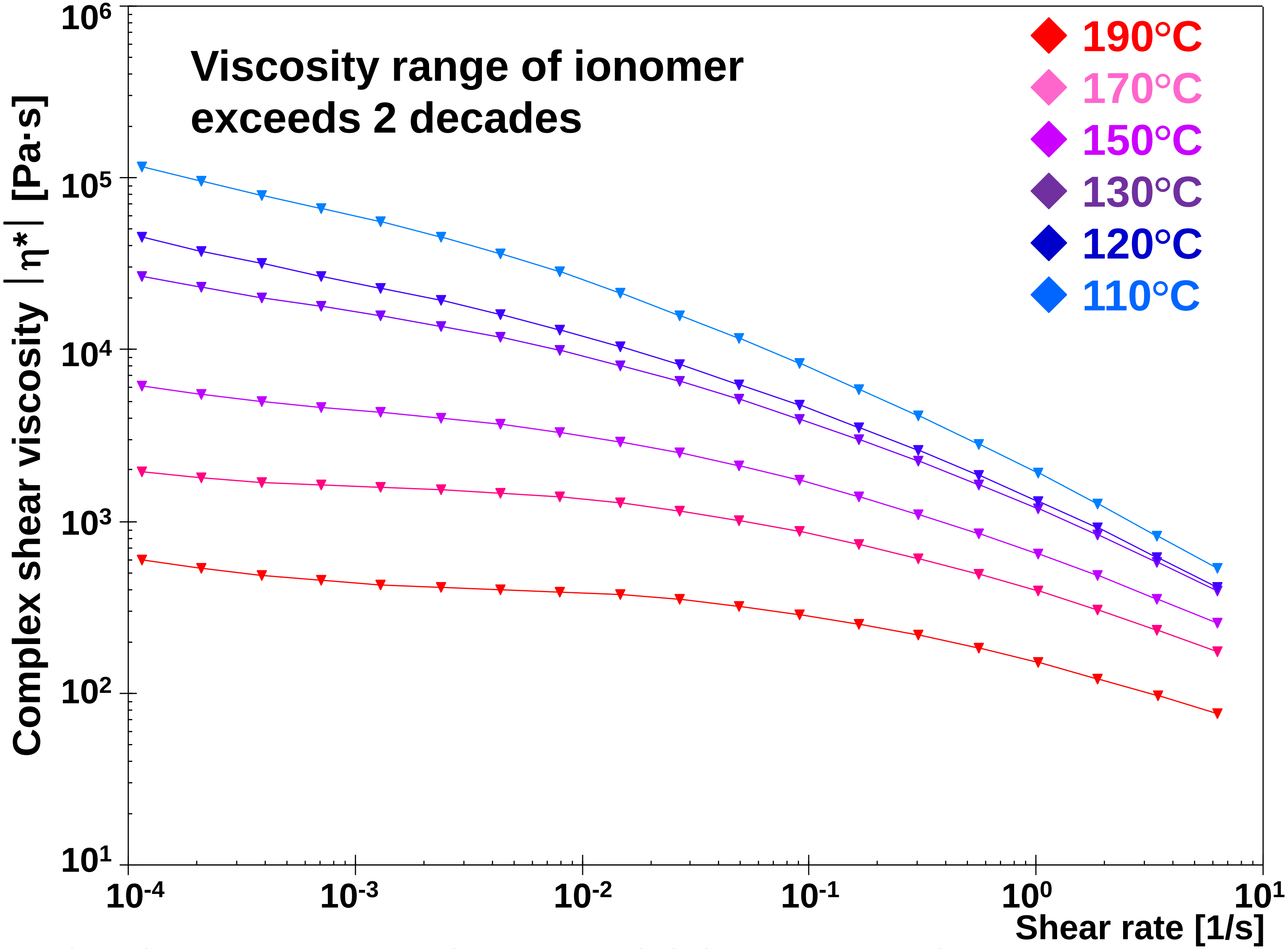
Viscosity curves of LDPE (MI 14) between 190°C and 110°C



Viscosity curves of EMAA (MI 8) between 190°C and 110°C



Viscosity curves of ionomer (MI 14) between 190°C and 110°C



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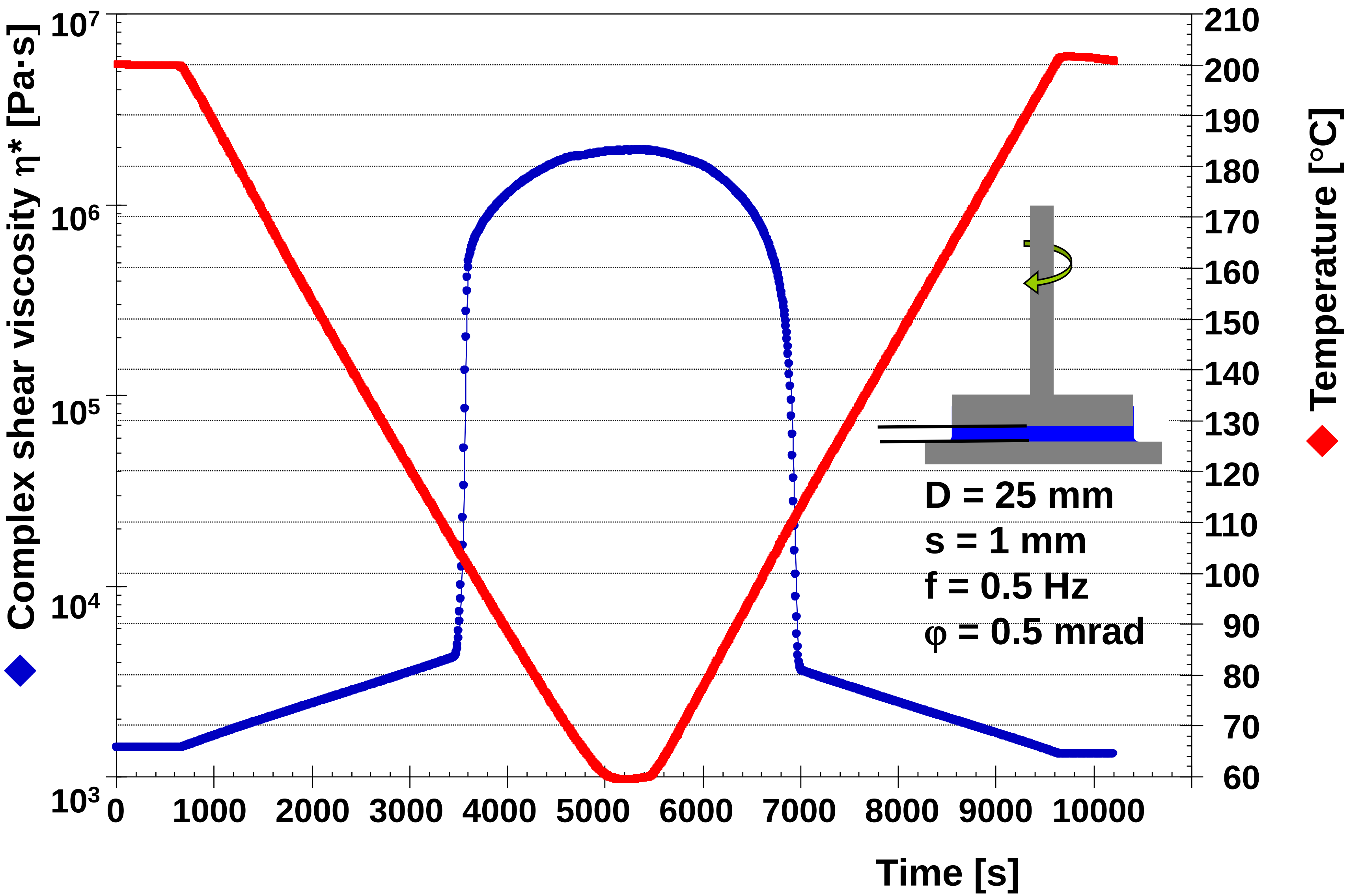
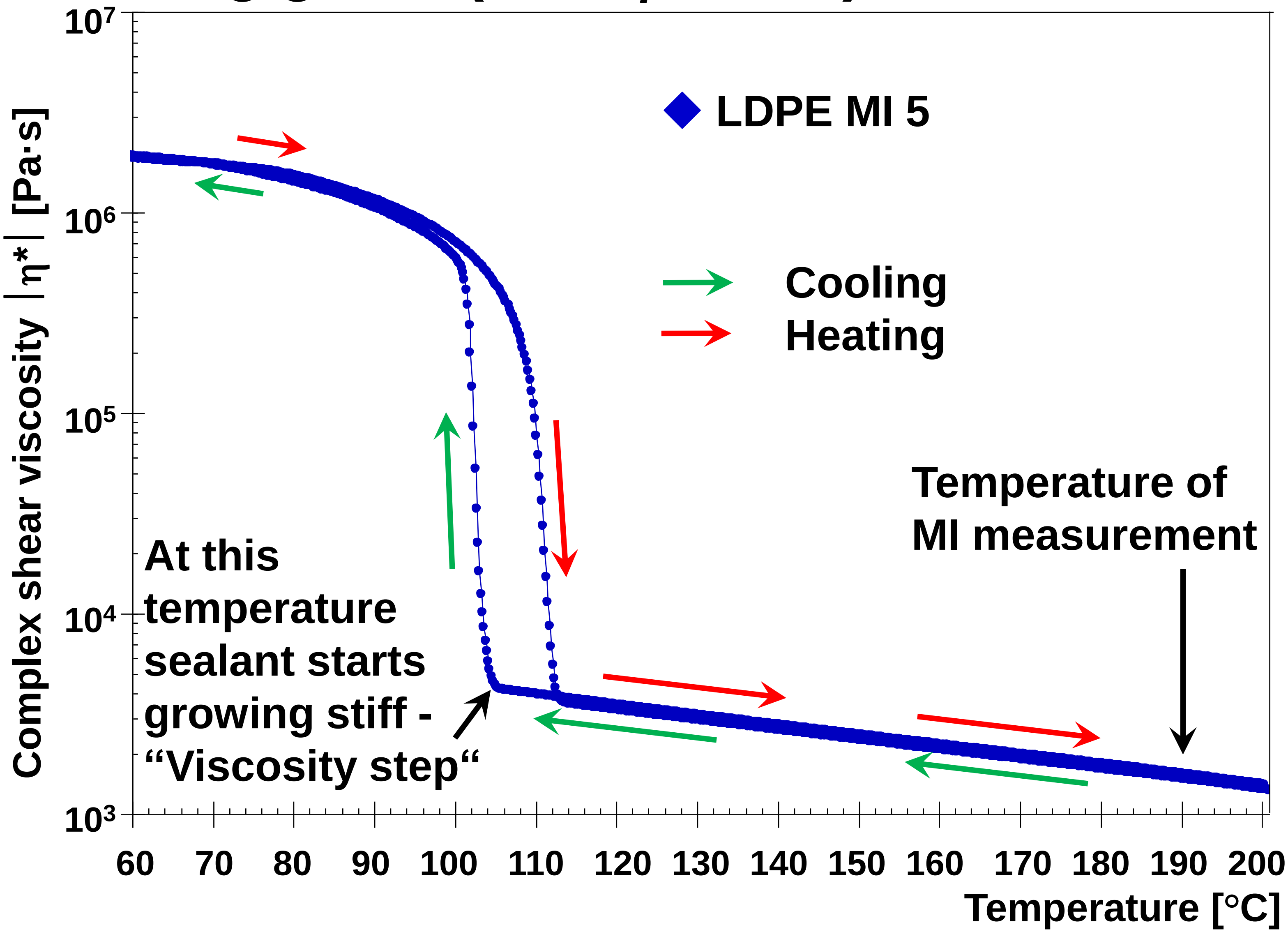
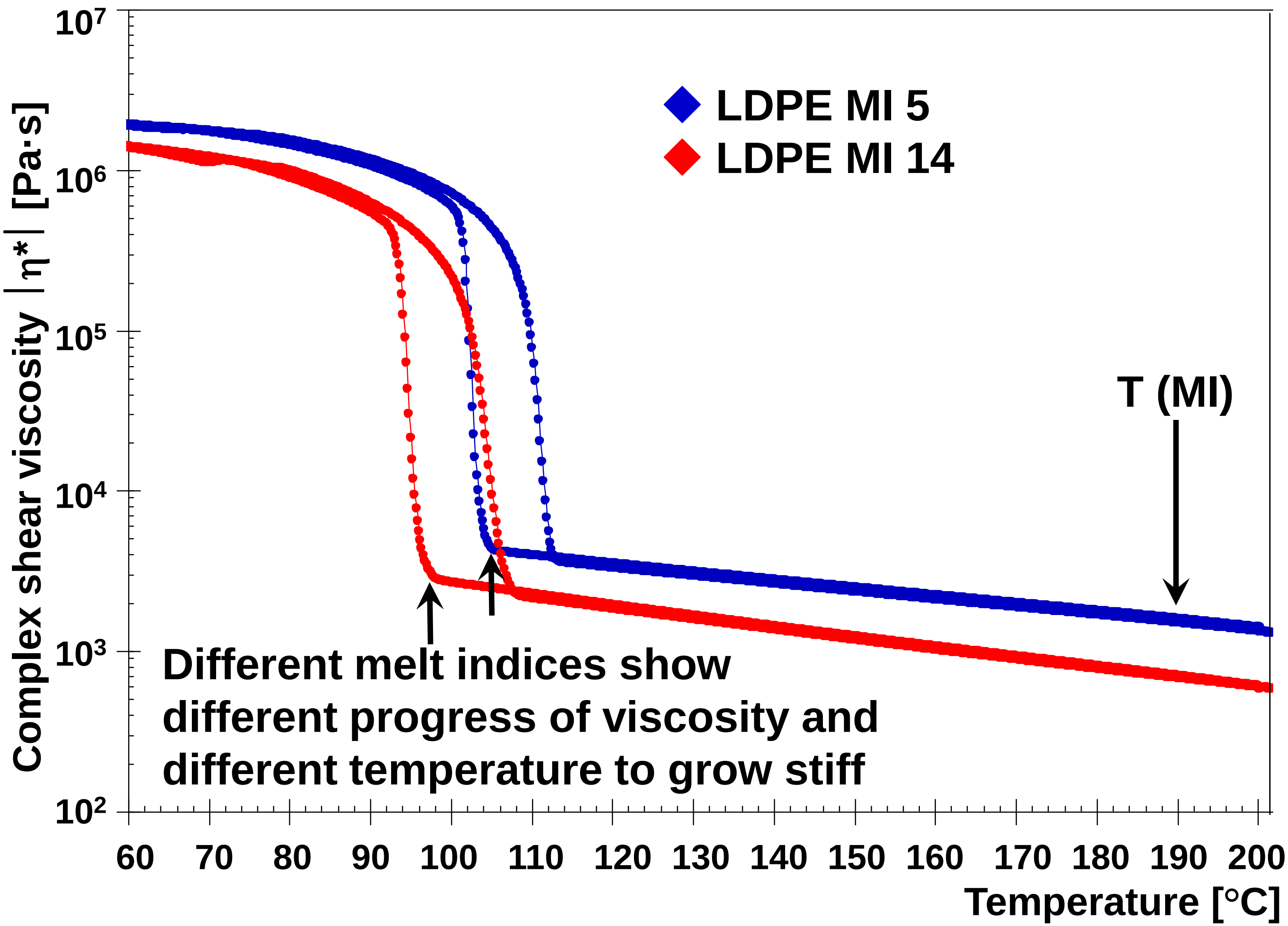
Temperature sweep of an LDPE (MI 5)



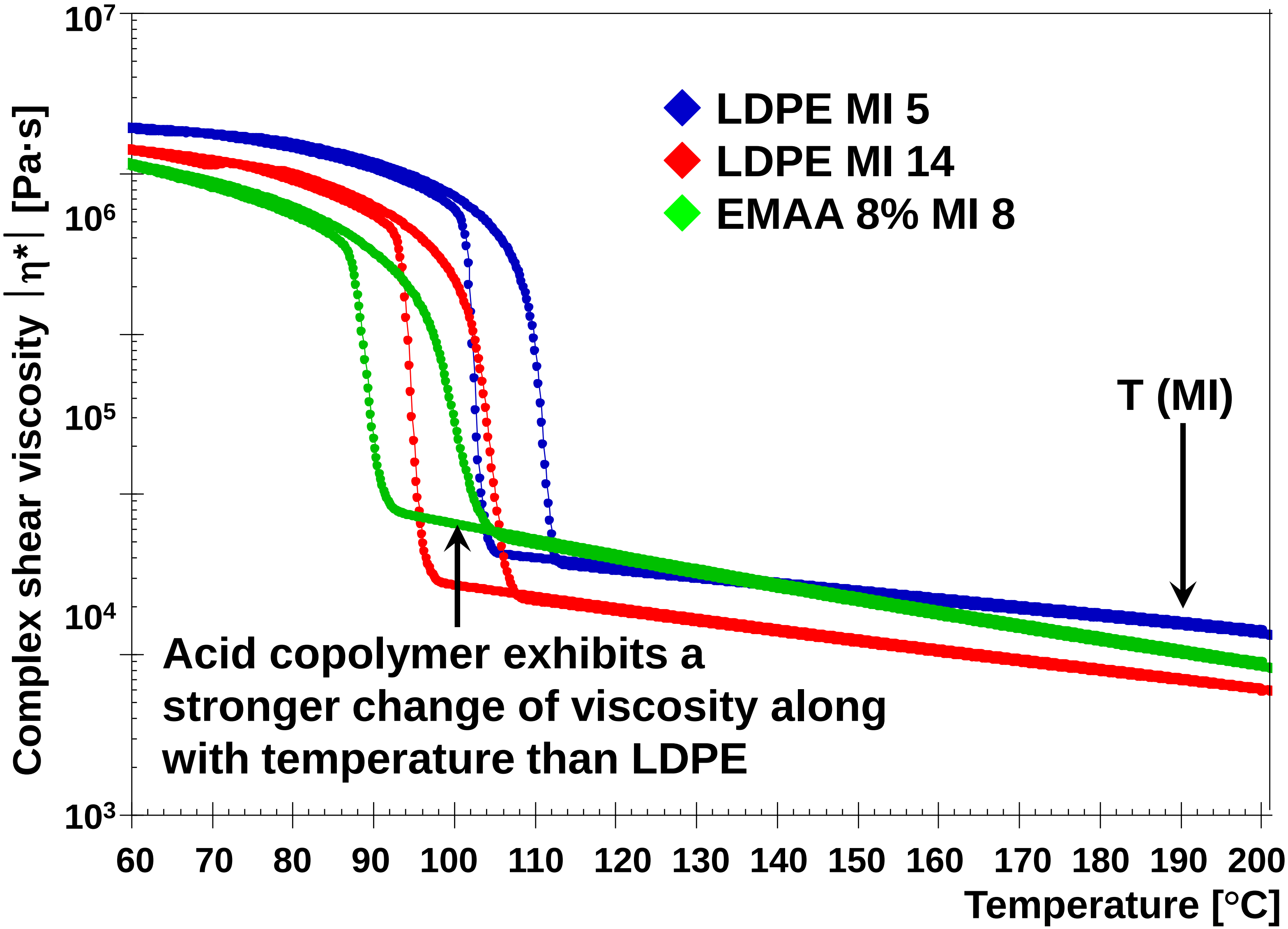
Temperature sweep of an LDPE extrusion coating grade (MI 5, ρ 0.923)



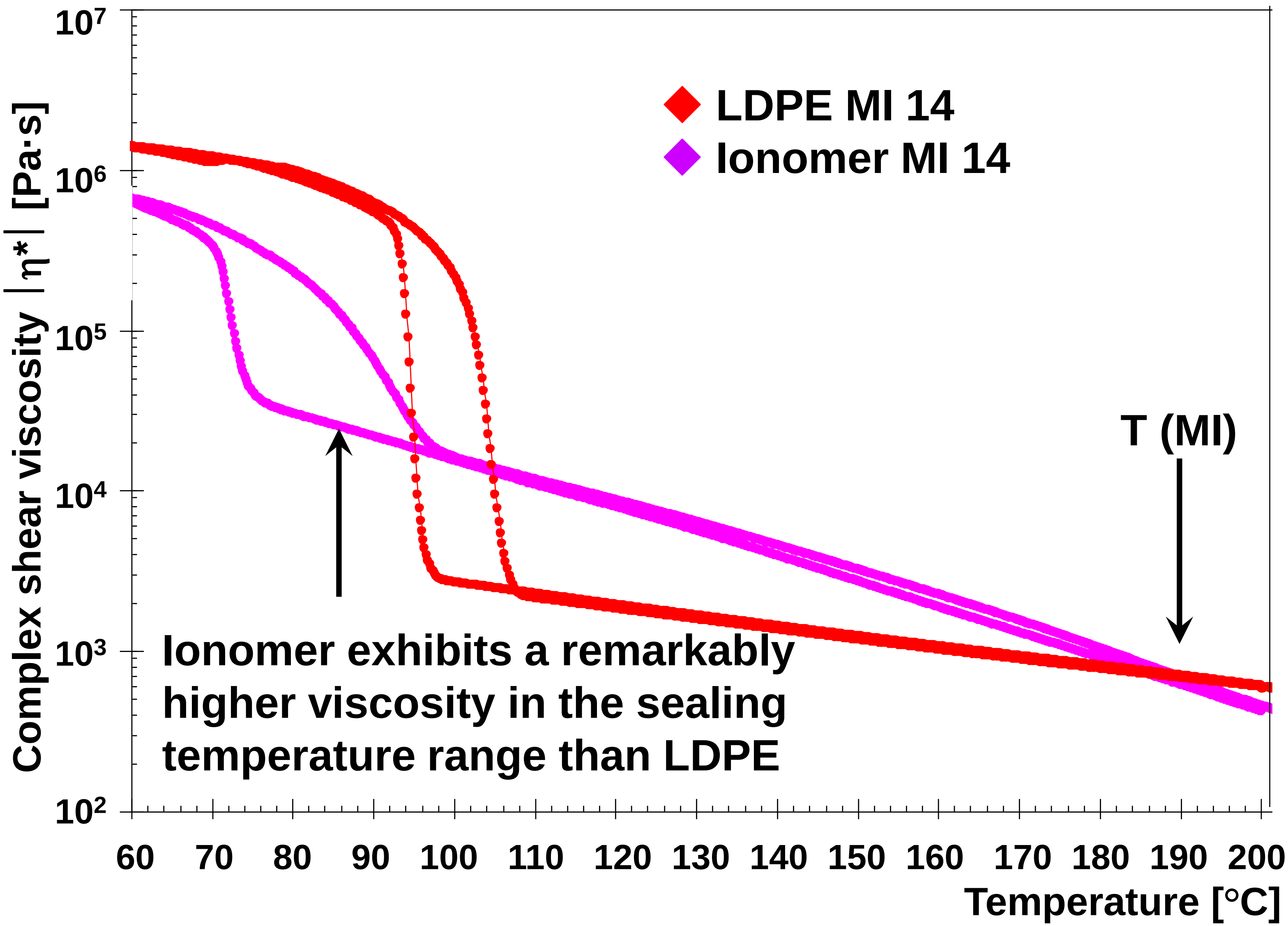
Temperature sweep of LDPE coating grades (MI 5, ρ 0.923 and MI 14, ρ 0.918)



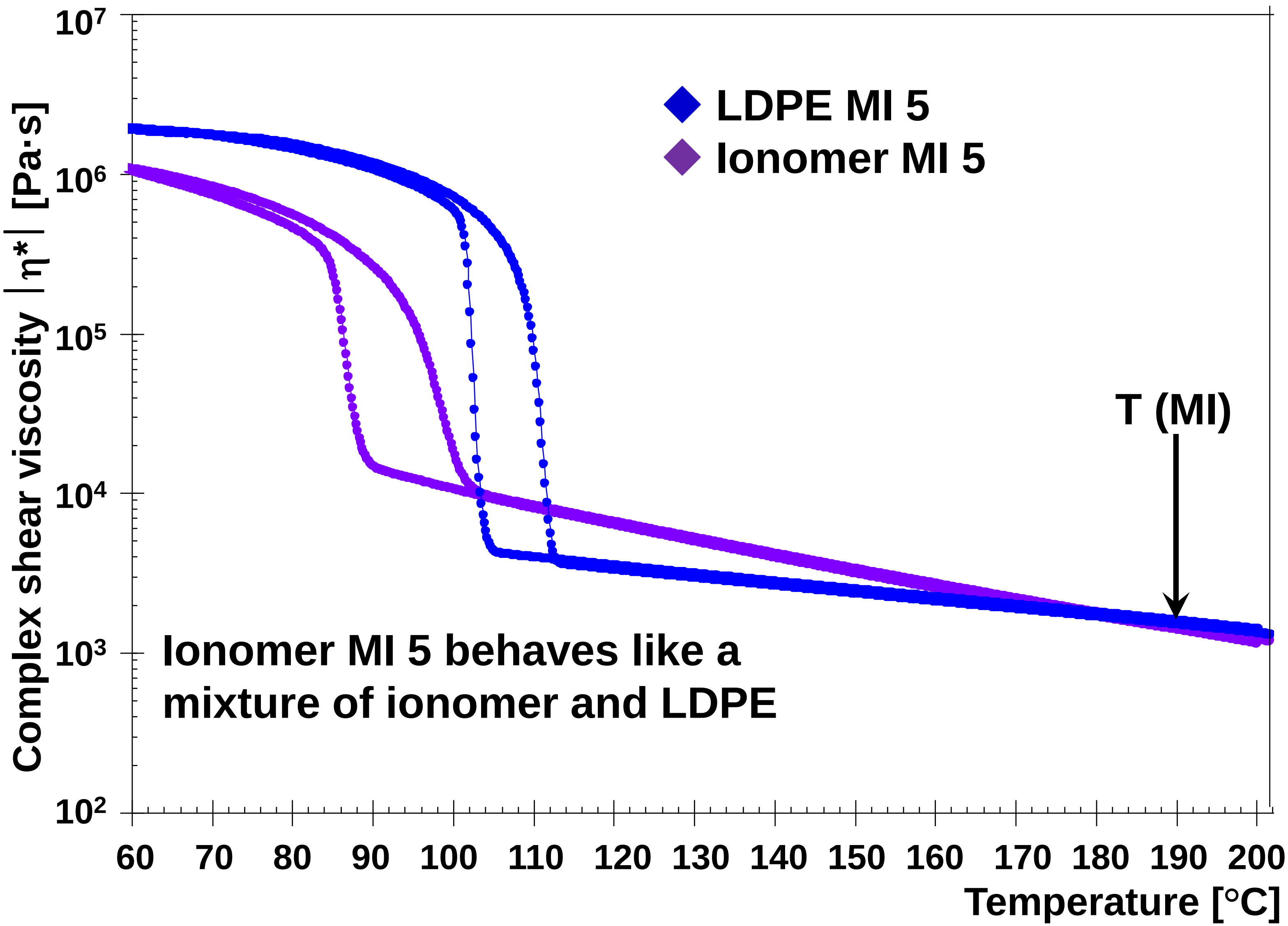
Temperature sweep of LDPE coating grades (MI 5 and MI 14) and EMAA 8% (MI 8)



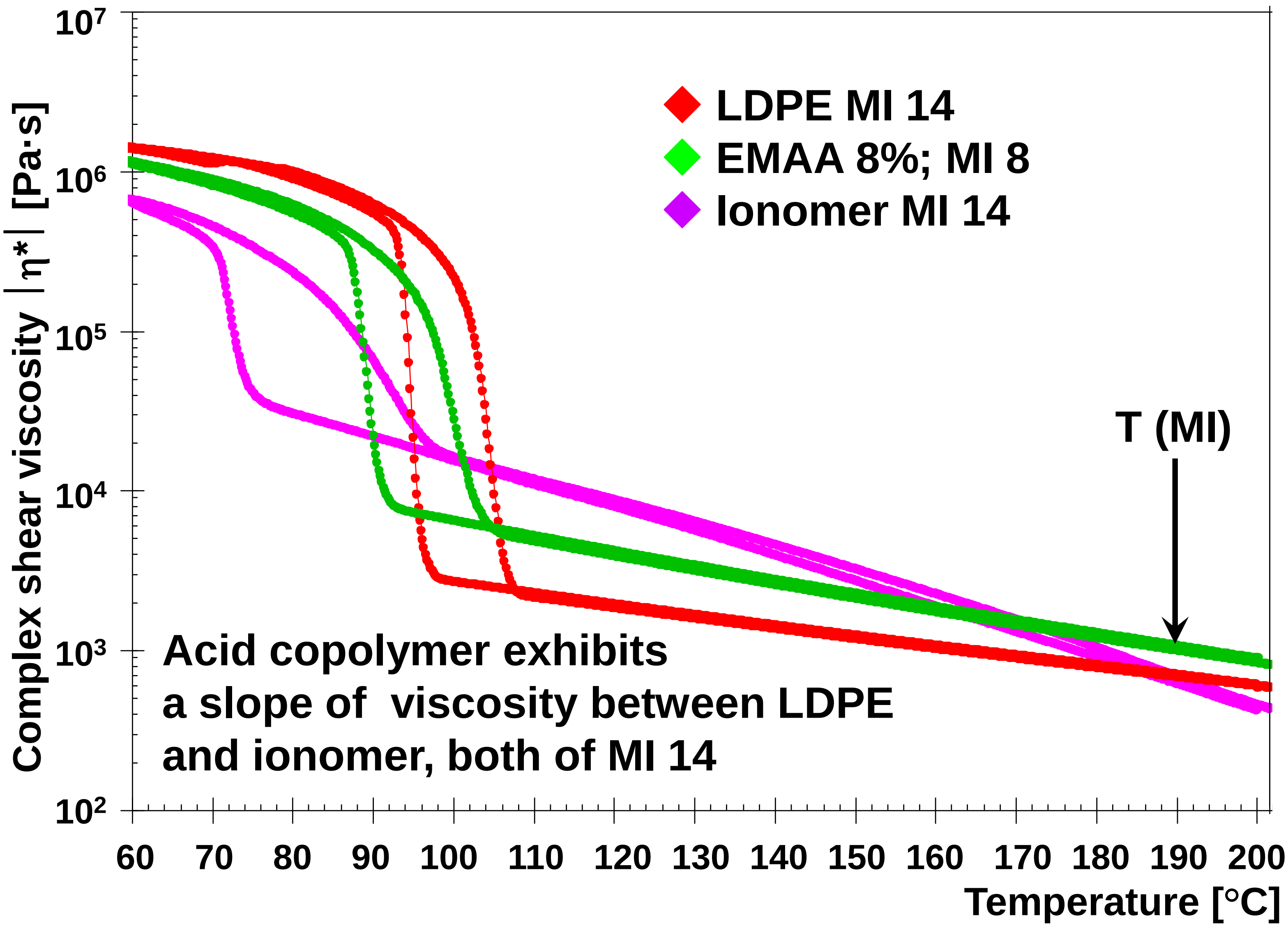
Temperature sweep of LDPE (MI 14, ρ 0.918) and ionomer (MI 14, ρ 0.938)



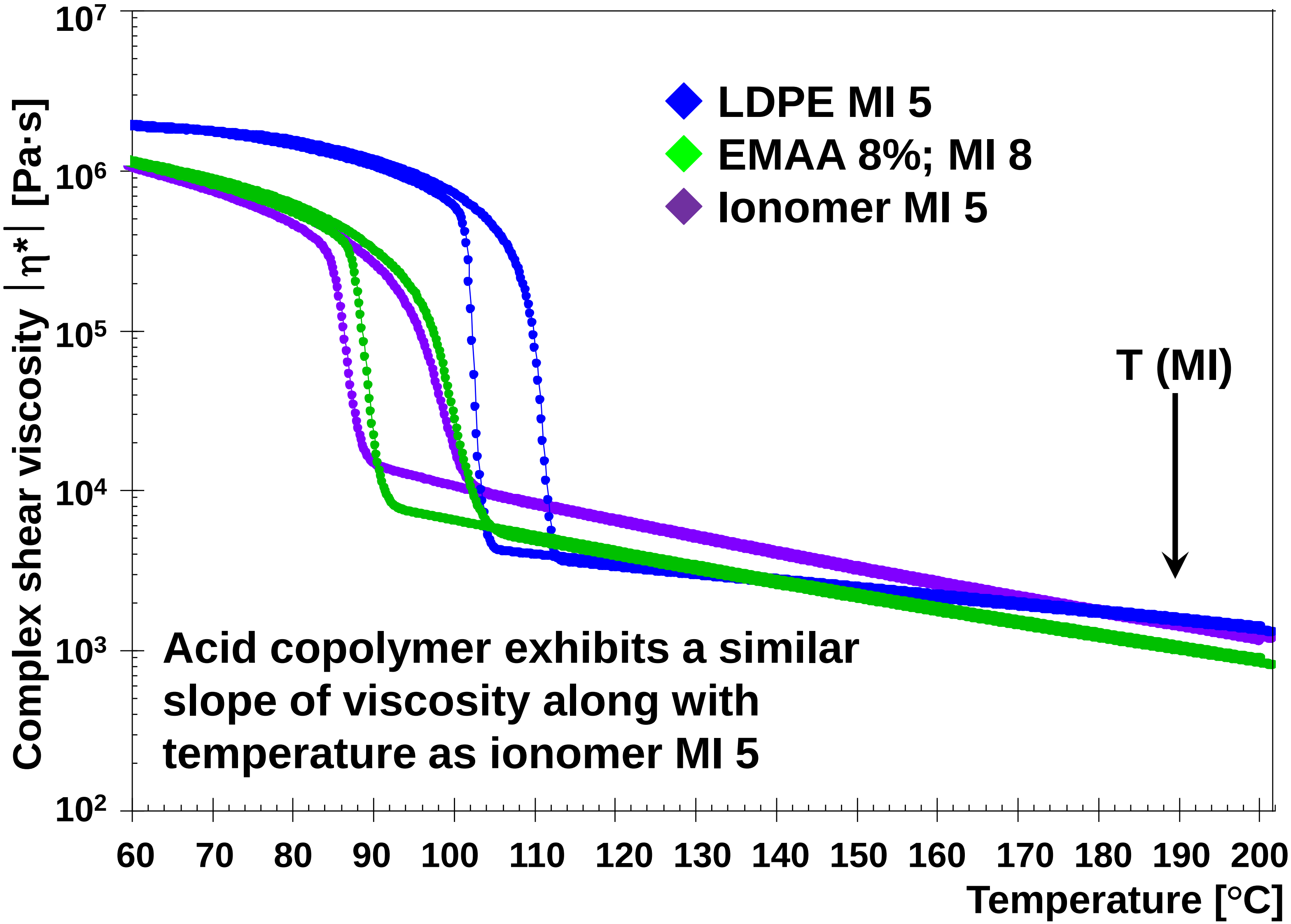
Temperature sweep of LDPE (MI 5, ρ 0.923) and ionomer (MI 5, ρ 0.939)



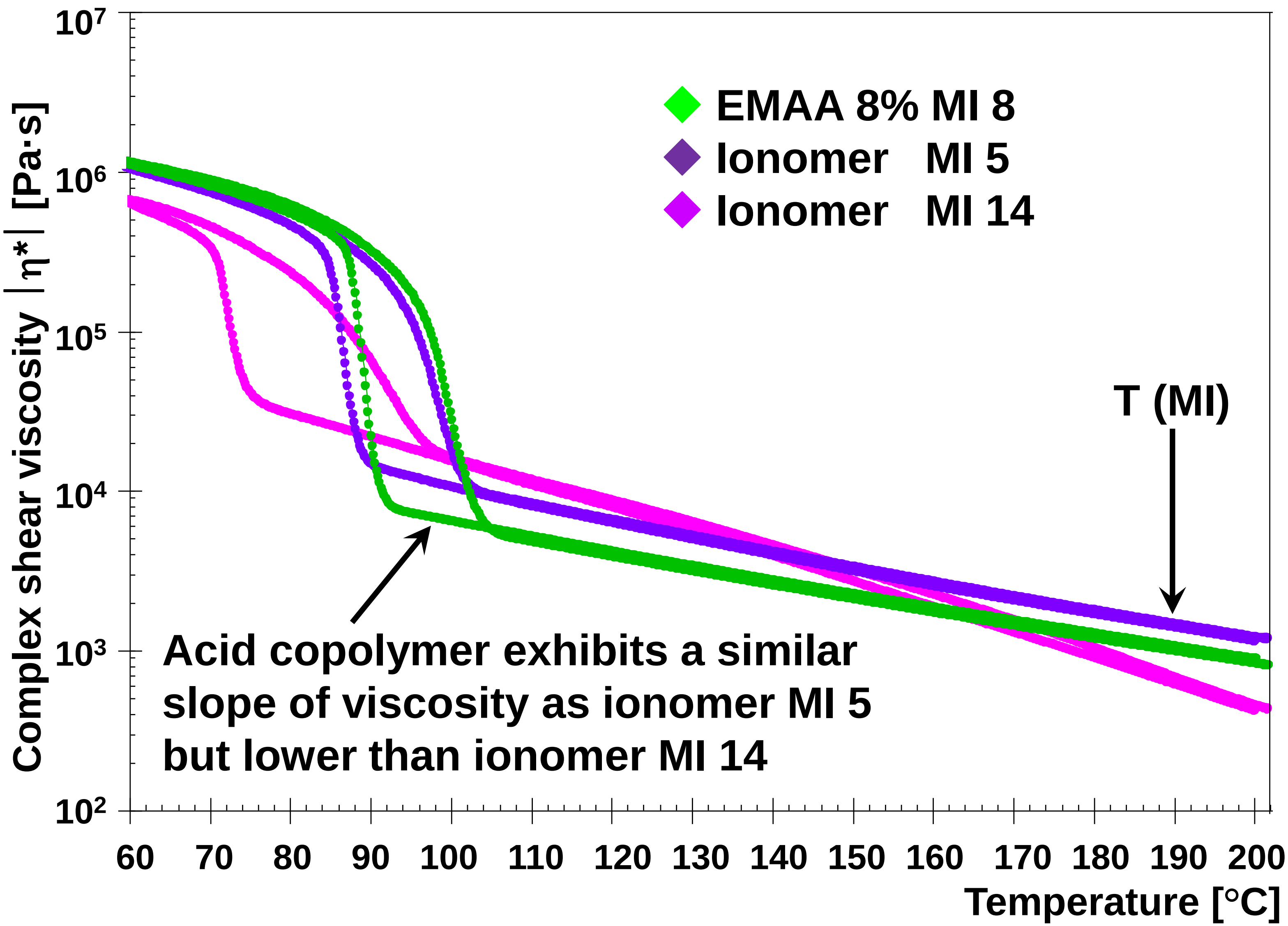
Temperature sweep of LDPE (MI 14, ρ 0.918), ionomer (MI 14, ρ 0.939) and EMAA (MI 8, ρ 0.938)



Temperature sweep of LDPE and ionomer (both MI 5) and an acid copolymer (MI 8)



Temperature sweep of LDPE and ionomer (both MI 5) and an acid copolymer (MI 8)



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Melt tack procedure in principle

Principle:

Lifting the upper geometry, here plate with a constant speed

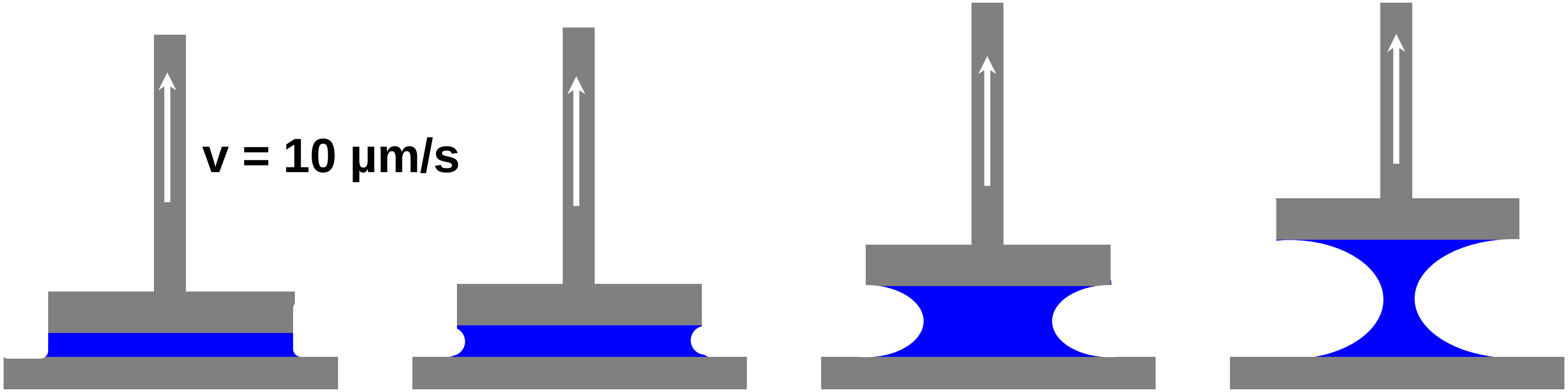
Monitoring the normal force along with the plate/plate distance at constant temperature

Plate D = 8 mm

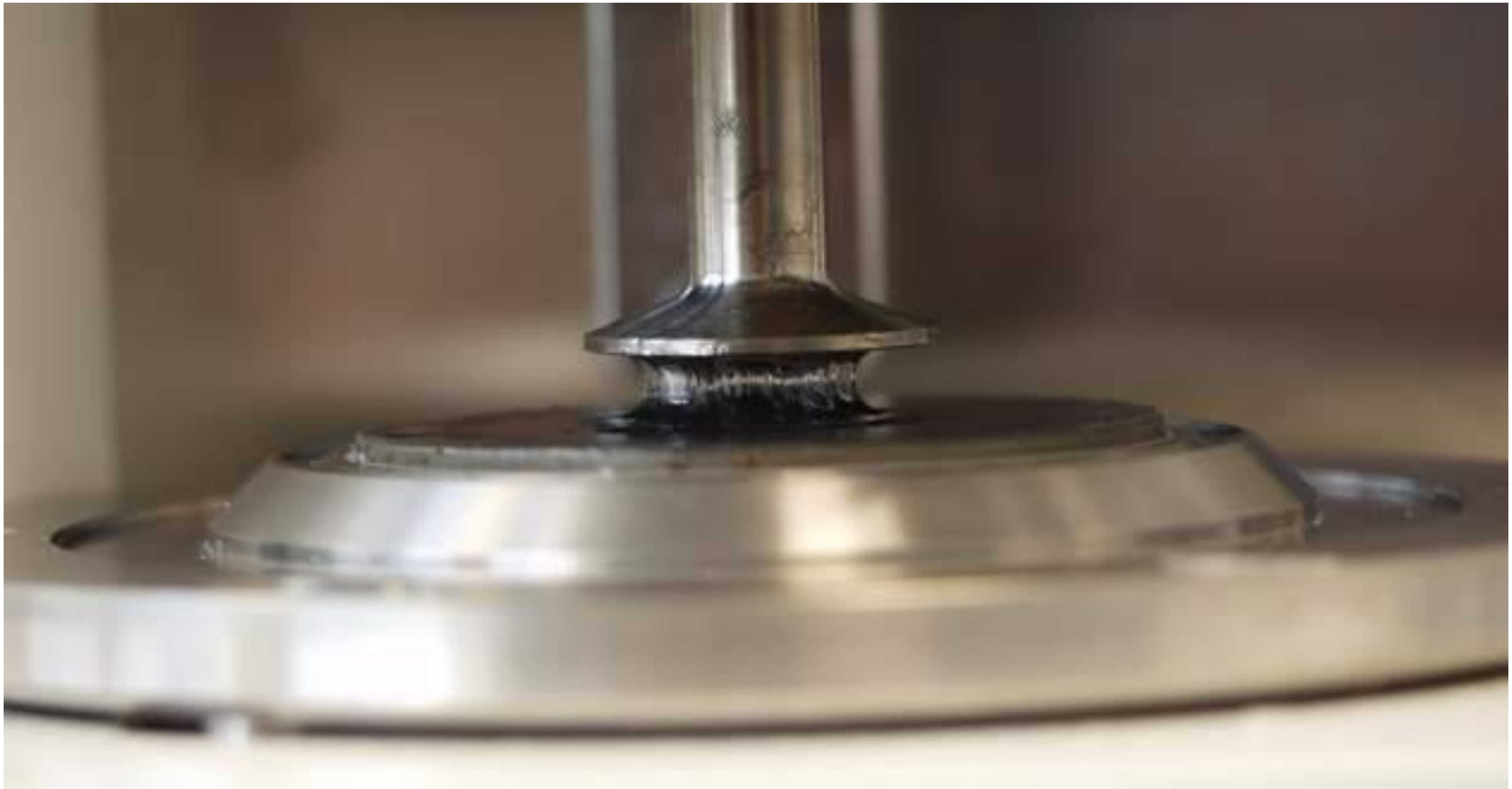
Initial gap = 0.4 mm

Final gap = 2 mm

Repeat the measurement in the desired temperature range

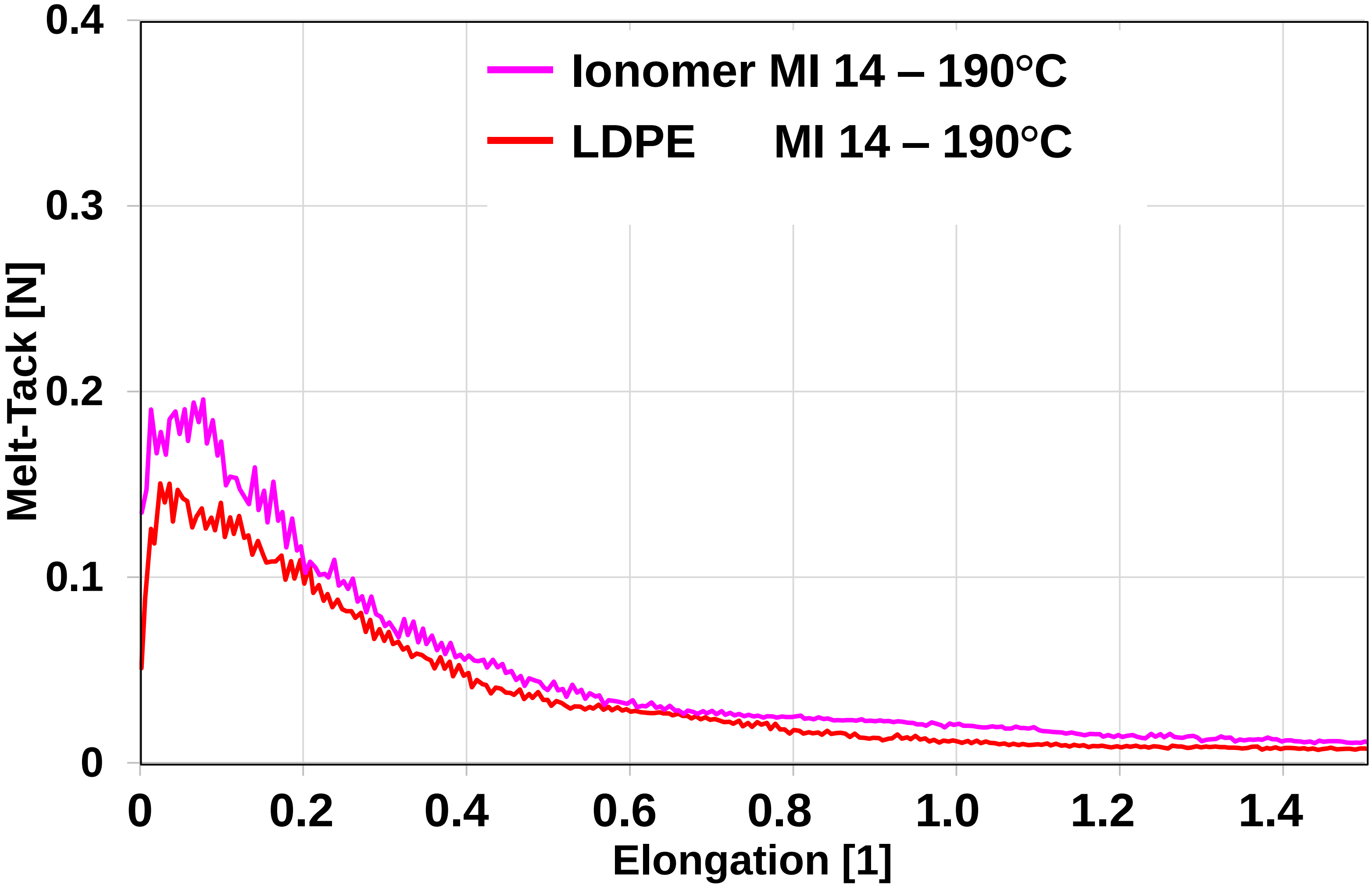


Melt tack sample after elongation at the final gap

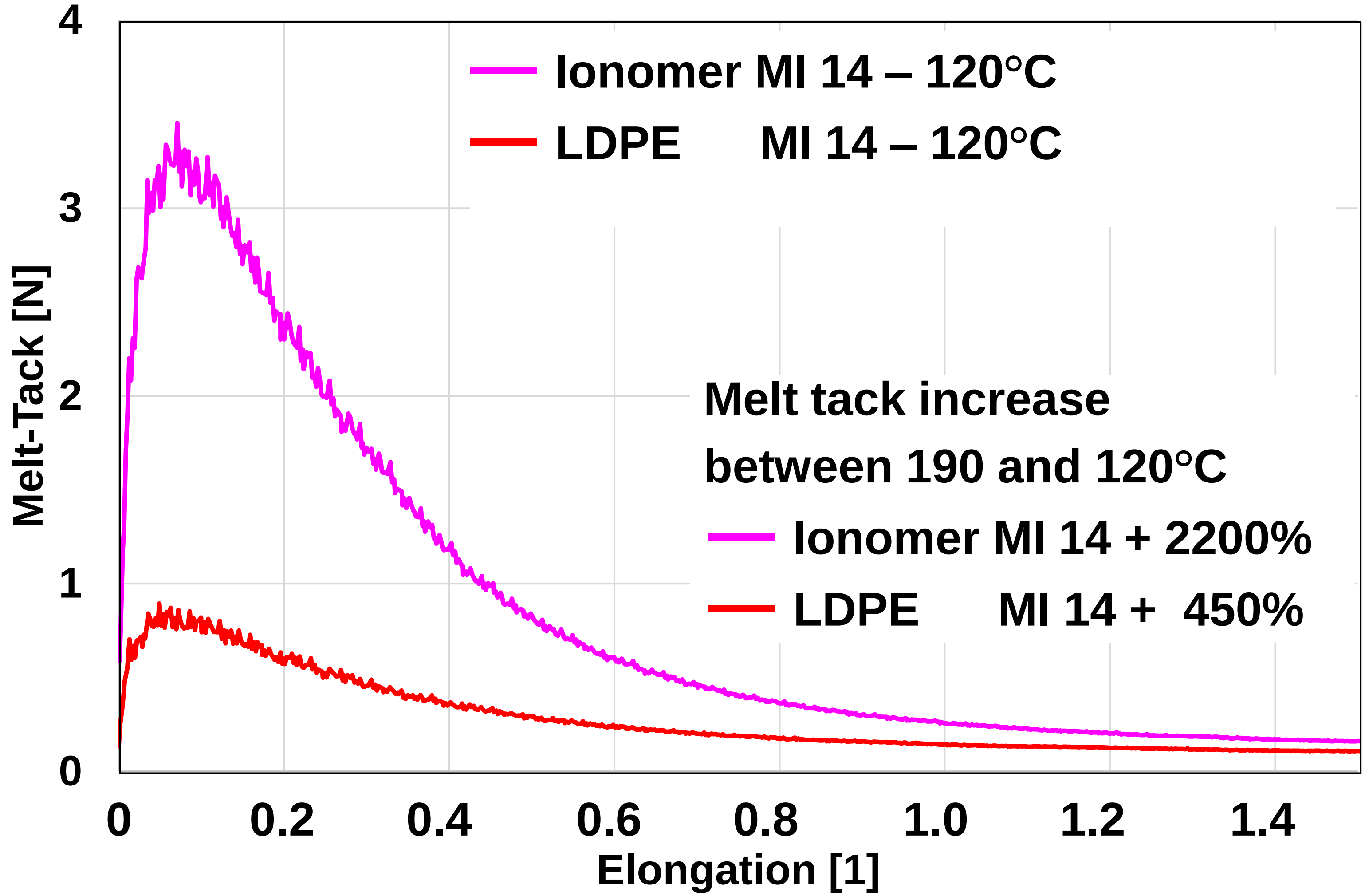


*** Plate/plate rheometer with melt**

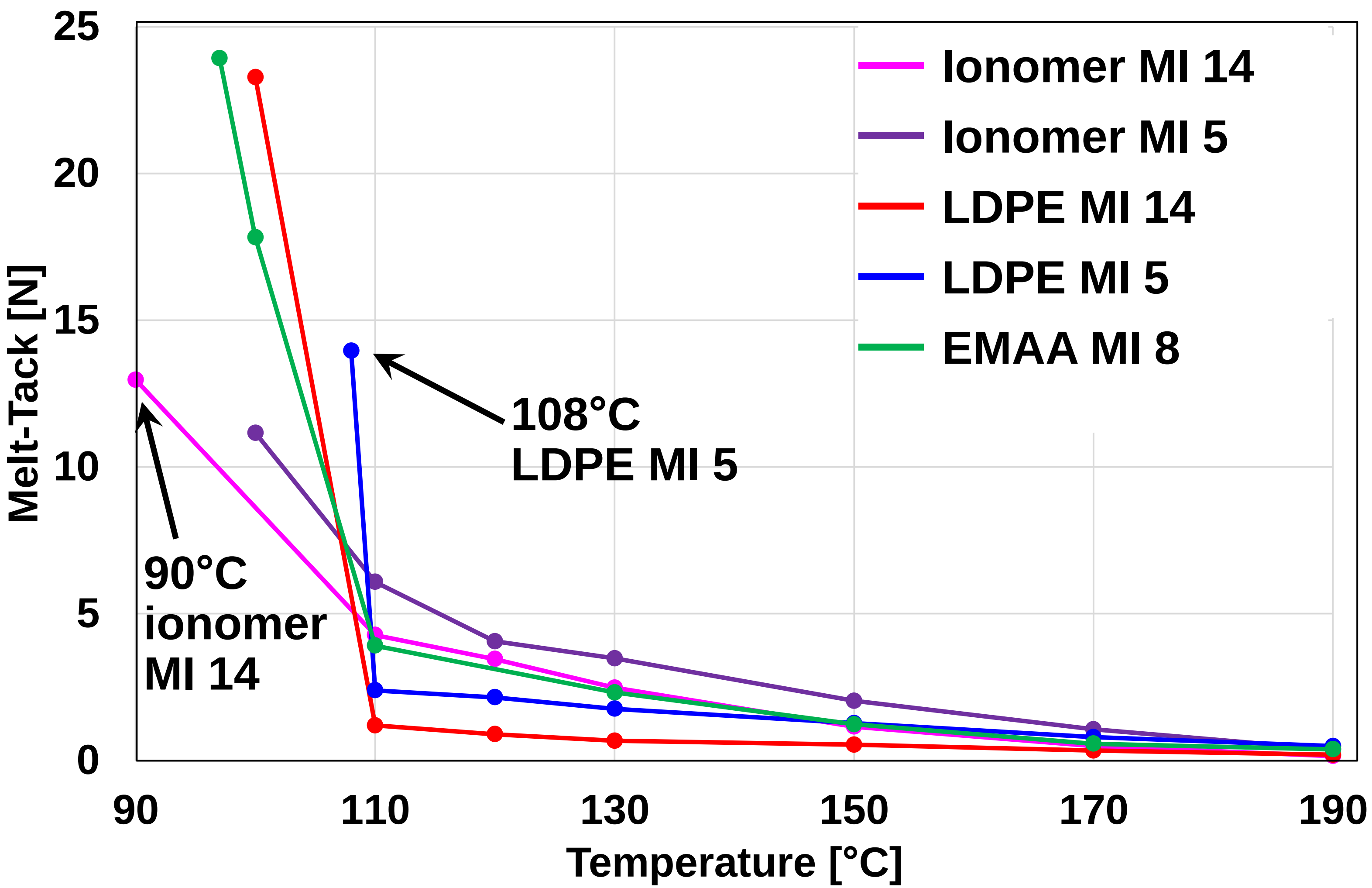
Comparison of the melt tack curve of ionomer (MI 14) and LDPE (MI 14) at 190°C



Comparison of the melt tack curve of ionomer (MI 14) and LDPE (MI 14) at 120°C



Comparison of the melt tack maxima between 190°C and 90°C



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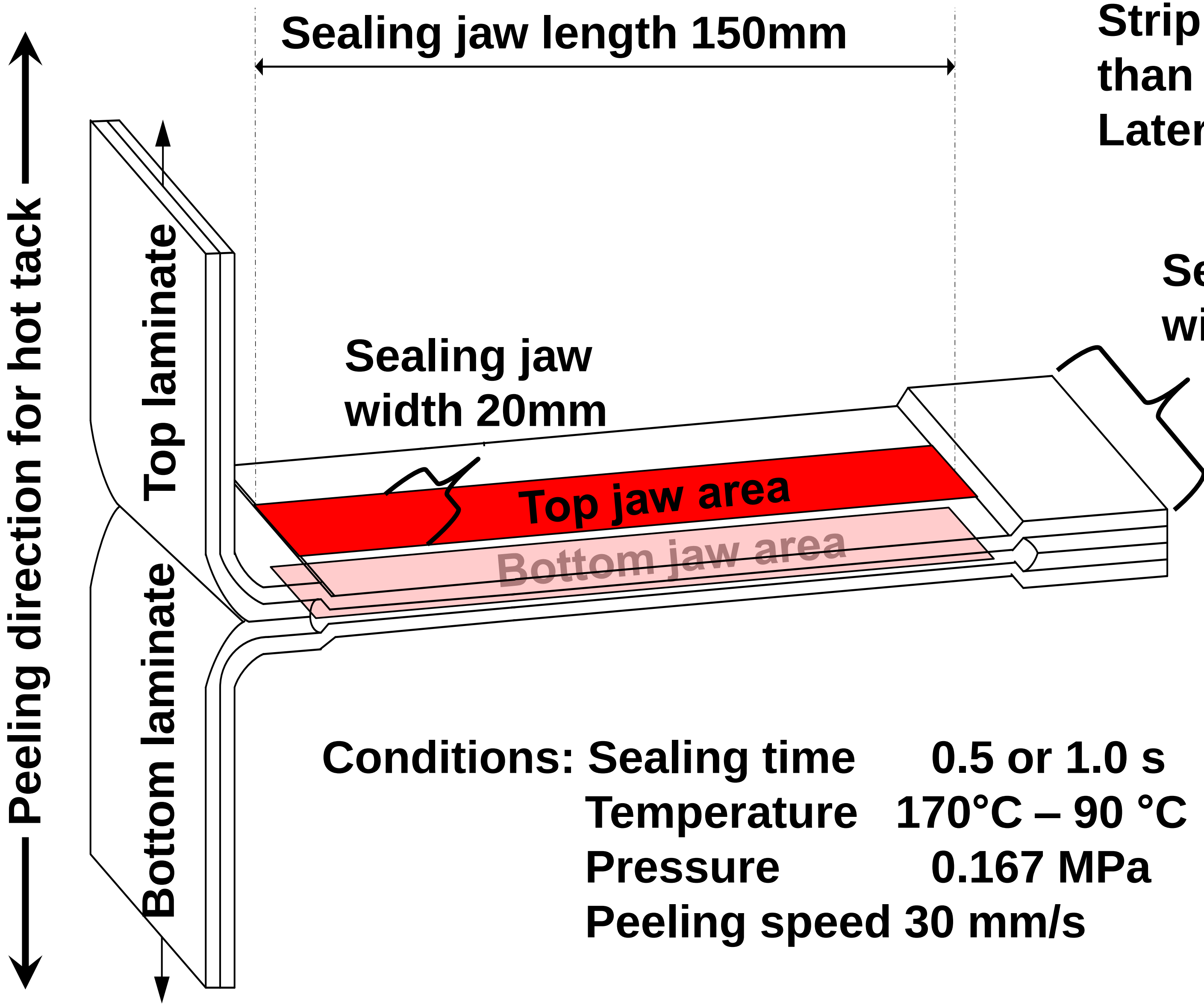
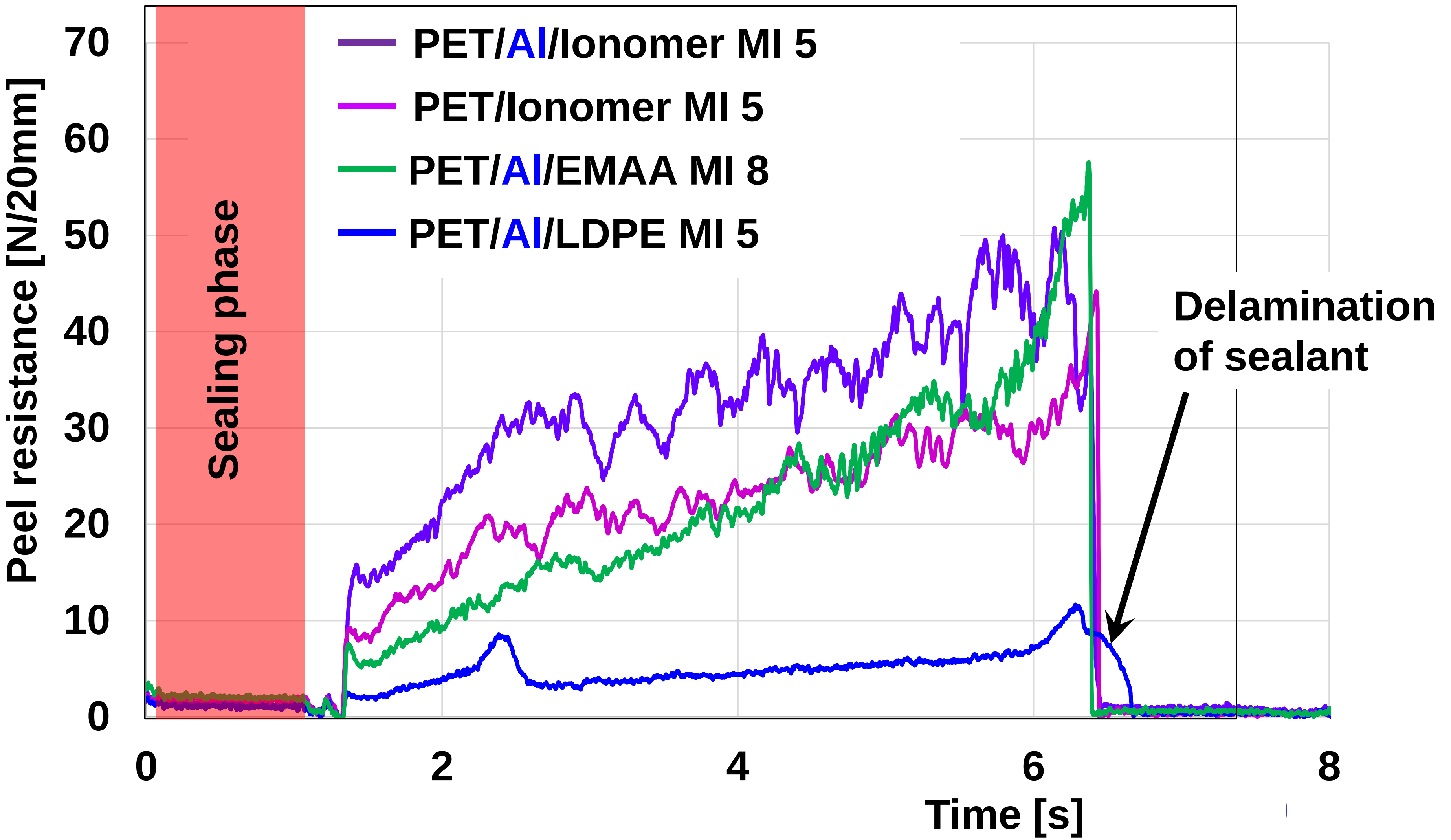
Hot tack peeling conditions



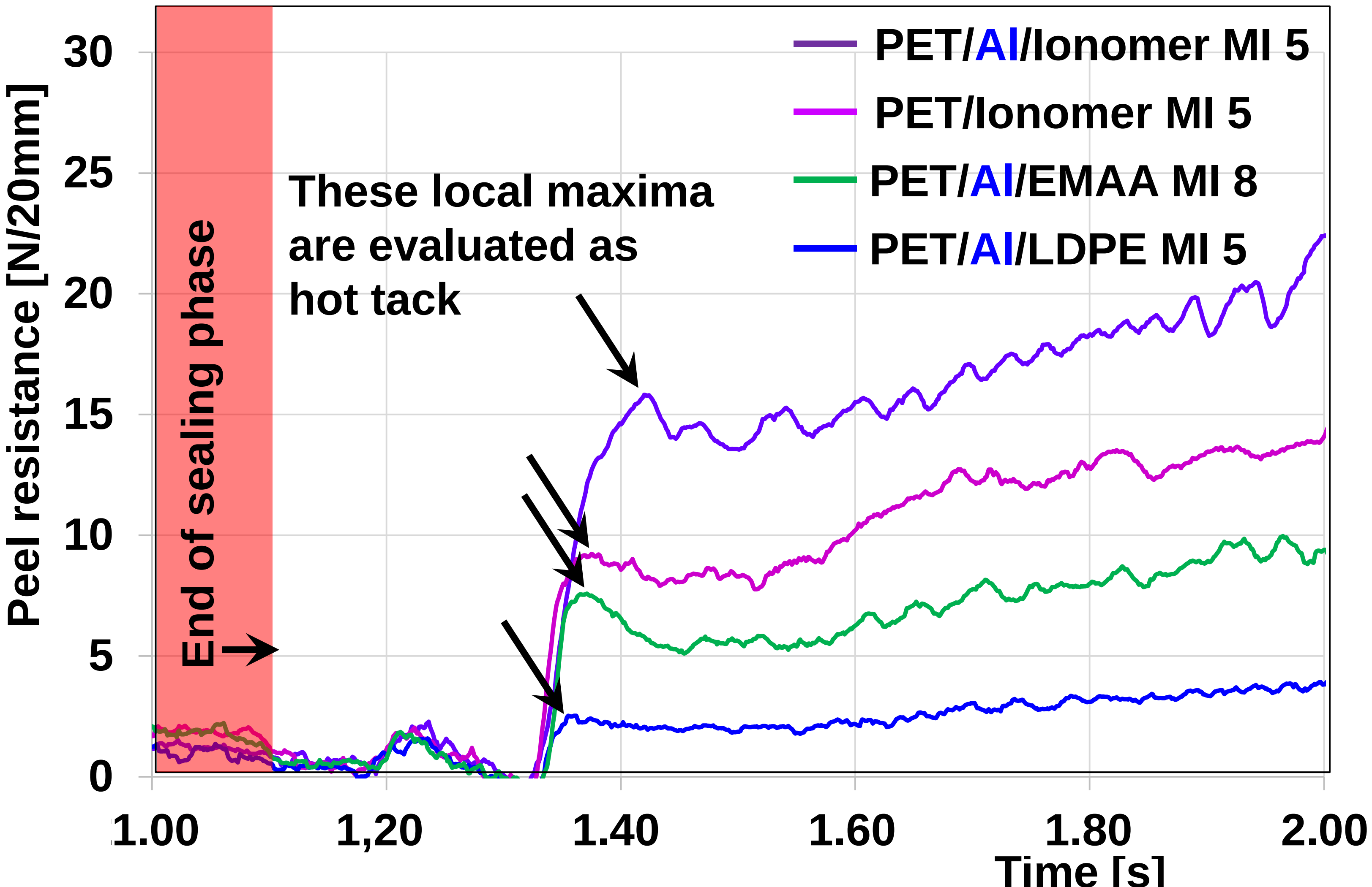
Strip is wider than the jaws – Lateral cooling

Conditions: Sealing time 0.5 or 1.0 s
Temperature 170°C – 90 °C
Pressure 0.167 MPa
Peeling speed 30 mm/s

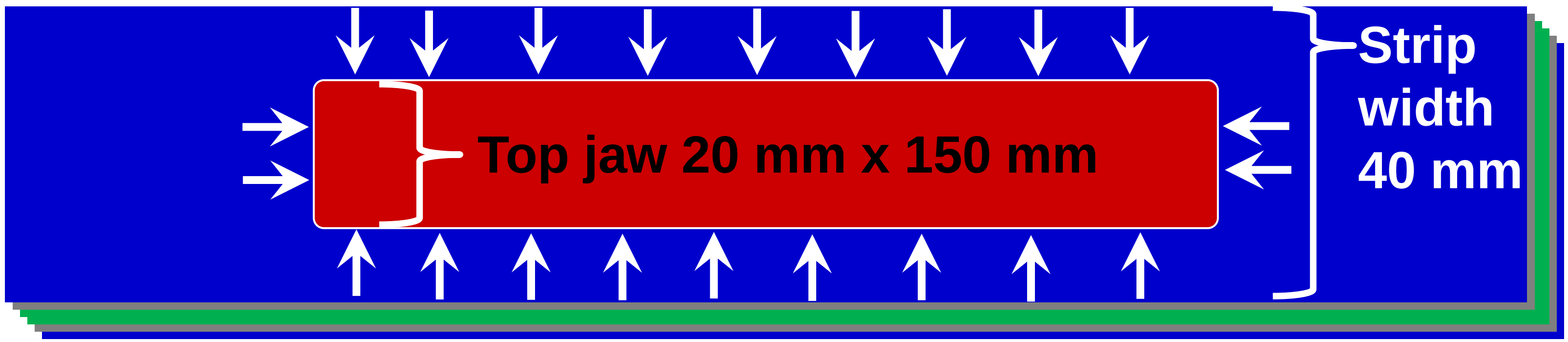
Hot tack curves of different sealants in aluminium laminates (120°C - 1s - 0.167 MPa)



Hot tack curves (detail) of different sealants in aluminium laminates (120°C - 1s - 0.167 MPa)

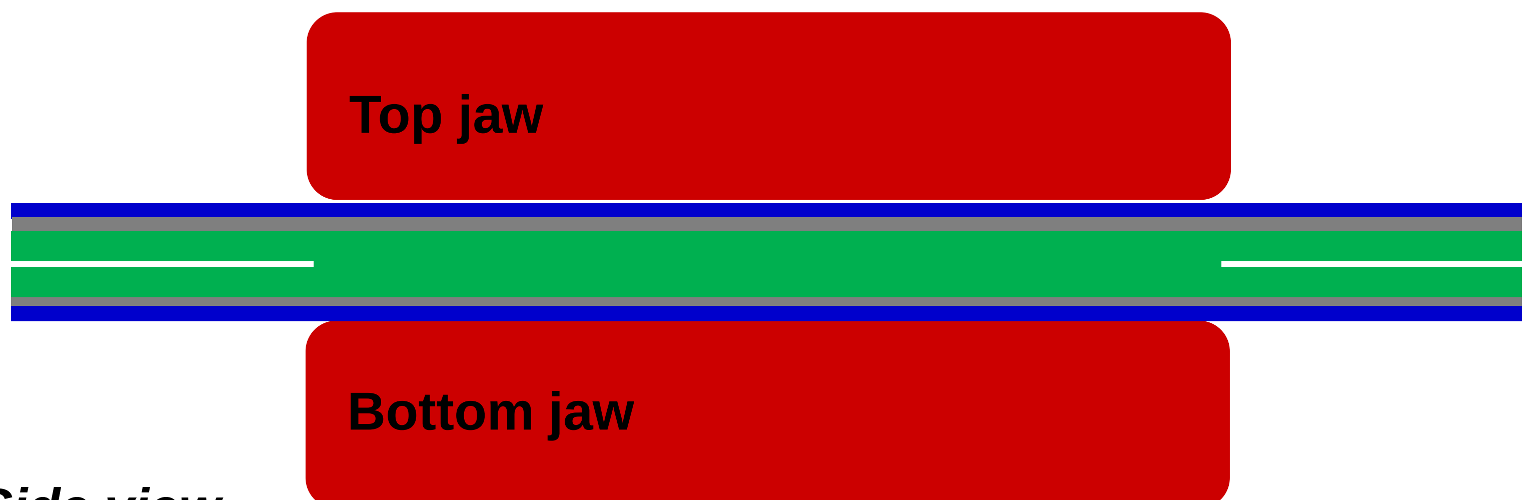


Sealing geometry for hot tack measurement - Strip is wider than the jaws – Lateral cooling



Top view

Lateral cooling (edge effect), similar to situation in a packaging machine



Side view

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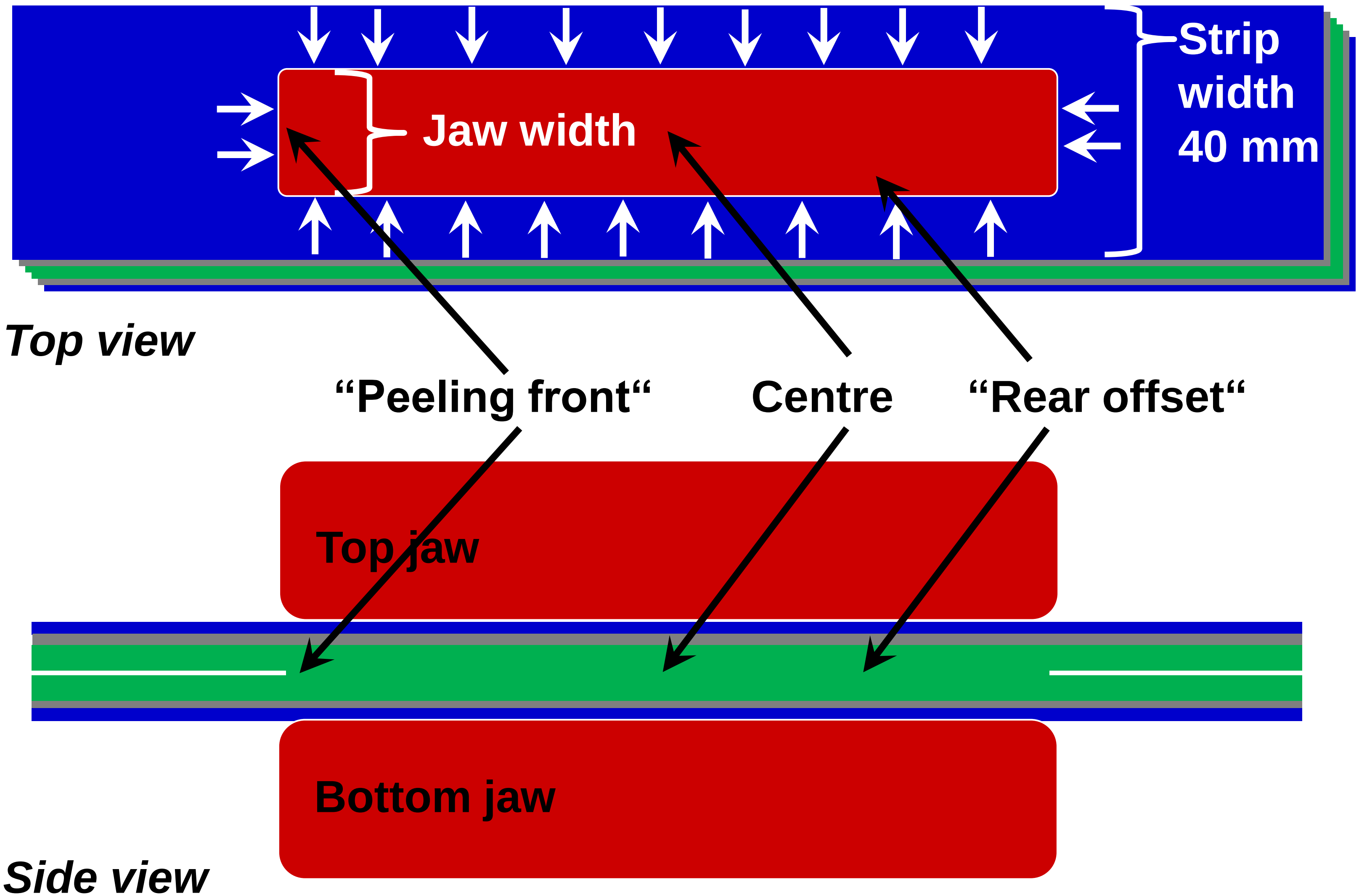
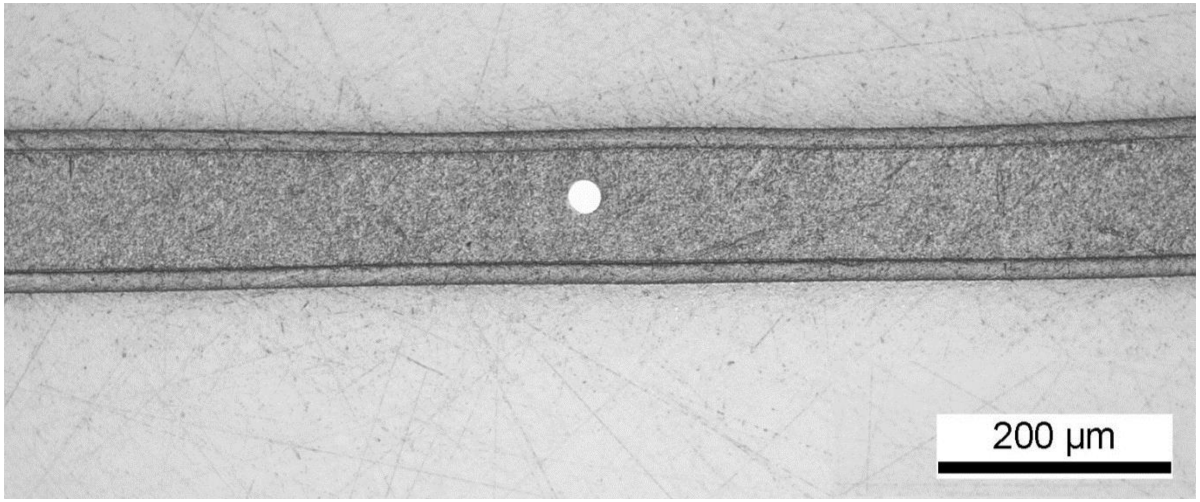
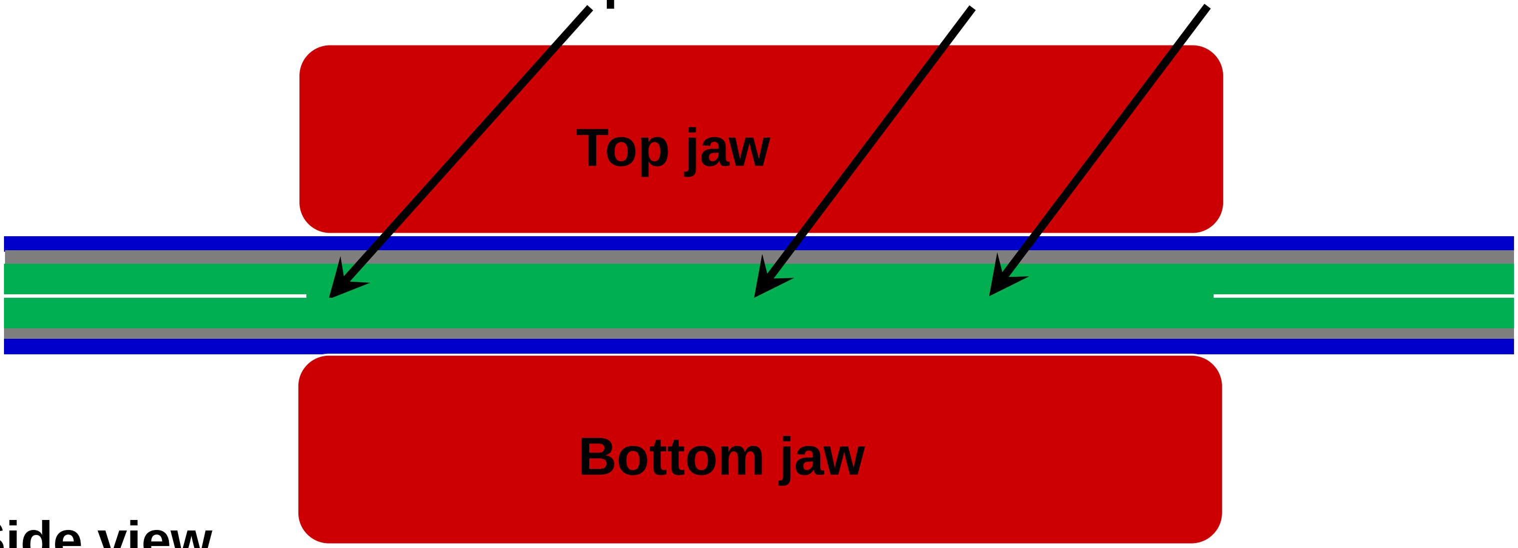
Sealing geometry for hot tack measurement – Positioning of thermocouples



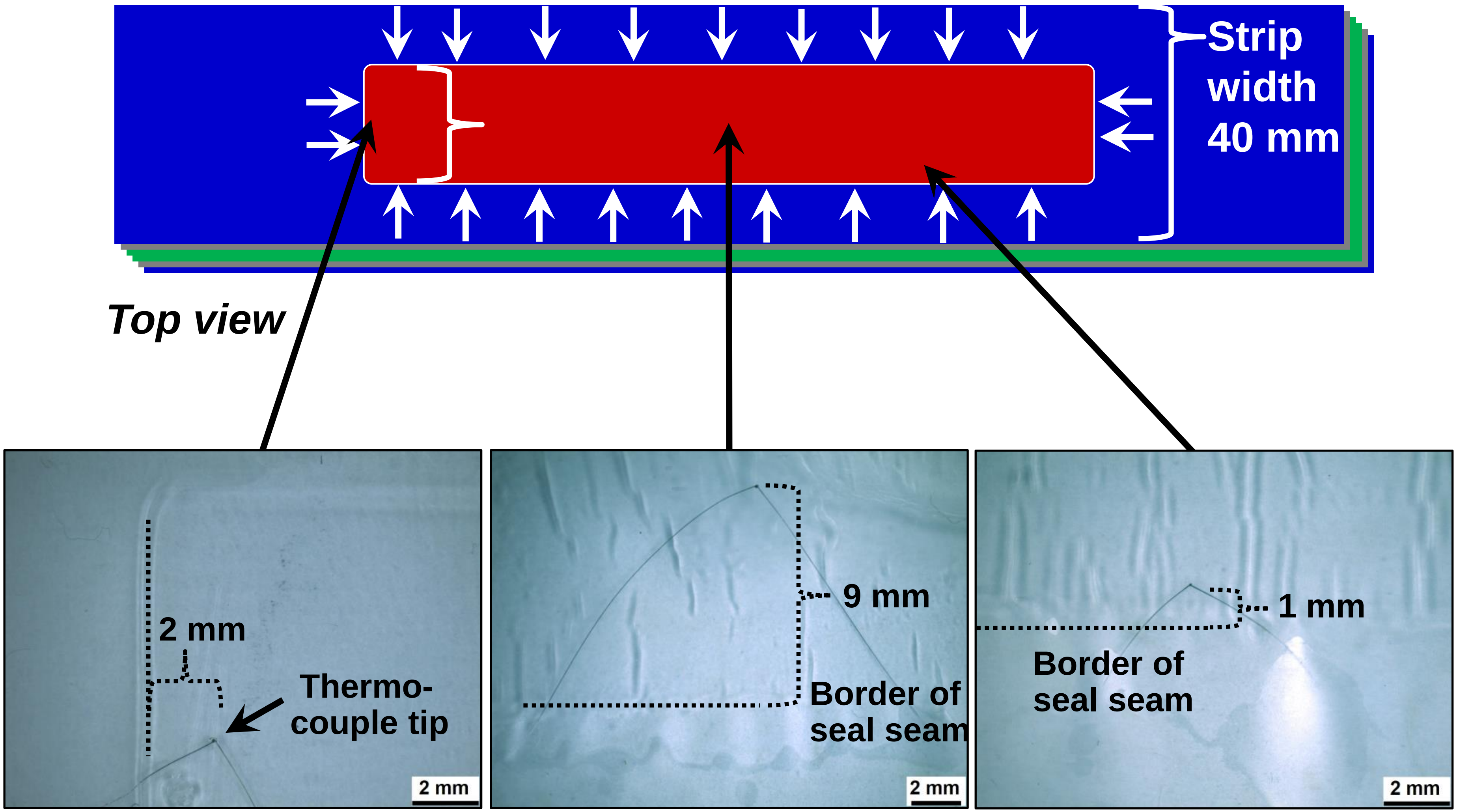
Thermocouple wire - Embedded in a seal seam



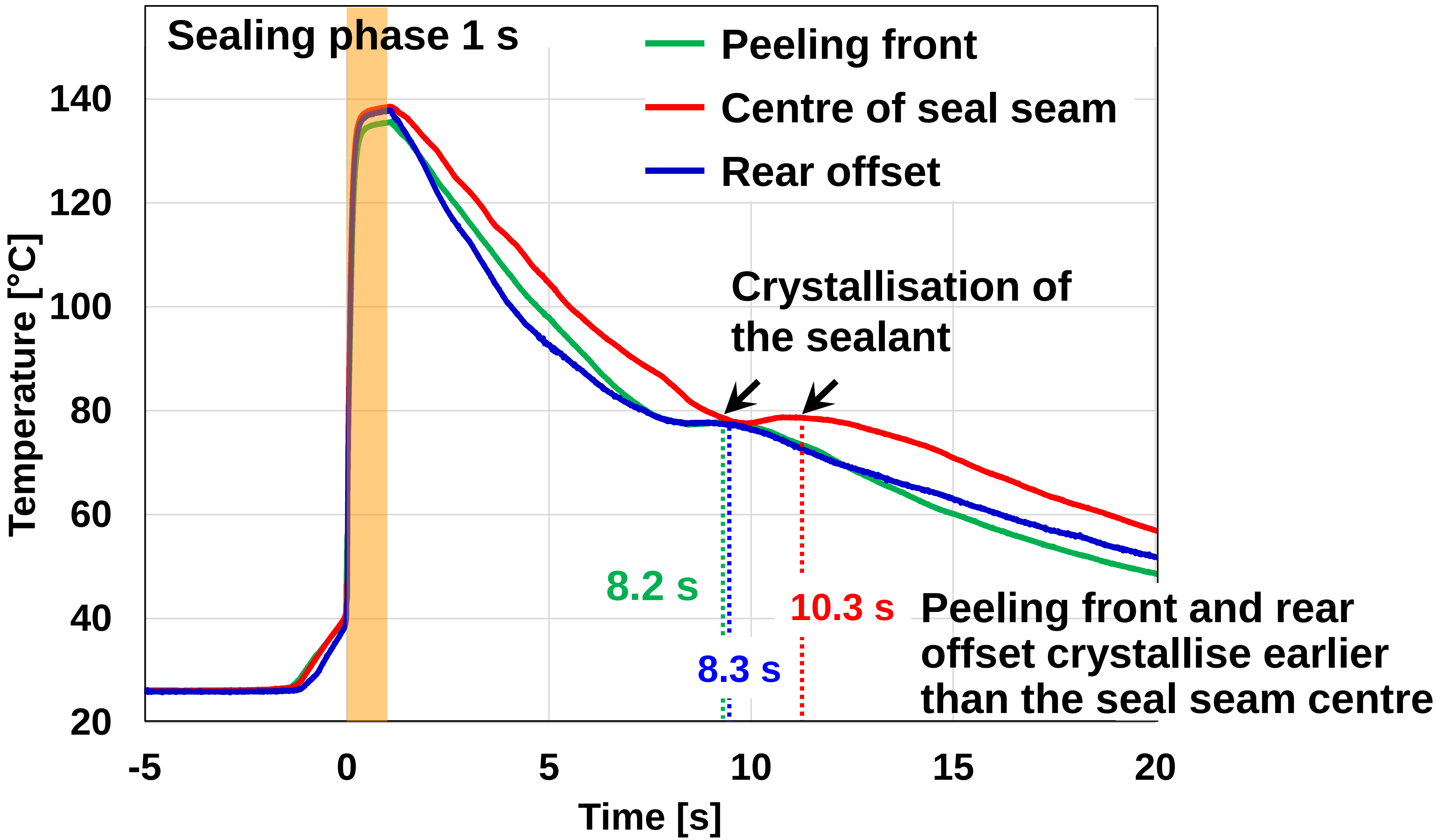


Side view

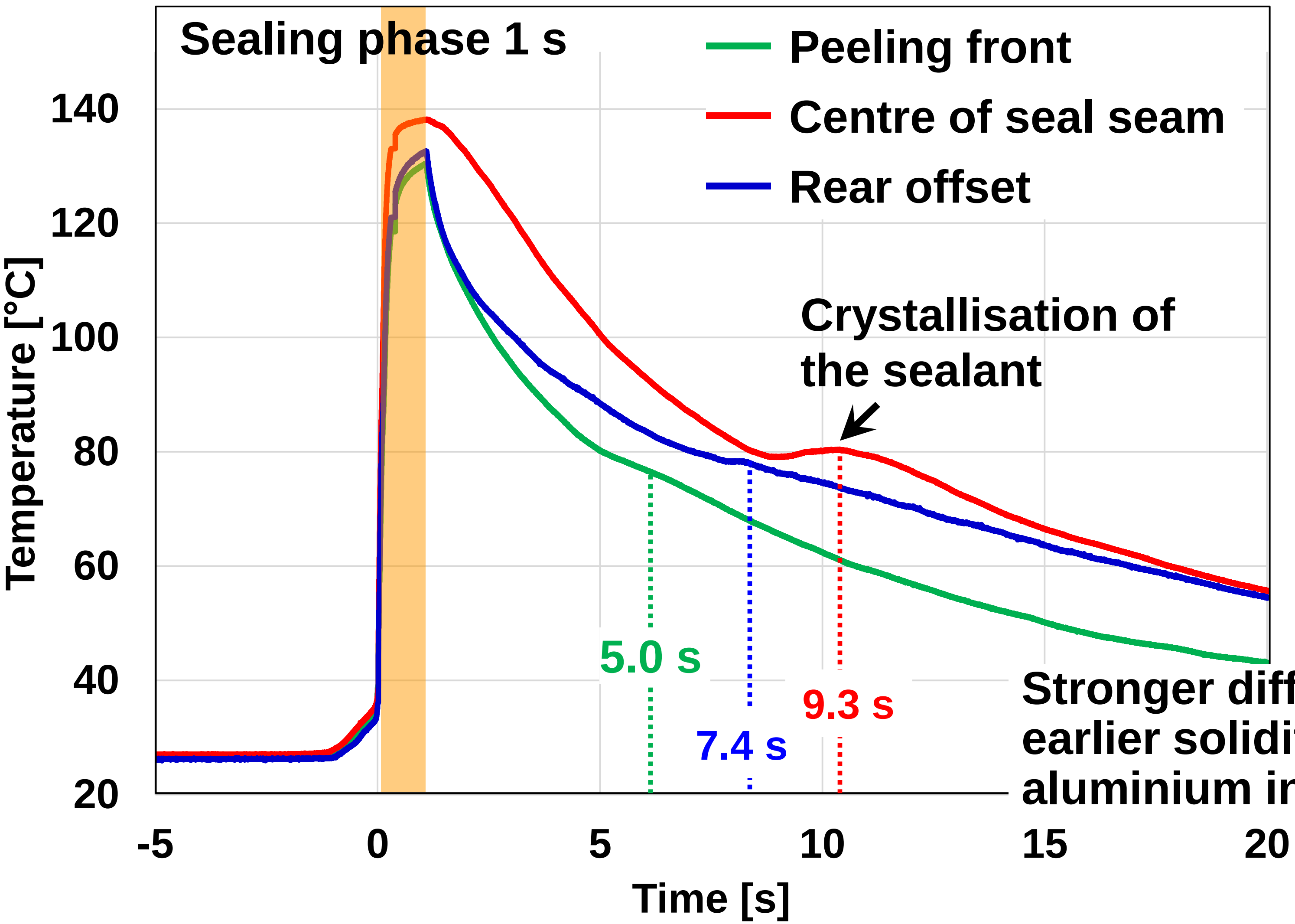
Sealing geometry for hot tack measurement – Positioning of thermocouples



Course of the interfacial temperature at different positions in the seal seam – PET 12 µm/ionomer(MI 5) 50 µm - 135 °C – 1 s

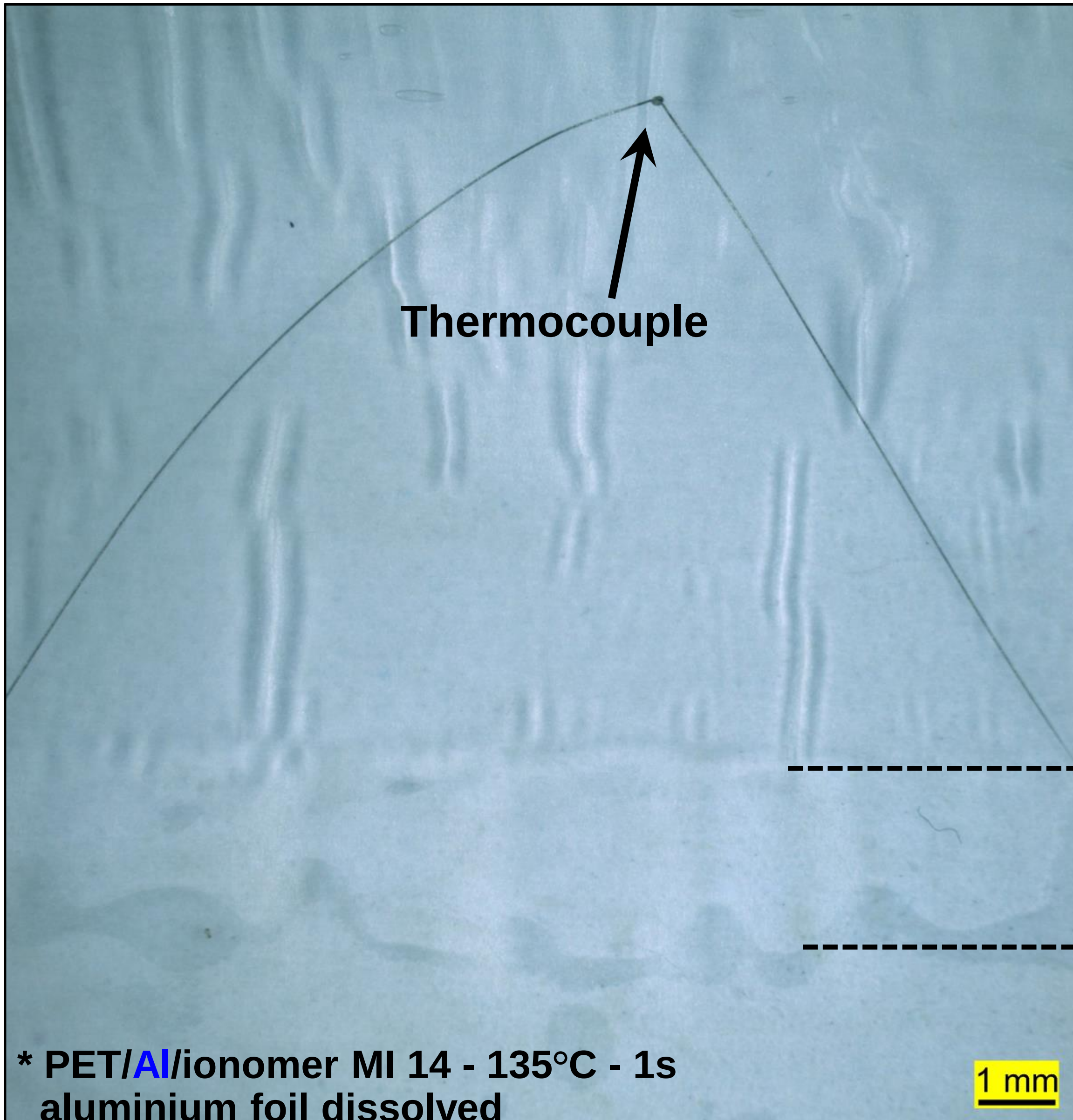


Course of the interfacial temperature at different positions in the seal seam – PET 12µm/Al 9µm/ionomer(MI 5) 50µm - 135°C - 1s



Stronger differences and earlier solidification with aluminium in the laminate

Secondary sealing edge effect in a seal seam*



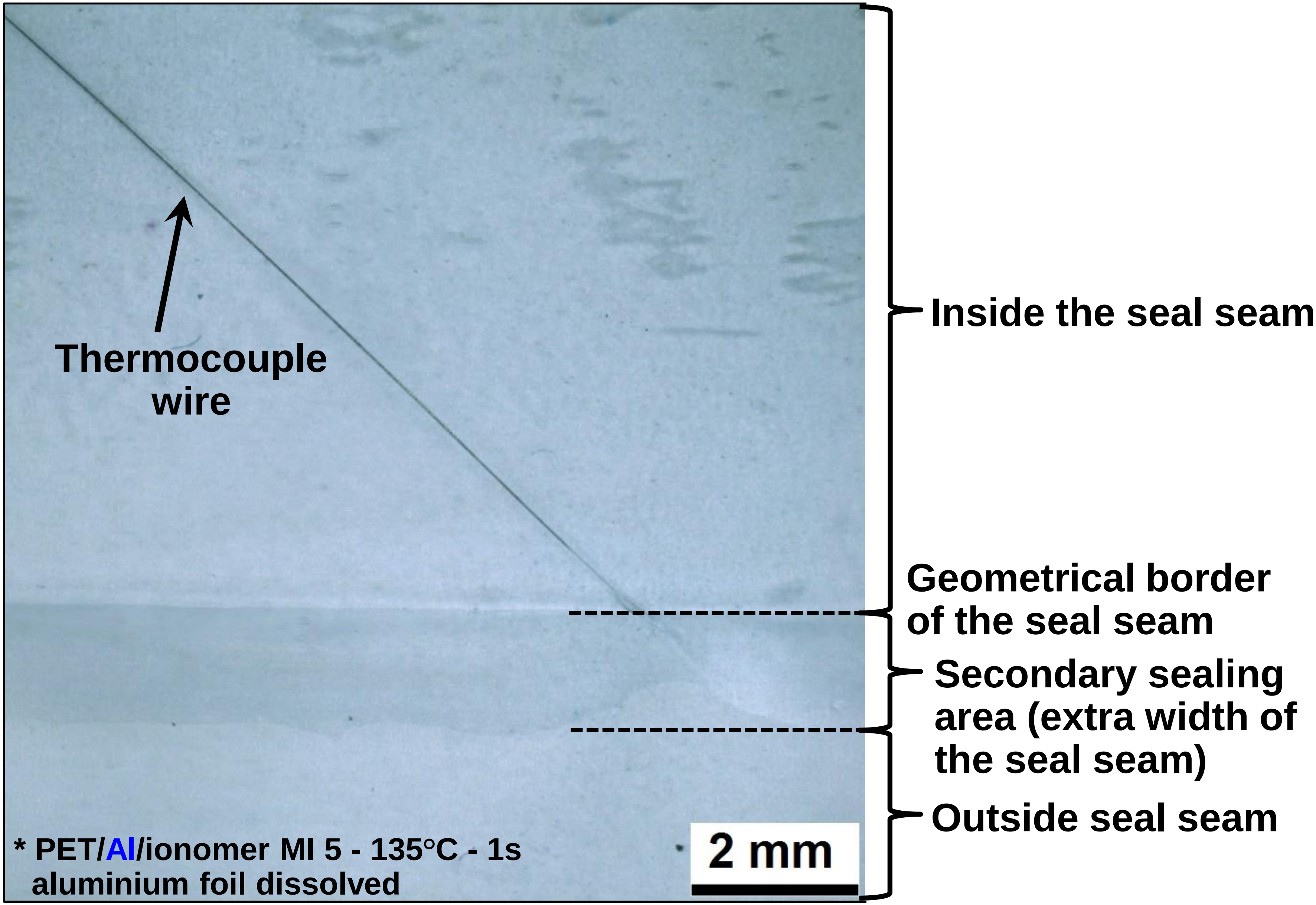
Inside the seal seam

Geometrical border of the seal seam

Secondary sealing area (extra width of the seal seam)

Outside seal seam

Secondary sealing edge effect in a seal seam*



* PET/Al/ionomer MI 5 - 135°C - 1s
aluminium foil dissolved

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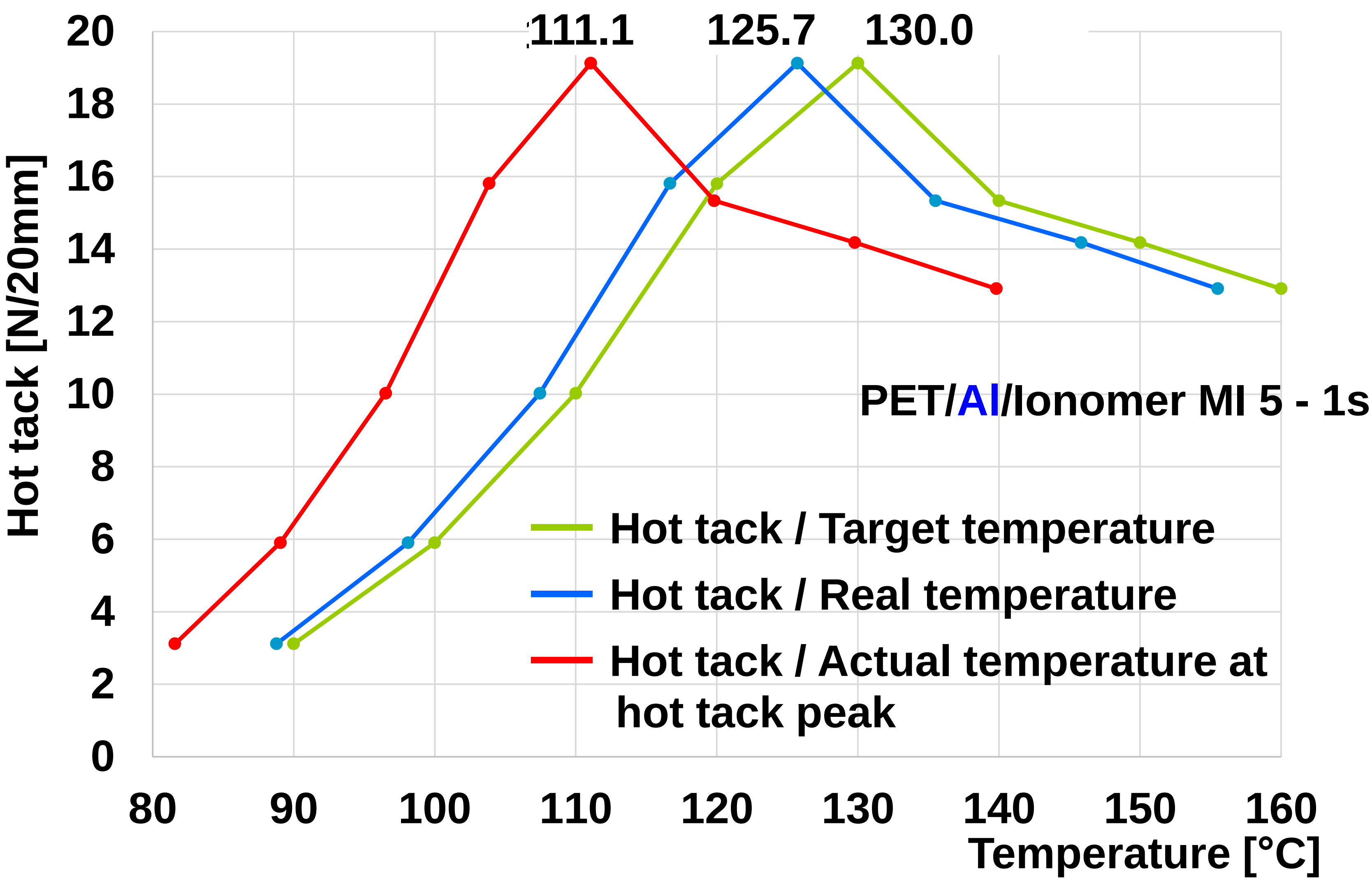
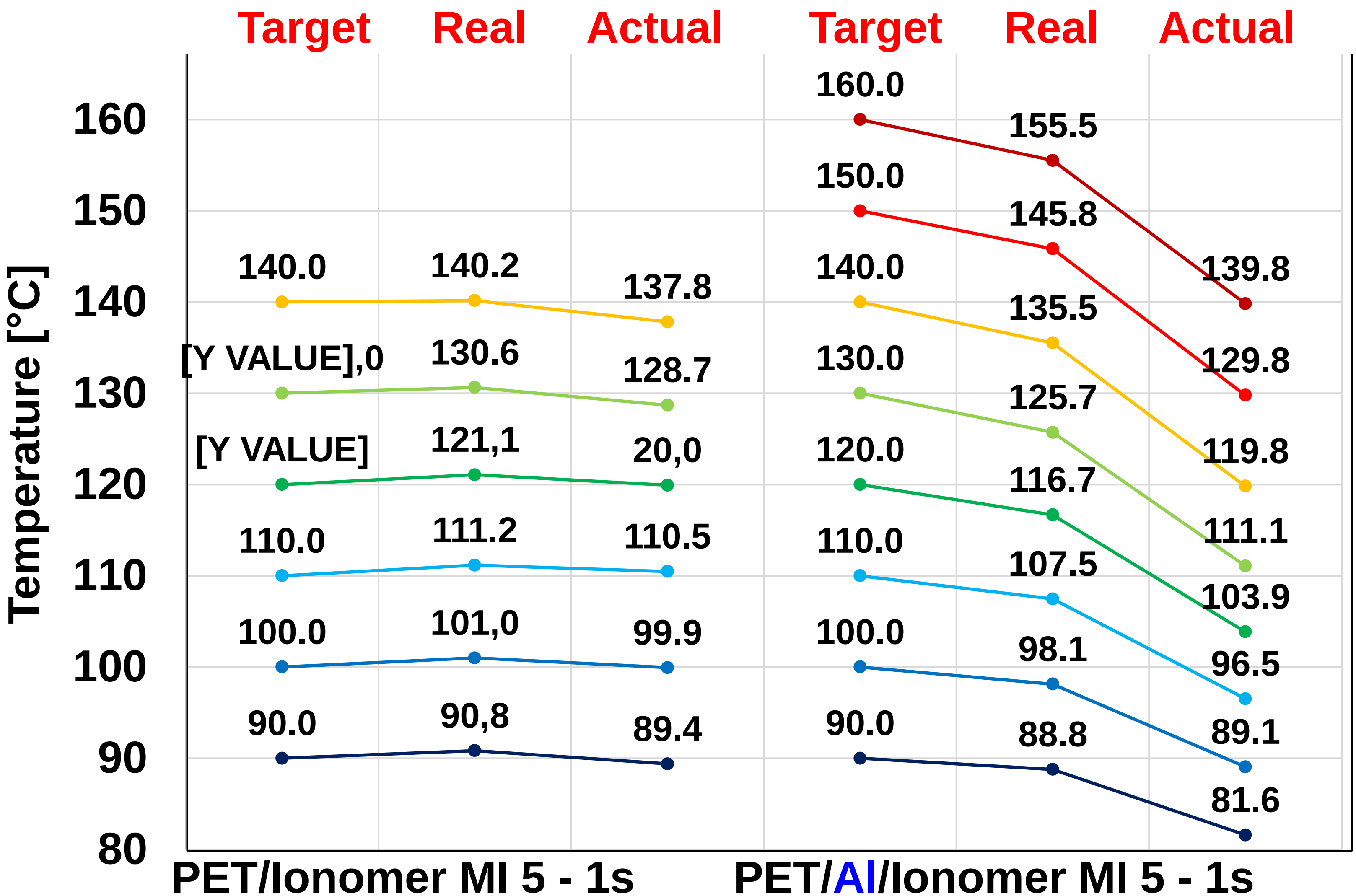
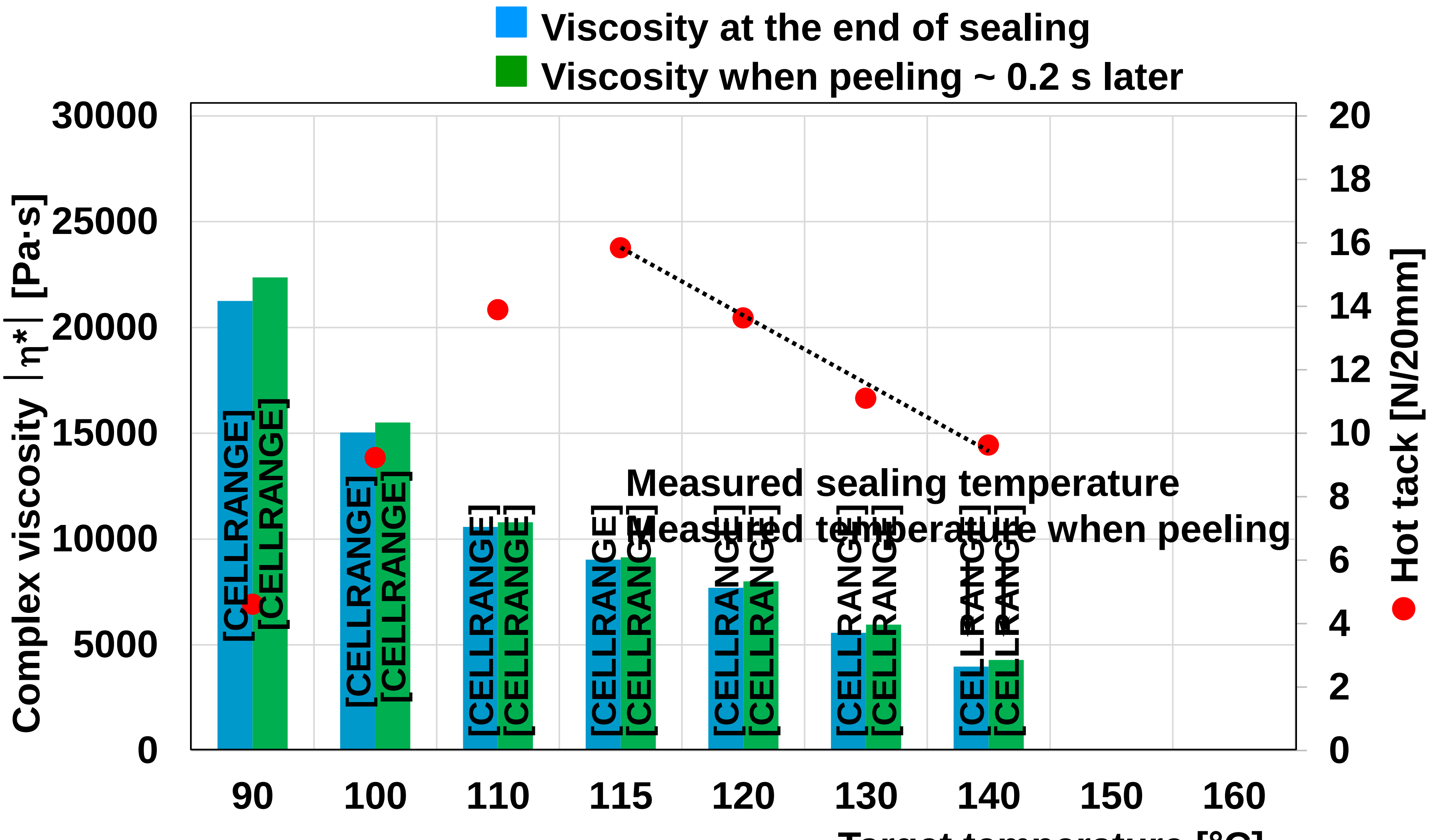
Hot tack curves at: target temperature, real sealing temperature and actual temperature of hot tack measurement



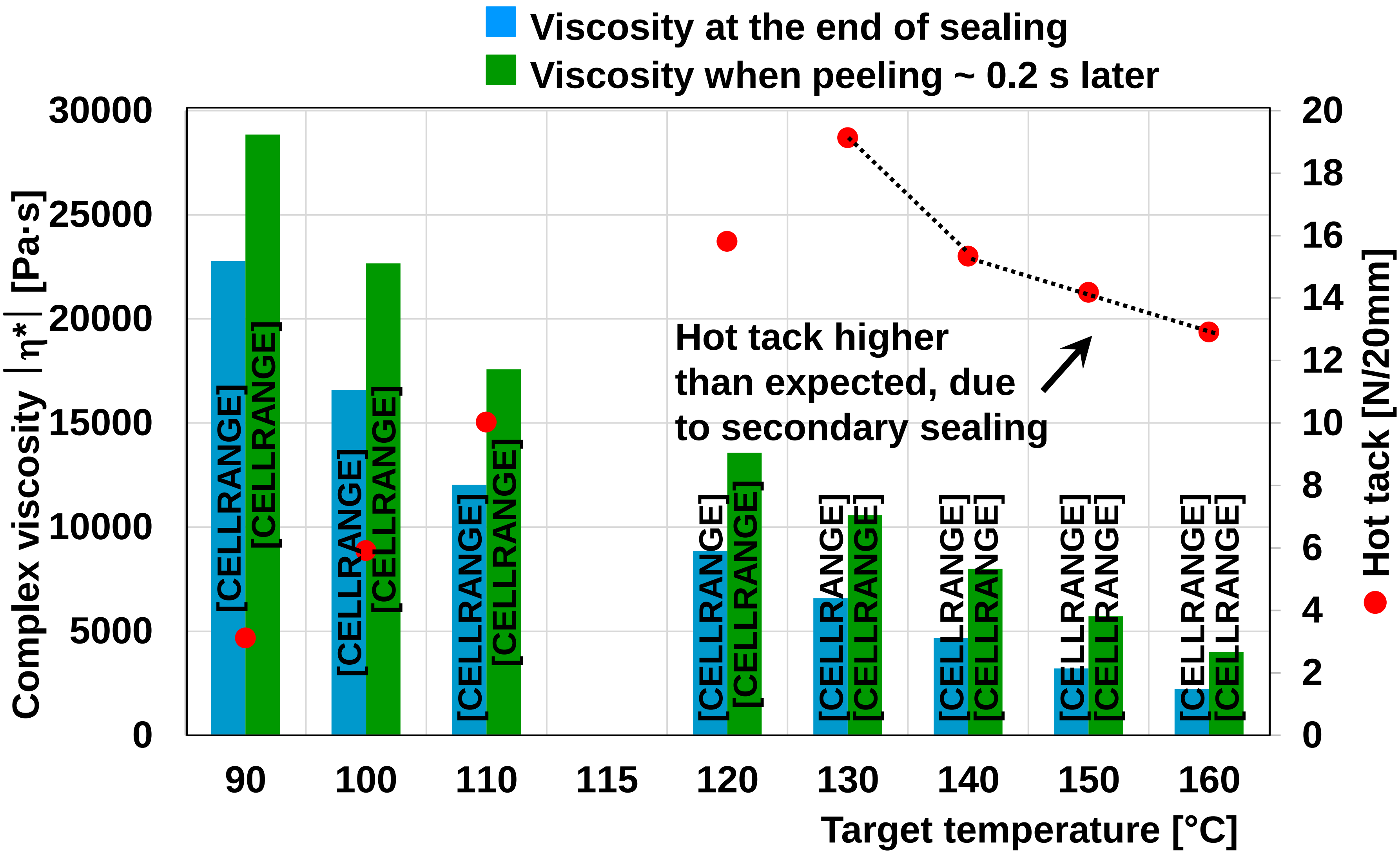
Hot tack curves at: target temperature, real sealing temperature and actual temperature of hot tack measurement



Interfacial temperatures, associated viscosities - for melt entangling and disentangling - related to hot tack - PET/ionomer MI 5



Interfacial temperatures, associated viscosities - for melt entangling and disentangling - and related hot tack - PET/Al/ionomer MI5



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Summary

- Ionomers and EMAA show a much more pronounced temperature dependent viscosity increase than LDPE, starting at 190°C to typical sealing temperatures, as indicated by melt tack and viscosity curves at the relevant temperature and by temperature sweeps following the solidfication and melting behaviour of the sealants.
- True interfacial temperatures at different positions of the seal seam, under the same conditions as the hot tack measurement, have been monitored.
- Seal seams are not as homogeneous in temperature as commonly thought. A hot tack measurement does not take place at a constant and single temperature, but in a time- and location dependent temperature range or profile.
- Aluminium laminates enhance the hot tack generally, also for high performance ionomer sealants, not only by lateral cooling effect on the seal seam,
- But also by secondary sealing which means an increase of the seal seam width

Acknowledgements

We thank

Jacques Roulin, Dupont CH, for providing ionomers and their films,

Marcus Pisanec, Michael Reynolds and their Henkel Liofol pilot line team for laminating,

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Kai Karhausen and Simon Jupp for intellectual discussions and Marcus Eue for proof-reading.

Thank You
for sticking again with me…

Remember, when measuring hot tack, what you see is not always what you get!

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HYDRO