Heat Stability of Polylactic Acid - Based Foams and its Measurement

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Agenda

- Background
- Methods
- Results

Biopolymer
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Background

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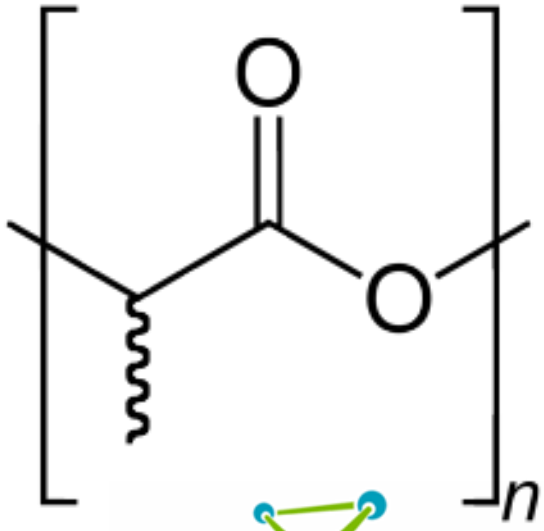
Polylactic acid (PLA)

- Biobased polymer: fermentation of starch (eg from corn) to lactic acid, then polymerised
- Similar properties as many plastics
- Compostable: via industrial composting
- Other disposable options:
  - physically recycled
  - incinerated
  - chemically recycled



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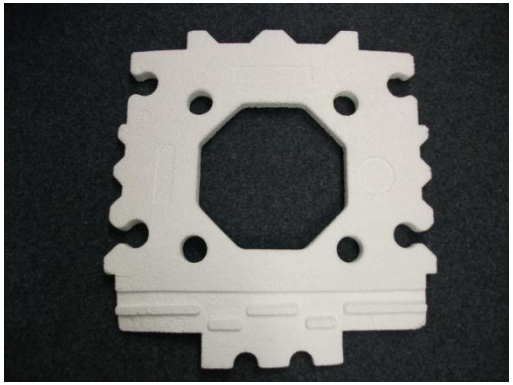
The Biopolymer Network (BPN) Process

CO_2 impregnation

Pre-foaming

Moulding



Patent # WO 2008/093284 A1

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The Biopolymer Network (BPN) Process

- Particle foam approach
- Drop-in technology for polystyrene moulders
- Use commercial PLA beads
- CO_2 as a "green" blowing agent
- Patented WO 2008/093284 A1
- Commercial trials

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Foam Properties

	EPS Foam	PLA Foam
Thermal resistance (m^2.K/W)	~0.68	~0.69
Thermal conductivity (W/m.k)	~0.035	~0.035
Compressive modulus (MPa)	5.3	2.9
Compressive strength (MPa)	0.12	0.07
Shear modulus (MPa)	3.2	3.0
Shear strength (MPa)	0.12	0.11
Shear stress, maximum (MPa)	0.17	0.18
Cross-breaking strength (kPa)	327	418

at 25 g/L

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Heat Stability?

- The resistance to change in properties as a result of heat encountered by a plastic compound in either processing or end use

- Heat stability is tested by an accelerated test used to predict stability with time

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Heat Deflection Temperature (HDT)

"Heat deflection temperature is defined as the temperature at which a standard test bar deflects a specified distance under a load. It is used to determine short-term heat resistance. It distinguishes between materials that are able to sustain light loads at high temperatures and those that lose their rigidity over a narrow temperature range"

ASTM D648

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HDT of Polymers

- Amorphous polymers HDT is related to T_g,
- Semi-crystalline polymers HDT is also related to crystallinity

- PLA - 55-60°C
- Polystyrene ~ 80°C
- Expanded polystyrene (EPS) ~ 100°C

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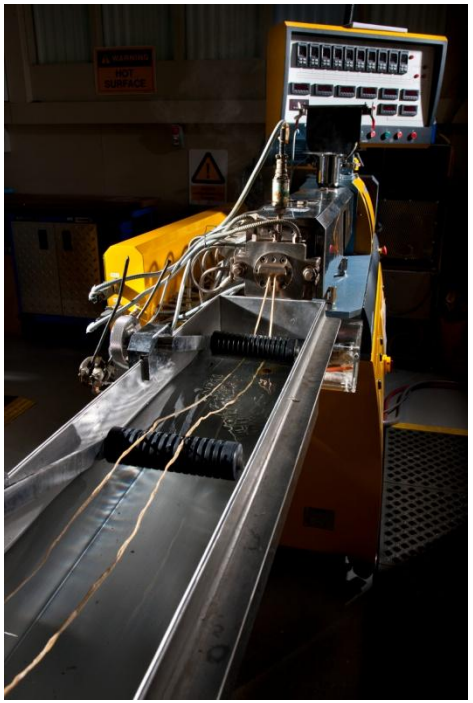
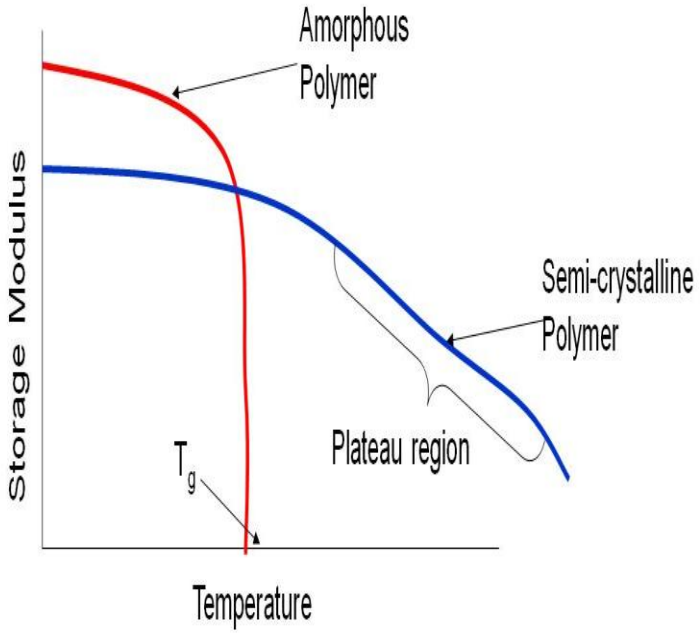
Methods





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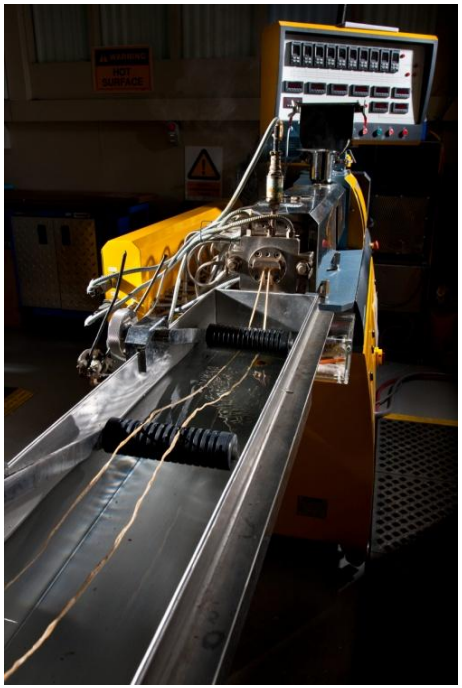
Sample Production

- 2 formulations; PLA and modified PLA (MPLA)



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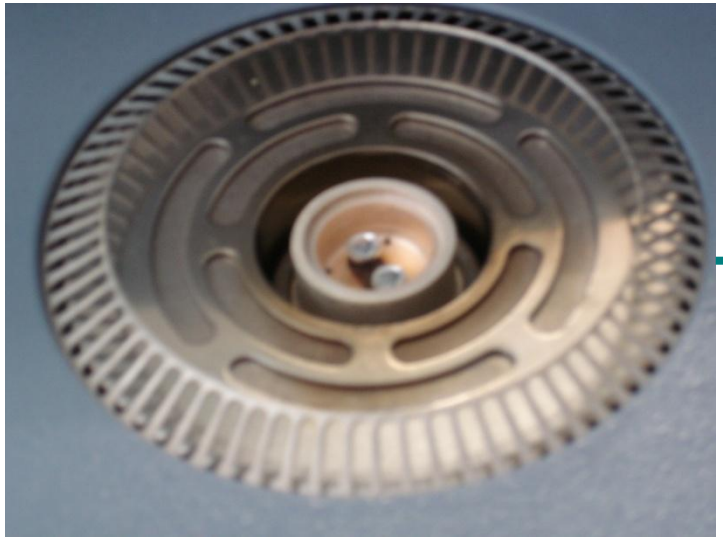
Differential Scanning Calorimetry (DSC)

- Both injection moulded and foamed samples
- Sample heated at 10ºC/min to 180ºC



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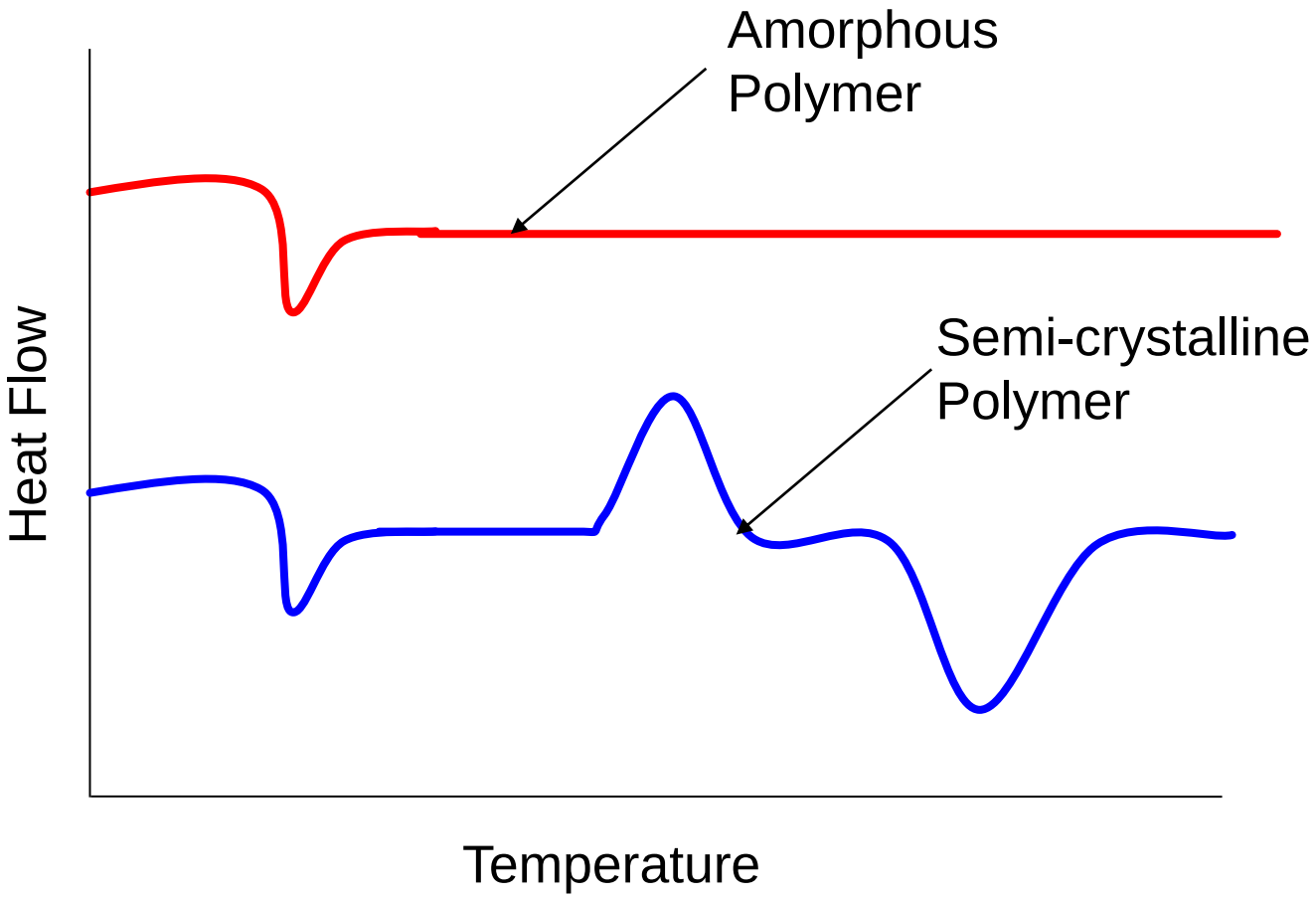
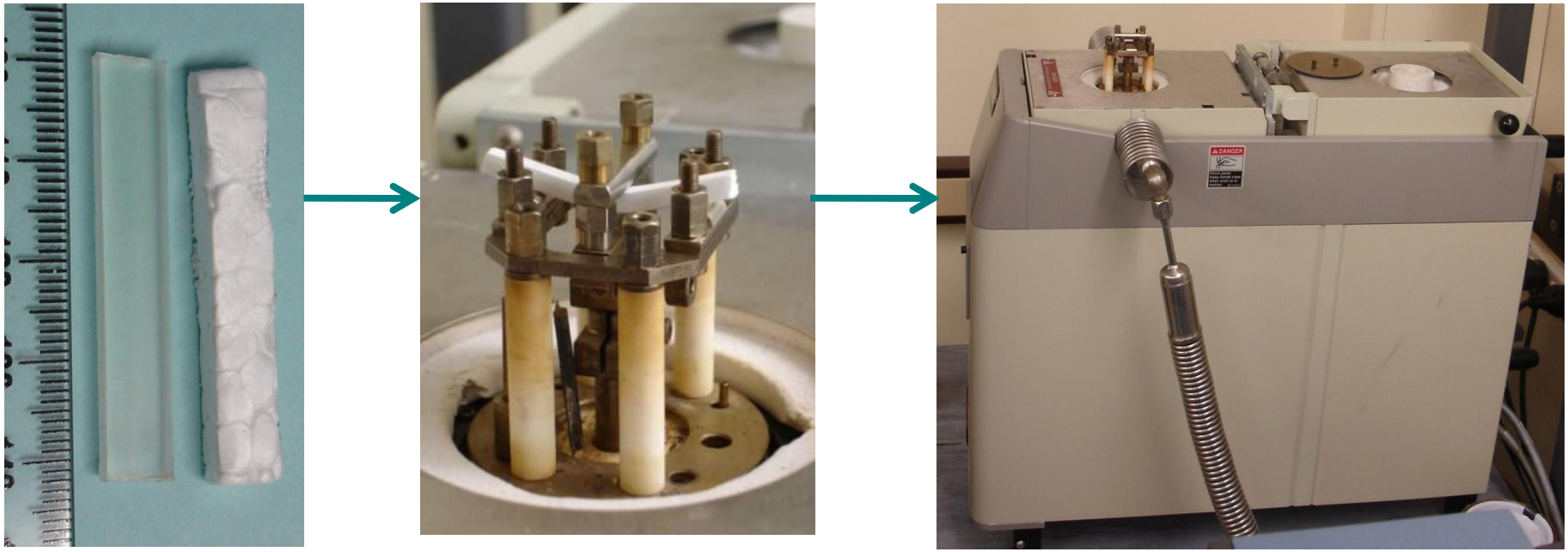


HDT – Dynamic Mechanical Thermal Analysis (DMTA)



3 x 7 x 40mm, were flexural tested at 1 Hz, 0.129% strain at 2°C/min heating rate (ASTM E2092)

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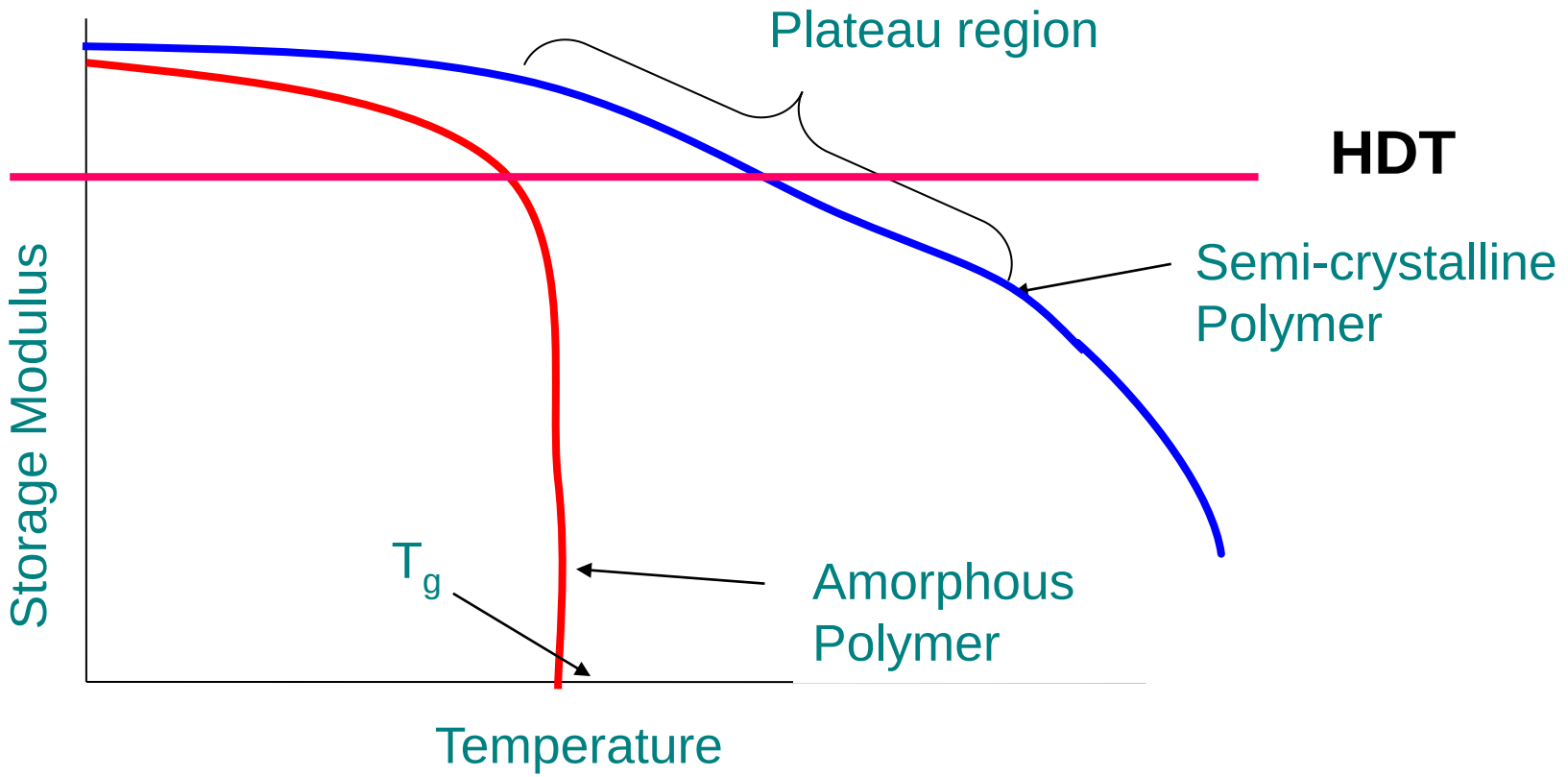

HDT is temperature when the log of storage modulus, log E', is 2.3×10^8 Pa (ASTM E2092)

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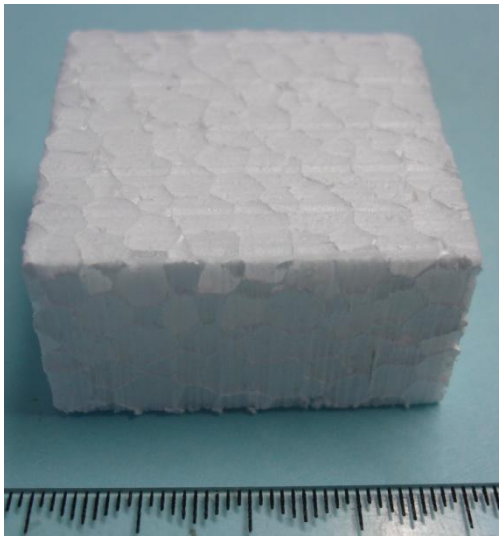
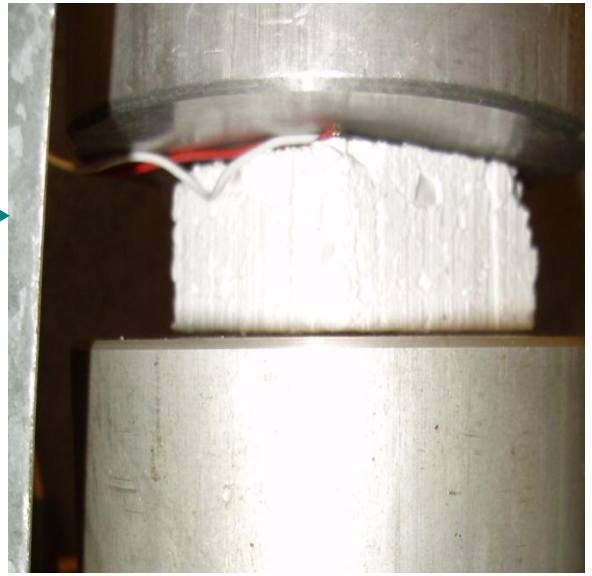
HDT - Compression





40 x 40 x 20mm, temperature ramp of 50ºC/hour and a 250 kPa force (DIN 53424)

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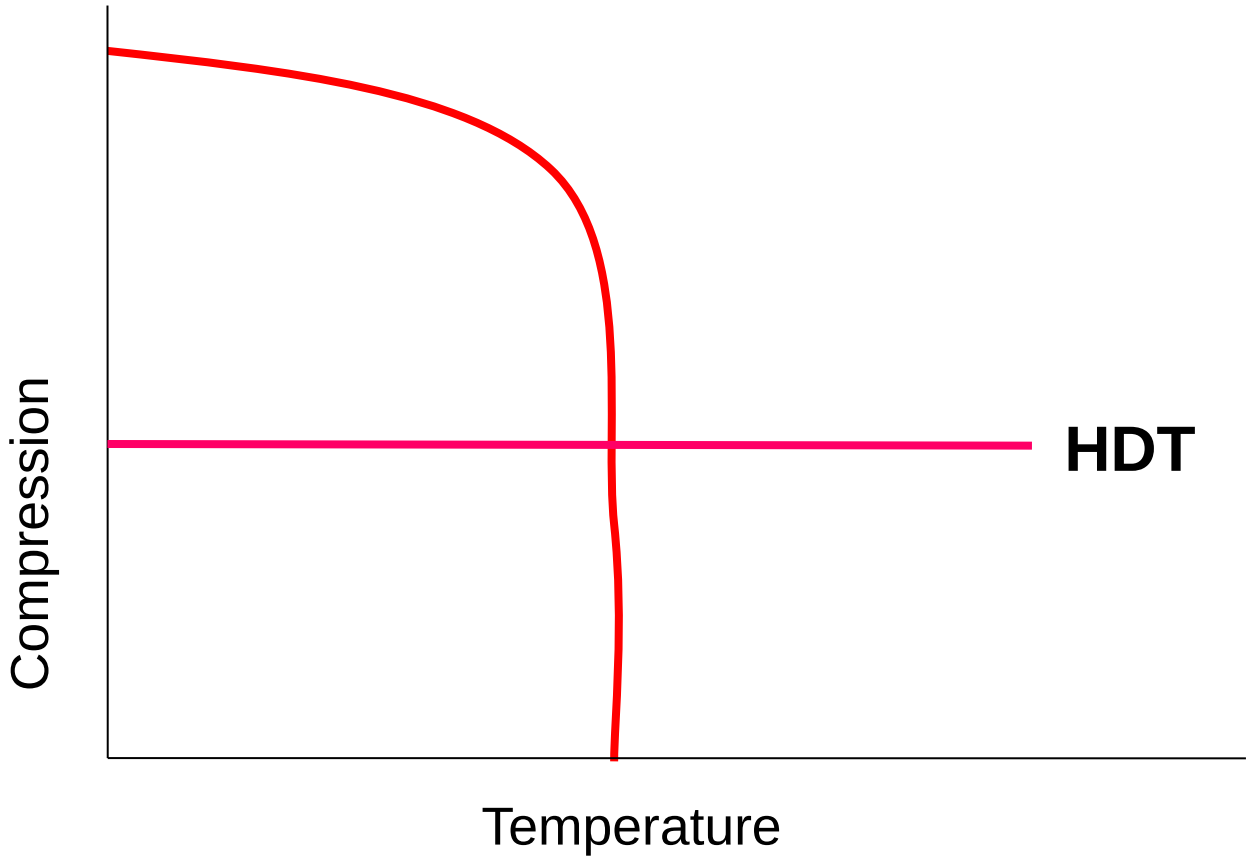

HDT is the temperature at where a foam specimen is compressed deflects by 2mm (DIN 53424)

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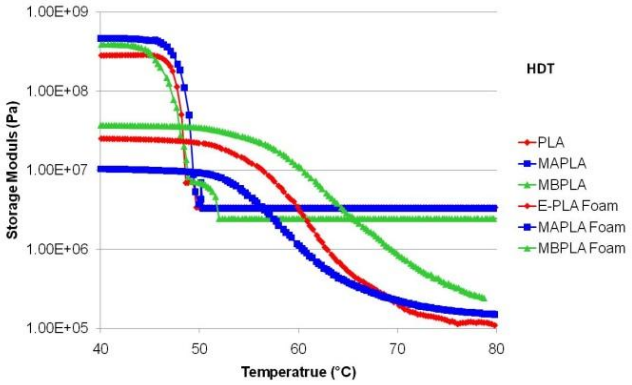
Results



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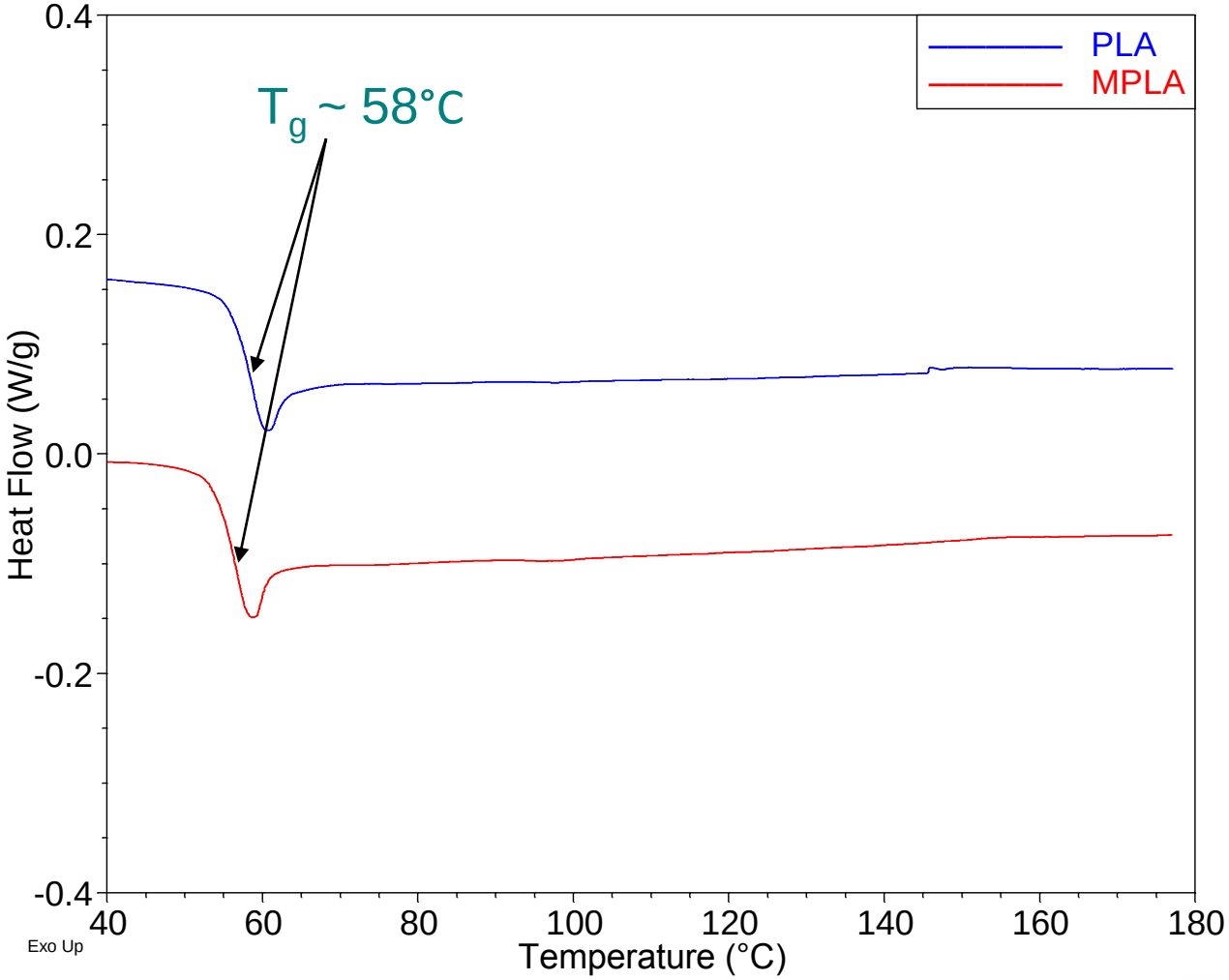
DSC – Unfoamed



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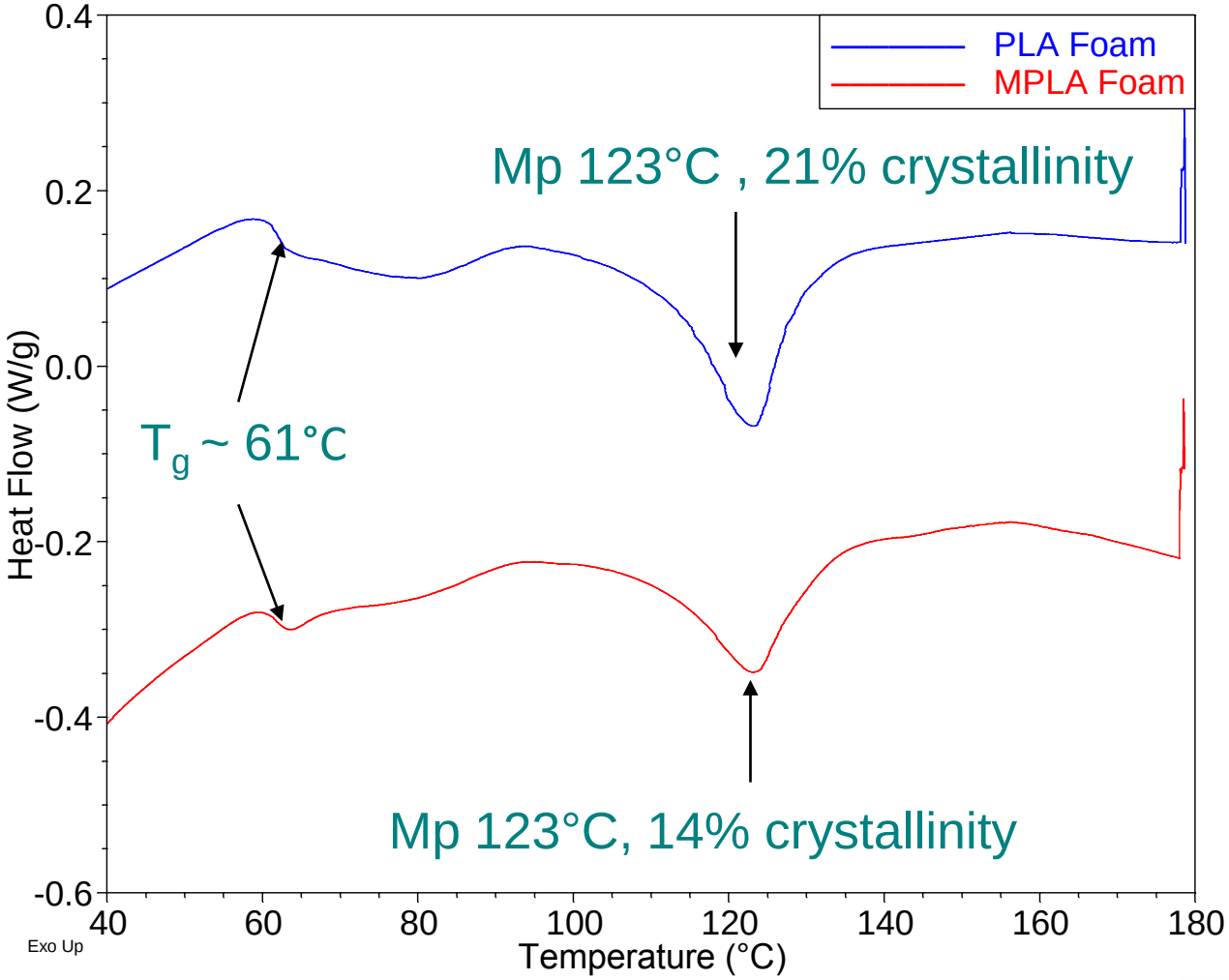
DSC - Foamed



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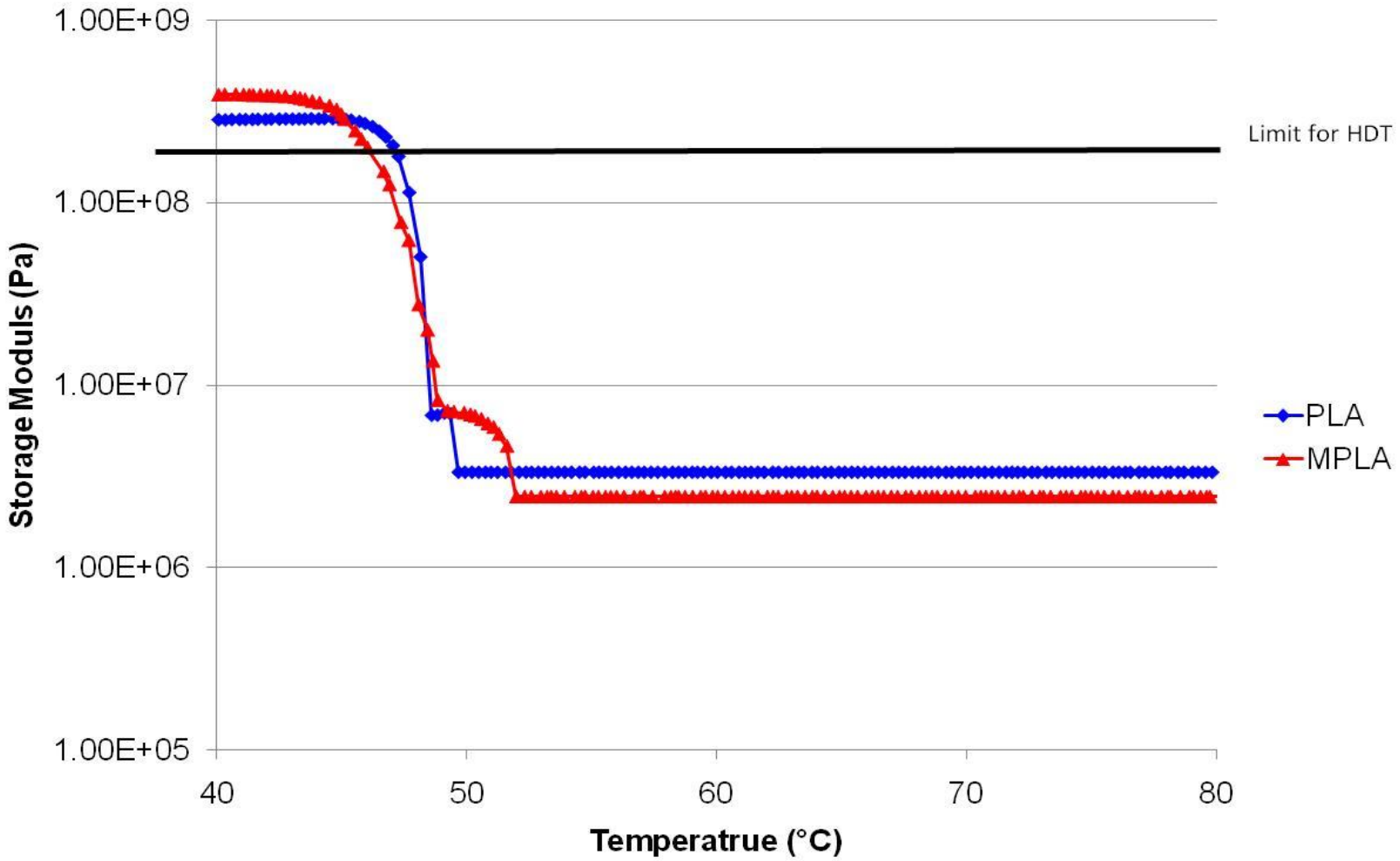
DMTA - Unfoamed



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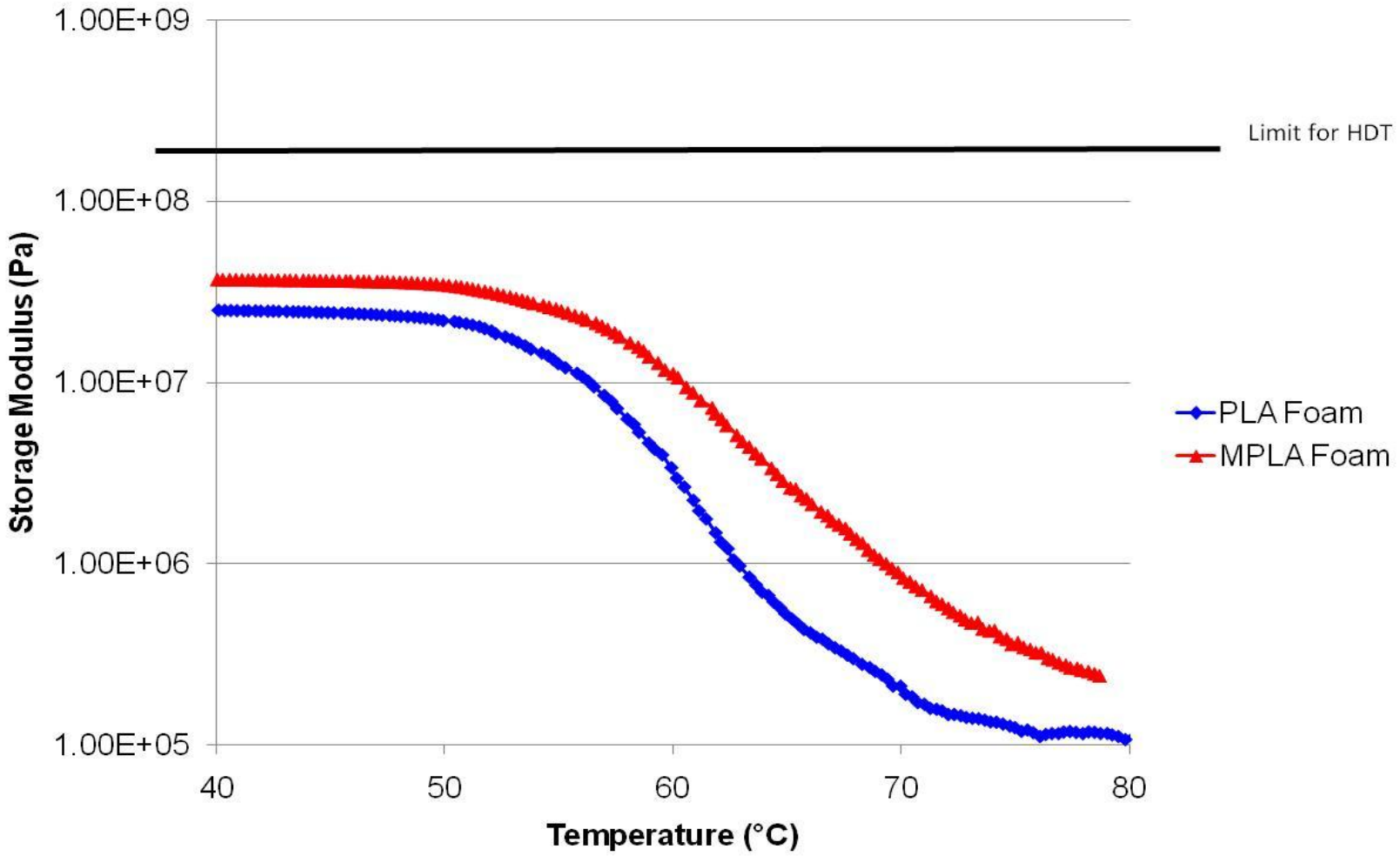
DMTA - Foamed



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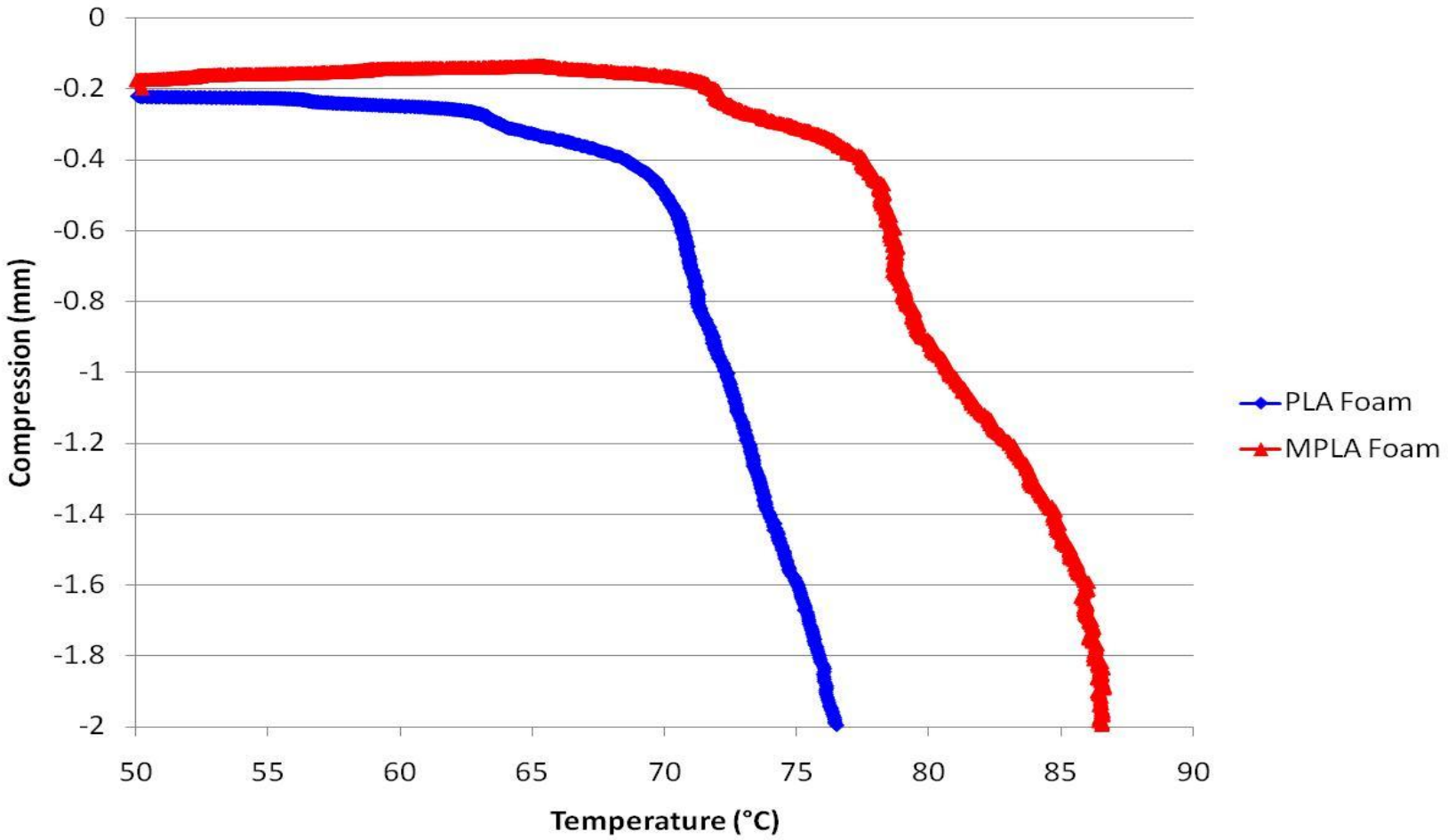
Compression - Foamed



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Conclusions

- Foaming increases HDT of PLA
- Modifying PLA can significantly increase the HDT of PLA foam
- The DMTA HDT method, according to the standard, is not as good as the compression HDT method for foams

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Acknowledgements

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