Grilamid BTR

Grilamid BTR: A Greener Future for Medical Devices

GreenLine

EMS

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Presentation Objectives

- Introduce EMS GreenLine bio-based PA series
- Demonstrate Grilamid BTR as full performance crude oil polymer alternative, highlighting:
  - Mechanical Properties
  - Chemical Resistance
  - Processability
  - Biocompatibility
- Show reduced CO_2 footprint via Life Cycle Assessment
- Highlight reduced CO_2 emissions from GreenLine manufacturing at Domat/Ems, Switzerland production site.

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EMS GreenLine Introduction

- EMS-GRIVORY GreenLine products are bio-based polyamides produced from renewable castor plant raw materials.
- 40–99% bio-based carbon (ASTM D 6866-12)
- Up to 75% lower manufacturing emissions than oil-based polyamides
- Same performance as conventional polyamides
- Non-biodegradable, equally durable

Castor Plant (Ricinus communis)

- High content of Castor Oil
- Robust annual plant
- Not a food plant
- Not competing with food crops for land
- Grown in semi arid areas (India, China, Brazil)

EMS GreenLine
Bio-Content Defined

Product Family	Polymer	Bio-Content
Grilamid 1S	PA 10,10	up to 99%
Grilamid 2S	PA 6,10	up to 62%
Grivory HT3	Polyphthalamide	up to 48%
Grilamid BTR	**Amorphous PA**	**up to 58%**

Crude Oil

- Millions of years old
- ^{14}C content = 0

Castor Oil

- Derived naturally ^{14}C content is equivalent to the ^{14}C concentration in the biosphere

- Radiocarbon dating (ASTM D6866) measures bio-based content by quantifying ^{14}C.
- Inorganic carbon from minerals (e.g., limestone) is excluded from measurement.

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GreenLine
Grilamid BTR

- Amorphous polyamide containing up to 58% renewable content
- Highly transparent, strong, & fatigue resistant
- Boiling water resistant
- Chemically resistant to broad range of solvents
- Low density
- Suitable for lighting, electronics, houseware, medical devices, eyewear.
- Similar in performance characteristics to **Grilamid TR 90**

Grade	Characteristics
BTR 400	40% Bio-content
BTR 600	54% Bio-content
BTR 600 LS	58% Bio-content, easy processing

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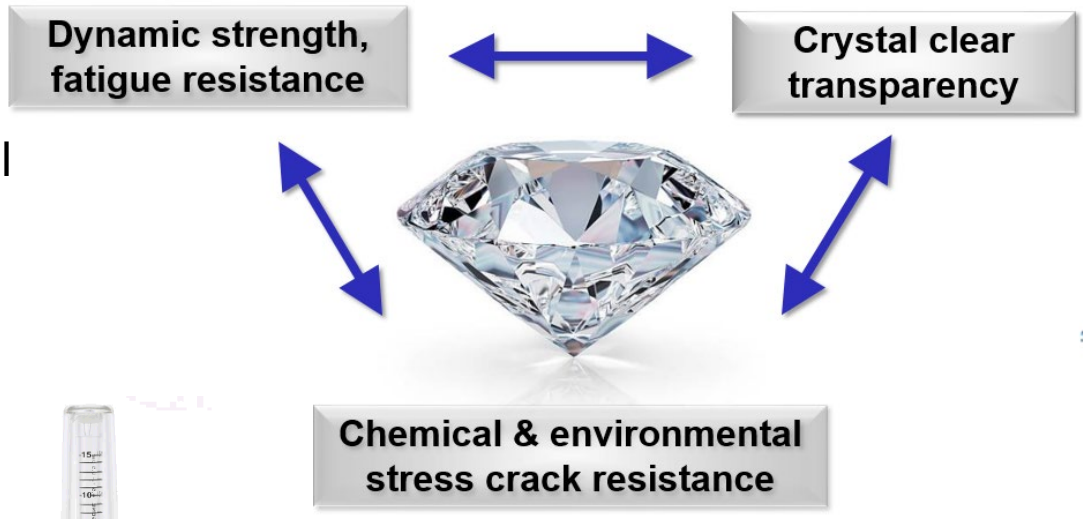
Grilamid TR 90 as Benchmark Material

- **Grilamid TR 90** is a well established crude oil-based amorphous PA displaying:
  - High chemical and environmental stress crack resistance
  - Excellent flexural & dynamic fatigue strength
  - High transparency
  - Excellent dimensional stability & UV resistance
  - High melt flow and easy processability



Material Overview
Grilamid BTR 600 LS vs Grilamid TR 90

Property	Standard	Unit	TR 90	BTR 600 LS
Tensile Modulus*	**ISO 527**	**MPa**	**1600**	**1700**
Strength at yield*	ISO 527	MPa	60	65
Elongation at Break*	**ISO 527**	**%**	**>50**	**100**
Notched Impact Charpy*	ISO 179	kJ/m^2	13	10
Glass Transition Temperature	**ISO 11357**	**˚C**	**155**	**118**
Moisture Absorption	ISO 62	%	1.5	2.0
Density	**ISO 1183**	**g/cm^3**	**1.00**	**1.02**
Mold Shrinkage, Longitudinal/Transverse	ISO 294	%	0.6/0.7	0.6/0.6
Transparency, 3 mm thickness	**ASTM D1003**	**%**	**91**	**91**
Bio–Content	**ASTM D6866**	**%**	**0**	**58**

* conditioned

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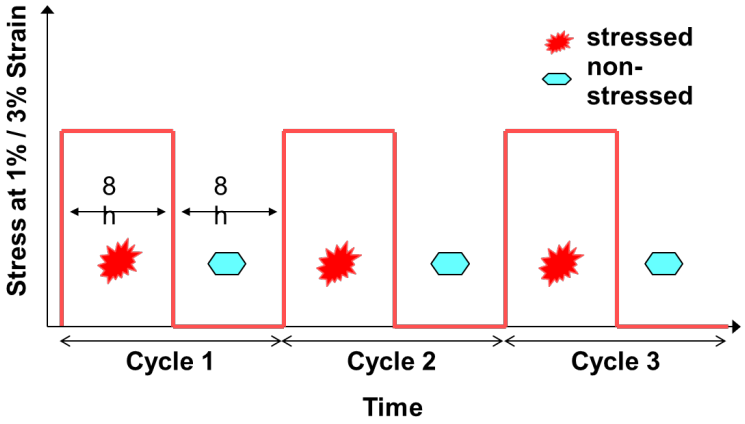
Cyclic Stress Relaxation
Grilamid BTR 600 LS vs Grilamid TR 90

Specimen: ISO 527 Tensile Bar

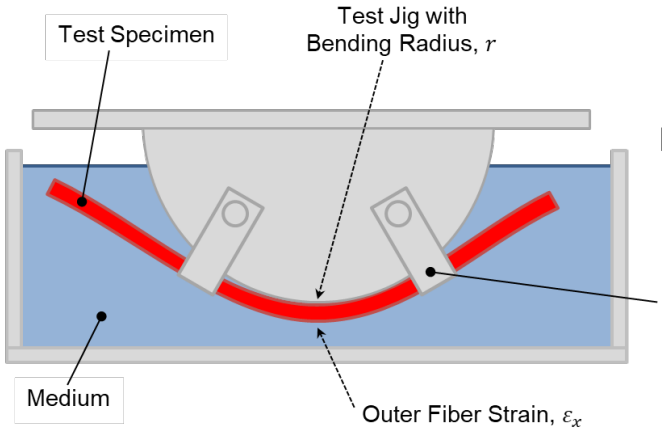
Procedure:
- 3 cycles @ 23 °C on same specimen
- 8 hours stressed and 8 hours non-stressed each cycle
- Stressed at 1% and 3% strain

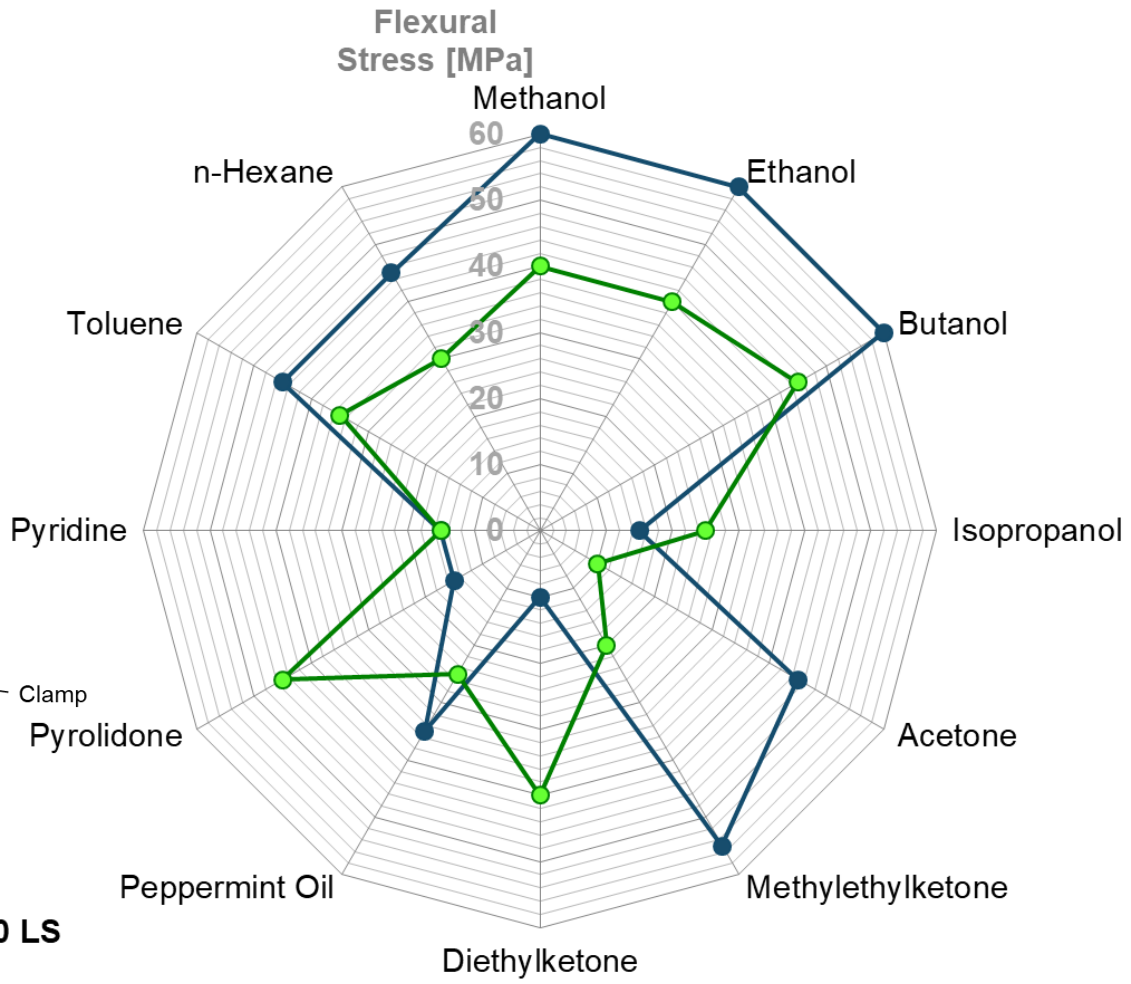


Product	Standardized Stress [MPa]	Δ relaxation [MPa]	Δ Cycle 1-cycle 3 [MPa]	Standardized Stress [MPa]	Δ relaxation [MPa]	Δ Cycle 1-cycle 3 [MPa]
Strain	**1%**			**3%**		
TR 90	15	0.7 (5%)	0.1	40	5.5 (14%)	0.5
BTR 600 LS	17	0.8 (5%)	0.2	47	2.3 (5%)	0.6

Stress Crack Resistance
Grilamid BTR 600 LS vs Grilamid TR 90

Bent Strip Test
Based on DIN 53449 Part 3
Tensile bars (4mm thick)
Concentration: 100%
Test Temperature: 23°C
Immersion time: 60 seconds





Healthcare Disinfectant Exposure

ASTM D543 1% Strain / 72 hrs	CaviCide™*	SteriCide™	Virex® TB	Virex® II 256
Grilamid BTR 600 LS	●	●	●	●
Grilamid TR 90 Nat	●	●	●	●
PC	◗	○	○	○
PC/ABS	○	○	○	○

Tensile Strength Retention

○ **≤69%** ◗ **≥70% to ≤94%** ● **≥95%**

Grilamid displays high chemical resistance to disinfectants containing quaternary ammonium compounds

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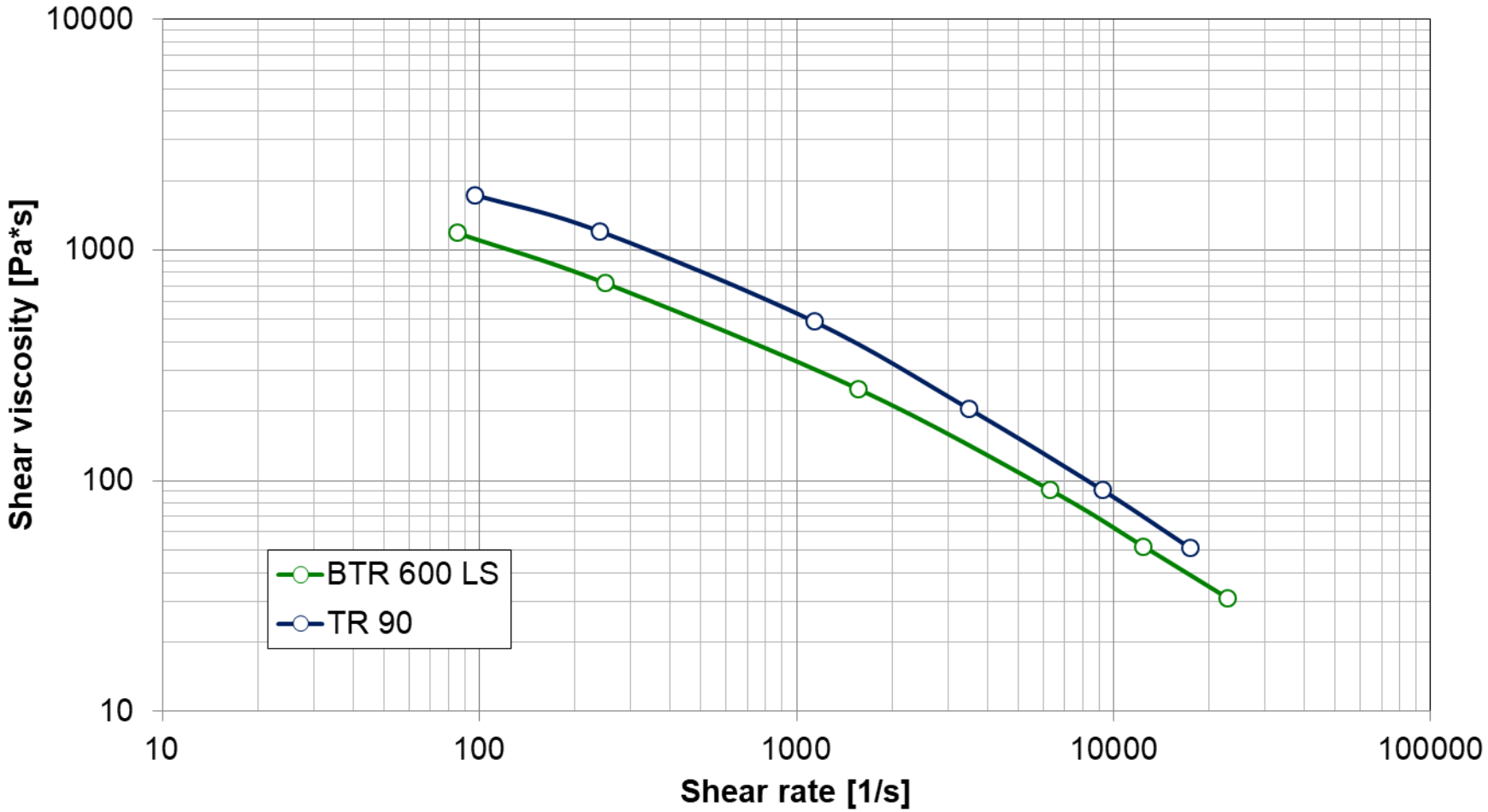
Shear Viscosity
Grilamid BTR 600 LS vs Grilamid TR 90



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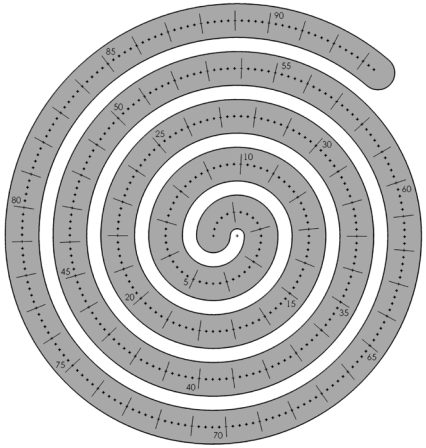
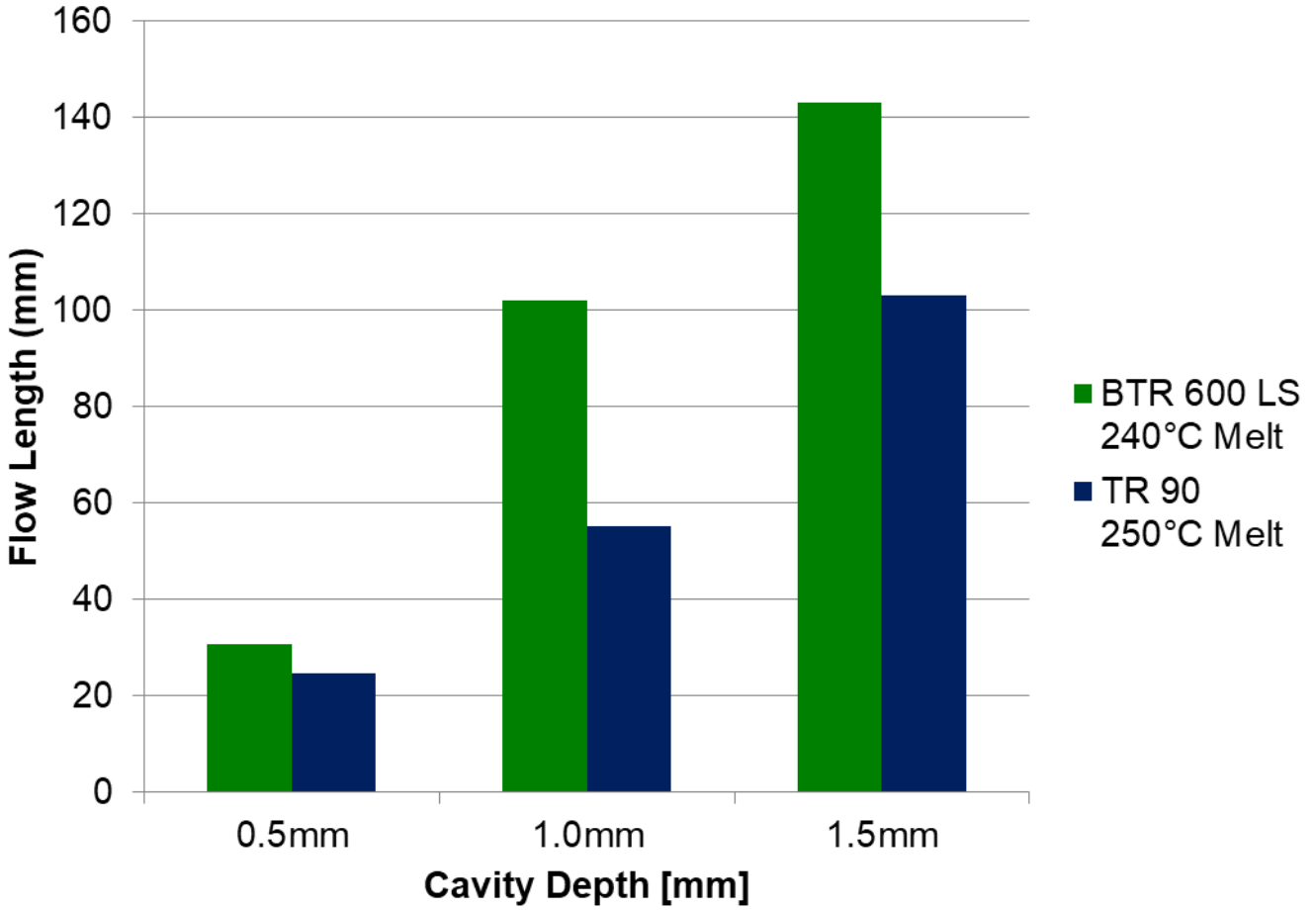
Flowability
Grilamid BTR 600 LS vs Grilamid TR 90

Spiral Flow Test
Cavity Width: 10 mm
Hold Pressure: 1000 bar





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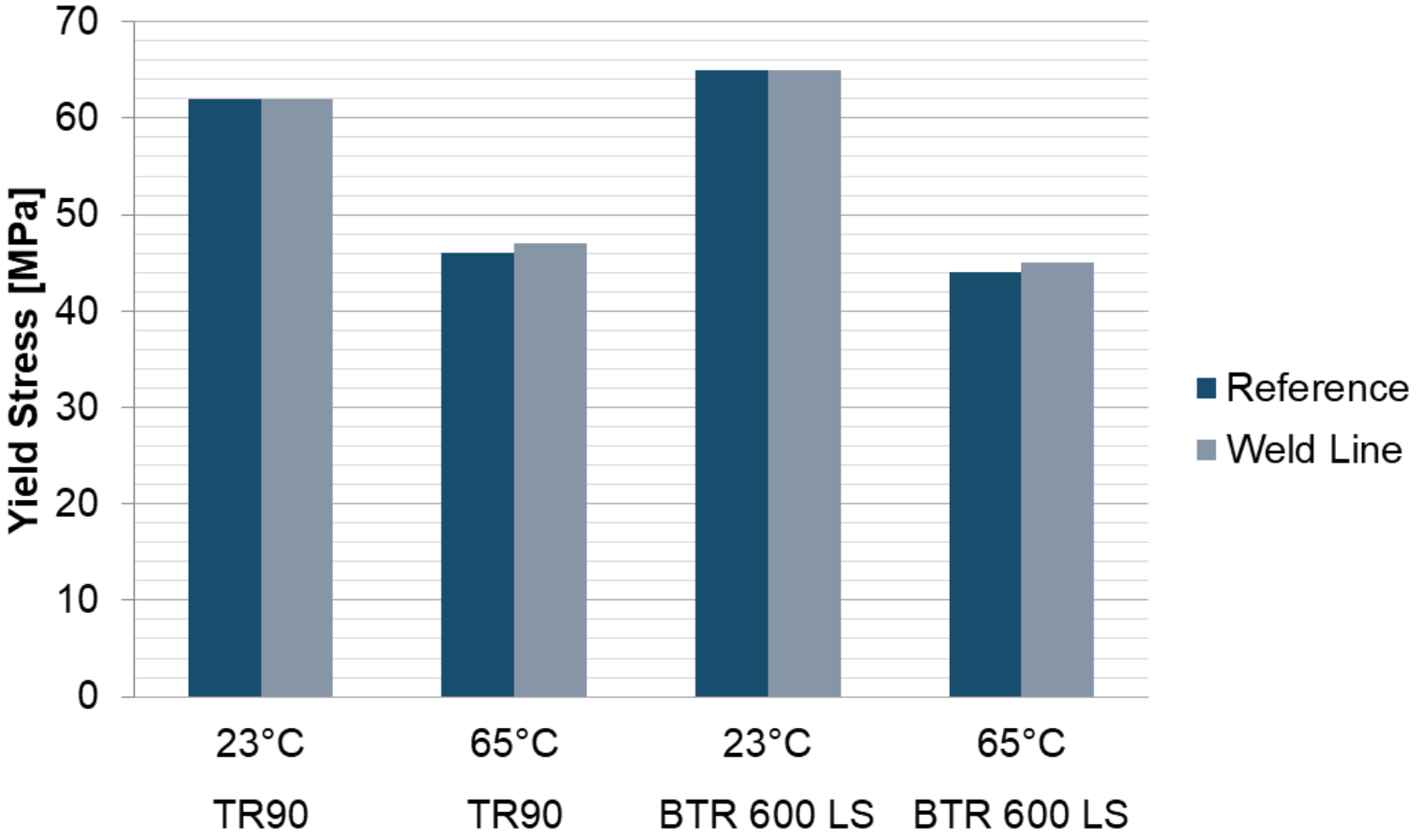
Weld Line Strength
Grilamid BTR 600 LS vs Grilamid TR 90



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Compliance & Sterilization
Grilamid BTR 600 LS & Grilamid TR 90

Approval	Description	Grilamid BTR 600 LS	Grilamid TR 90 Nat
ISO 10993-5	Tests for in vitro cytotoxicity	✓	✓
ISO 10993-10	Tests for skin sensitization	✓	✓

Product	Steam Sterilization 134°C/7 mins	Ethylene Oxide	Gamma Irradiation <45 kGy	H_2O_2 50°C/54 min (Single Cycle)
Grilamid BTR 600 LS	☒	✓	✓	✓
Grilamid TR 90	≤ 20 Cycles	✓	✓	✓

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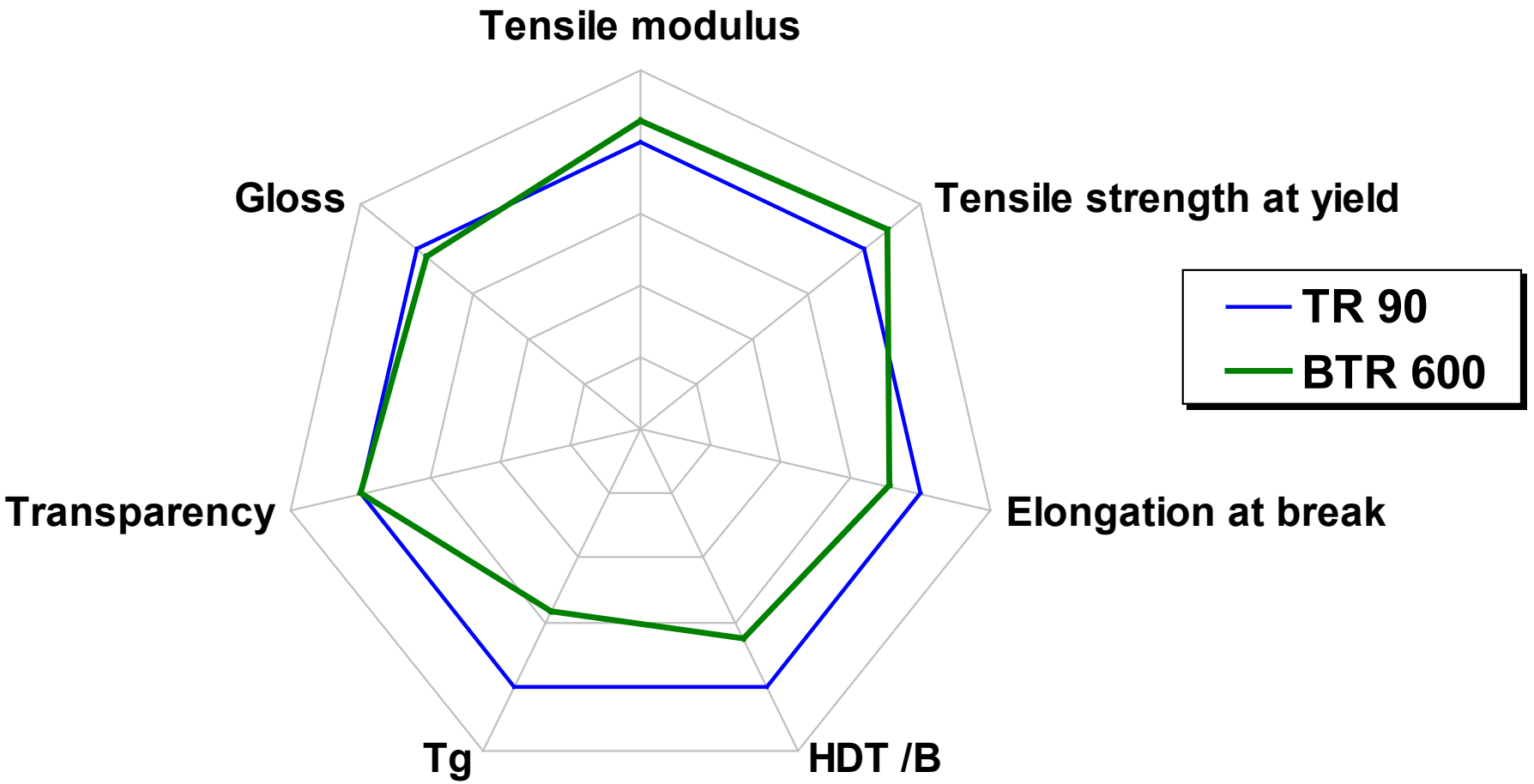
Property Comparison Summary



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Life Cycle Assessment Objectives

Life Cycle Assessment (LCA) is a cradle-to-grave method that measures a product's environmental impacts by tracking inputs, outputs, and their effects.

Tool	EMS-GRIVORY in house assessment using Boustead Model 5.0 software
Scope	From castor oil farming to polyamide granulate production
Inputs	Energy, fuel, raw material, secondary raw material, steam, and water
Outputs	Finished product(s)
Process	Solid/waste water, emissions, and heat release
Data Sources	• Raw Materials: suppliers and databases for secondary intermediates • Energy Mix: databases for relevant countries, **Axpo AG** (DOMAT/EMS), and suppliers • Process: Suppliers, EMS, and databases
Focus	• CO_2 Balance • GWP (Global Warming Potential = impact of green house gases) • Energy Balance

Life Cycle Assessment Grilamid BTR 600 LS

Parameter	Unit	BTR 600 LS(1)	PMMA(2)	Polycarbonate(2)
Total Energy	MJ/kg	149	116	113
Total Energy	kg oil/kg equivalent	3.0	2.3	2.3
CO_2 Balance	g/kg	3300	5900	6000
Land Use	m^2/kg	6	0	0
GWP(3) 20 years 100 years 500 years	CO_2 equivalent	 4000 3600 3400	—	—
Organic Content	% bio-based	58.0	0	0
Organic Content	% non bio-based	42.0	100	100
Inorganic Content	%	0	0	0

(1) Amorphous, transparent, partially bio based PA
(2) Base resin, generic data published by Plastics Europe
(3) Global Warming Potential

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Life Cycle Assessment: Sustainable Production

- Axpo AG in Domat/Ems is Switzerland's largest biomass energy producer.
- Biomass energy produces CO_2-neutral heat & electricity via 100,000 lbs/year of process steam.
- Powers EMS's polymerization and compounding operation in Domat/Ems, Switzerland.
- Provides 85% reduction (44,000 tons) in CO_2 emissions at Domat/Ems production site, **achieving CO_2 emission- free status**.

Questions & Discussion

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