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Fibers Considered for (Ultra) High Performance Tires

Tire Technology Expo 2008

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Materials

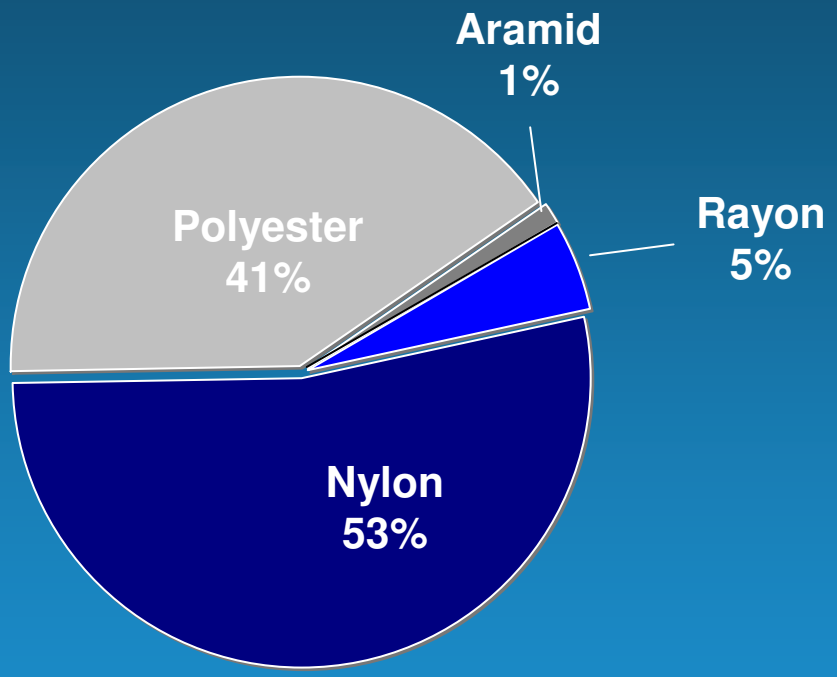
Typical Passenger Car Tire consists of *)

- 80% Compound
  rubber, carbon black, silica …
- 10% Steel
  Belt cord, Bead wire
- 10% Textiles
  Carcass, Capply, Bead RF

*) **Approximate values given per weight**

Textiles for Tires

•Global Tire Cord Market



Volume 2006: 1,300 kt

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Fibers for (U)HP Tires

Common denominator

- **Safeguarding Tire Integrity and Precise Tire Geometry in all stages under and after all circumstances**

Standards to beat by any candidate material

- **Steelcord, Polyamide and Rayon**
  (Tire manufacturing process leaves role for Aramid as a Hybrid)

Basics Reinforcing Materials

High tensile properties

- achieved by *orientation*
  (steel by drawing and cabling; textiles by spinning and twisting)

Flexibility

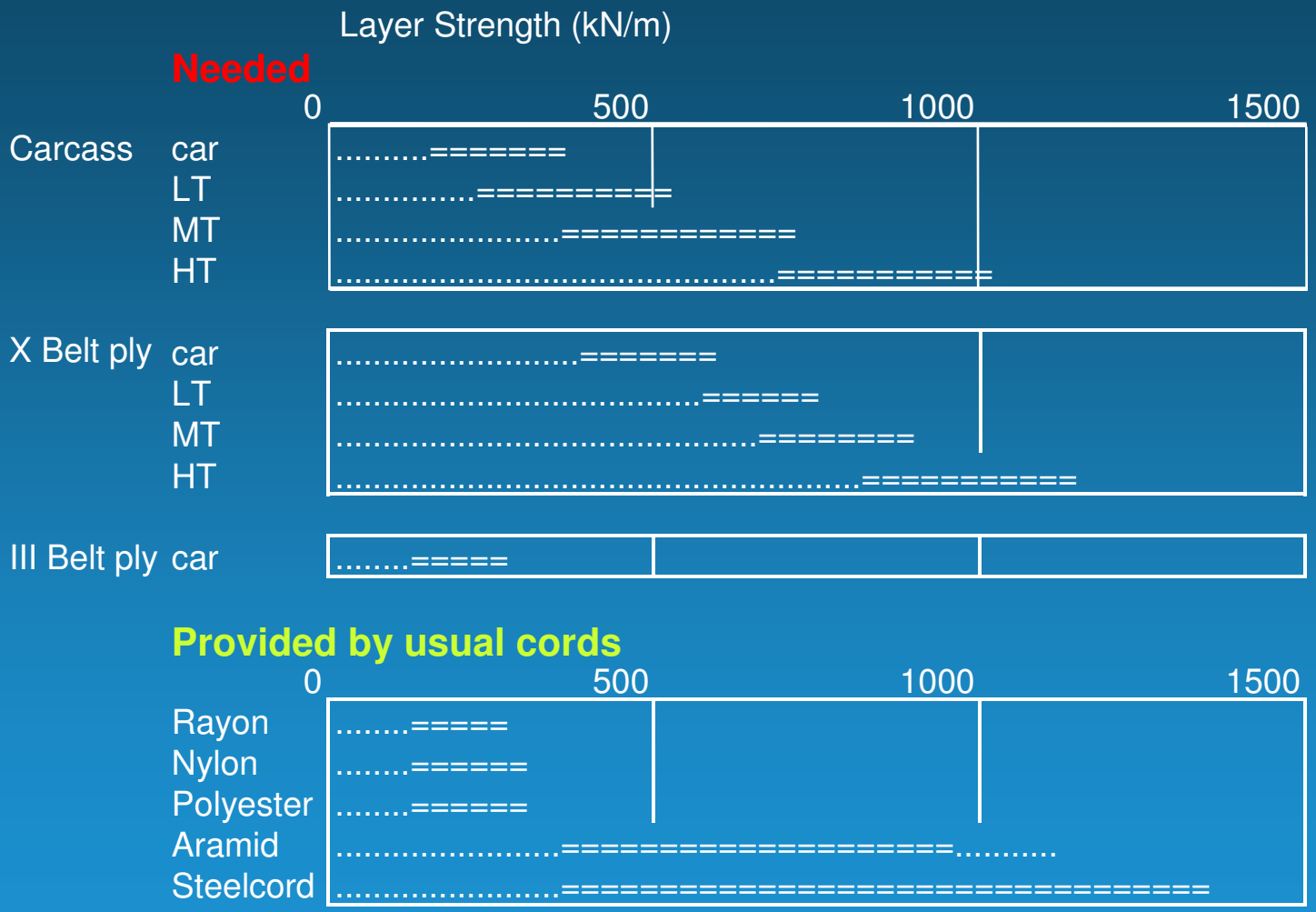
- Bundle or cord principle
- Thin filaments
- Adequate impregnation

Fatigue resistance

- Material structure
- Size filament
- Helix angle ("lay length"/ "twist")
- Adequate impregnation

Durable adhesion to rubber

Strength needed and provided



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What are high performance Tires ?

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What are high performance Tires ?

HP-Tires

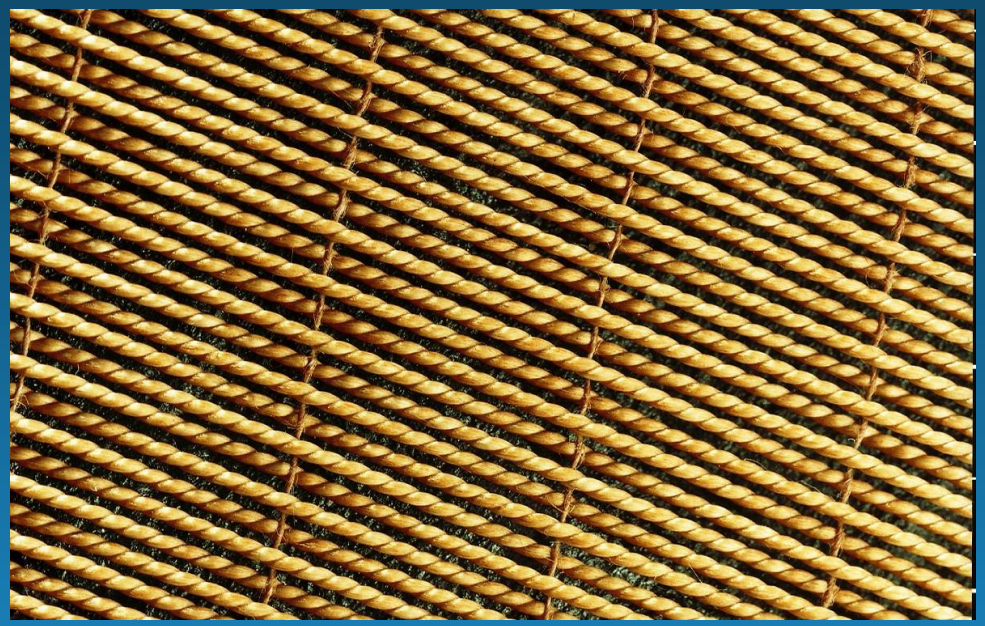
Tires with high requirements regarding high speed performance (Speed Rating >= H), combined with additional performance (handling, comfort, flat spot, noise, rolling resistance…)

UHP - Tires

The typical size range for UHP is:

Width:	>= 215 mm
Aspect ratio:	<= 50%
Rim size:	>= 17”
Speed Rating:	>= W (270 km/h)

Carcass



The carcass is the backbone of the tire.

The carcass determines the load carrying capacity, the comfort of the tire and the dynamic behavior.

Therefore the carcass material needs well-balanced proportion of strength to elasticity at all circumstances.

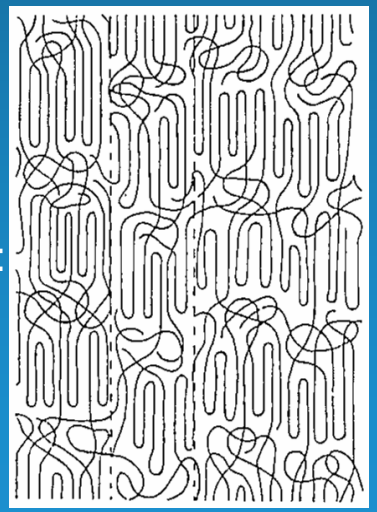
Intrinsic: Structure Materials

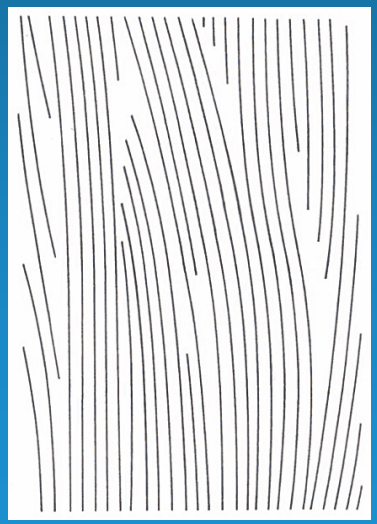
Semicrystalline
(meltspun)
Polyamide (PA 6, PA 6.6)
Polyester (PET)

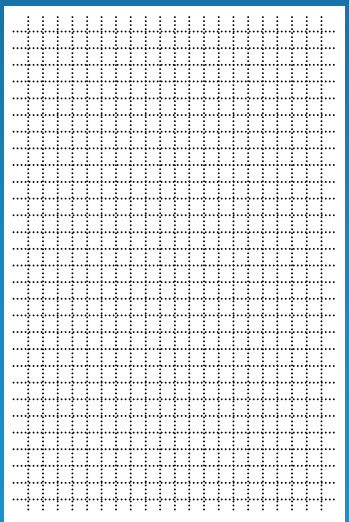
Paracrystalline
(wetspun)
Aramid
Cellulose (Rayon)

Crystalline-3D
(drawing)
Steel wire

:







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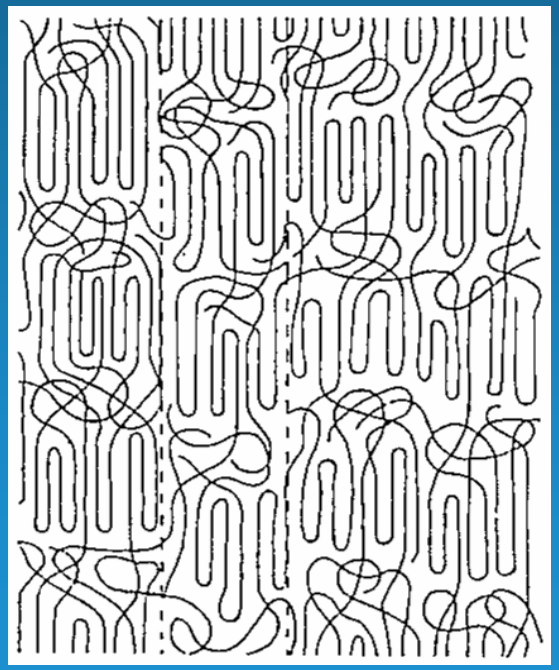
Intrinsic: Structure Meltspun Materials

- **Semicrystalline (meltspun)**

  Polyamide (PA 6, PA 6.6)
  Polyester (PET)



moderate strength
moderate modulus
high elongation at break
shrinkage
creep
no compression modulus
high flexibility
properties = f (T)

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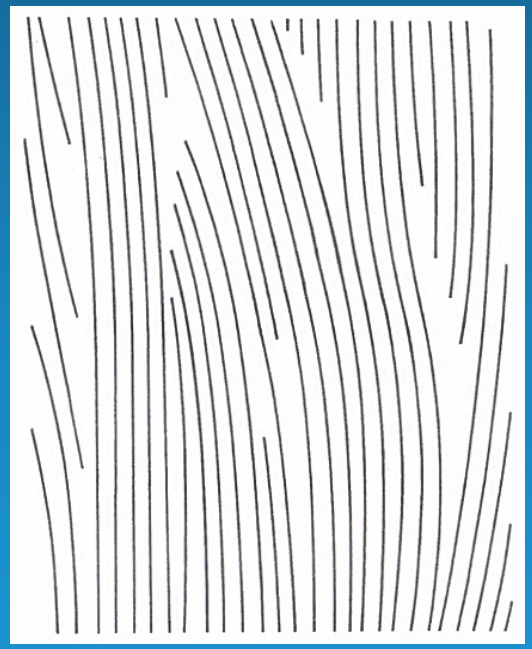
Intrinsic: Structure Wetspun Materials

- **Paracrystalline (wetspun)**

Aramid

very high strength
very high modulus
small elong. at break
no shrinkage
no compr. modulus
high flexibility
properties ≠ f(T)

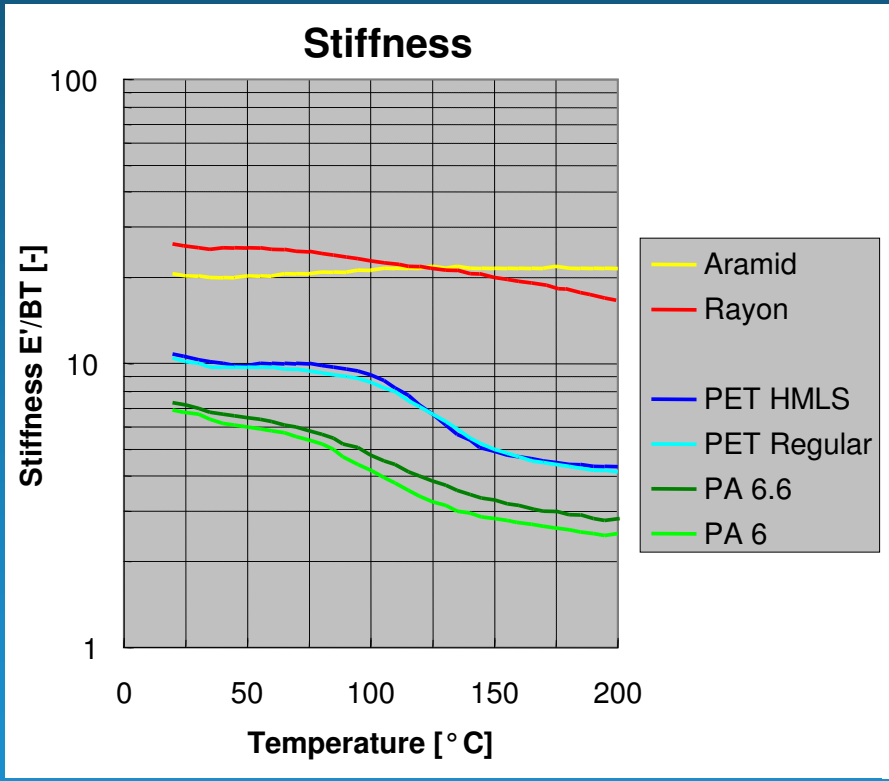


Cellulose (Rayon)

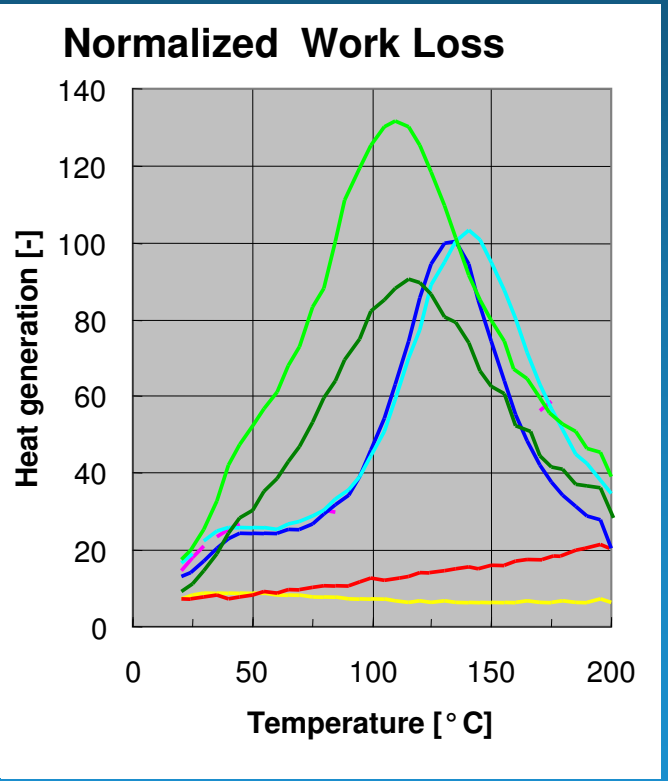
moderate strength
high mod./strength
high elong. at break
no shrinkage
no compr. modulus
high flexibility
properties ≠ f(T)

Temperature Scan: 6 materials, TF = 175, Load: 7-15% BS

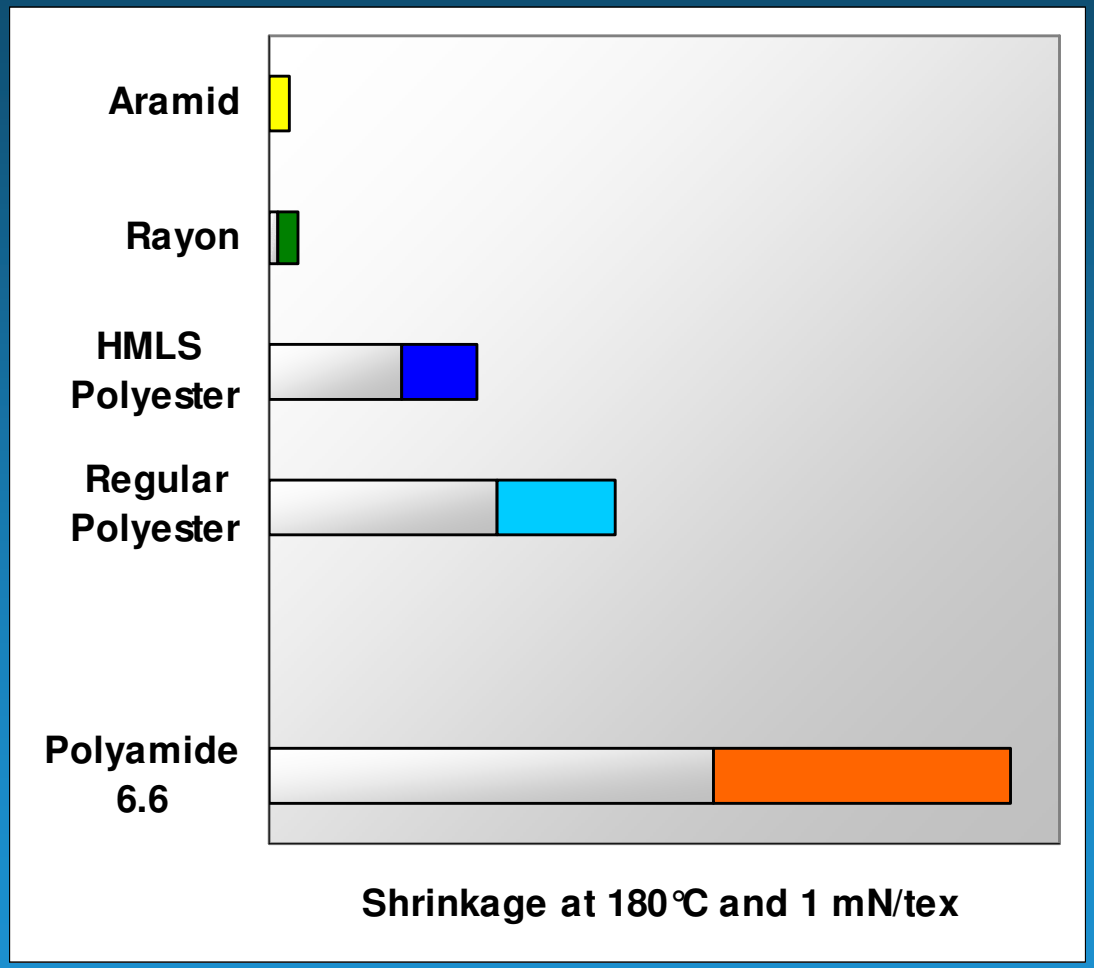
Dynamic Modulus



Work Loss / Heat generation



Wetspun vs. Meltspun
Thermal Shrinkage



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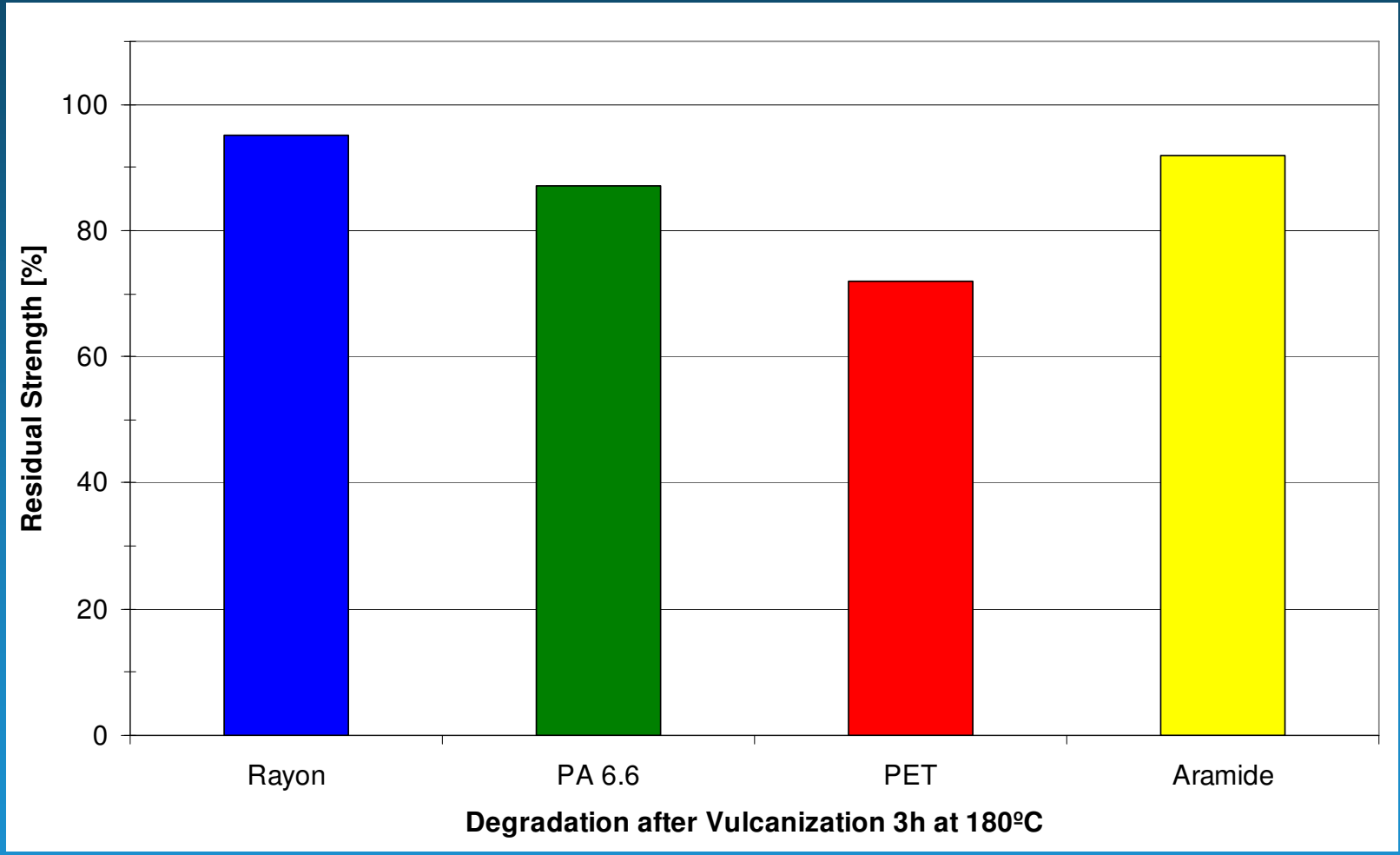
Wetspun vs. Meltspun
Thermal Degradation



Current Material in the Carcass

Carcass	PET	Rayon	Property
Handling	0	+	dyn. modulus
Uniformity	0	+	shrinkage
Side Wall Indentation	0	+	modulus
Flat Spotting	0	+	modulus (T,load)
Stability over time	0	+	
Robustness (Temp.)	-	+++	Temp. sensitivity
Fatigue Resistance	++	+	
Rolling Resistance	0	+	work loss, modulus
Noise	0	+	
Environment	0	0	
Renwable	no	yes	
Price	+	0	

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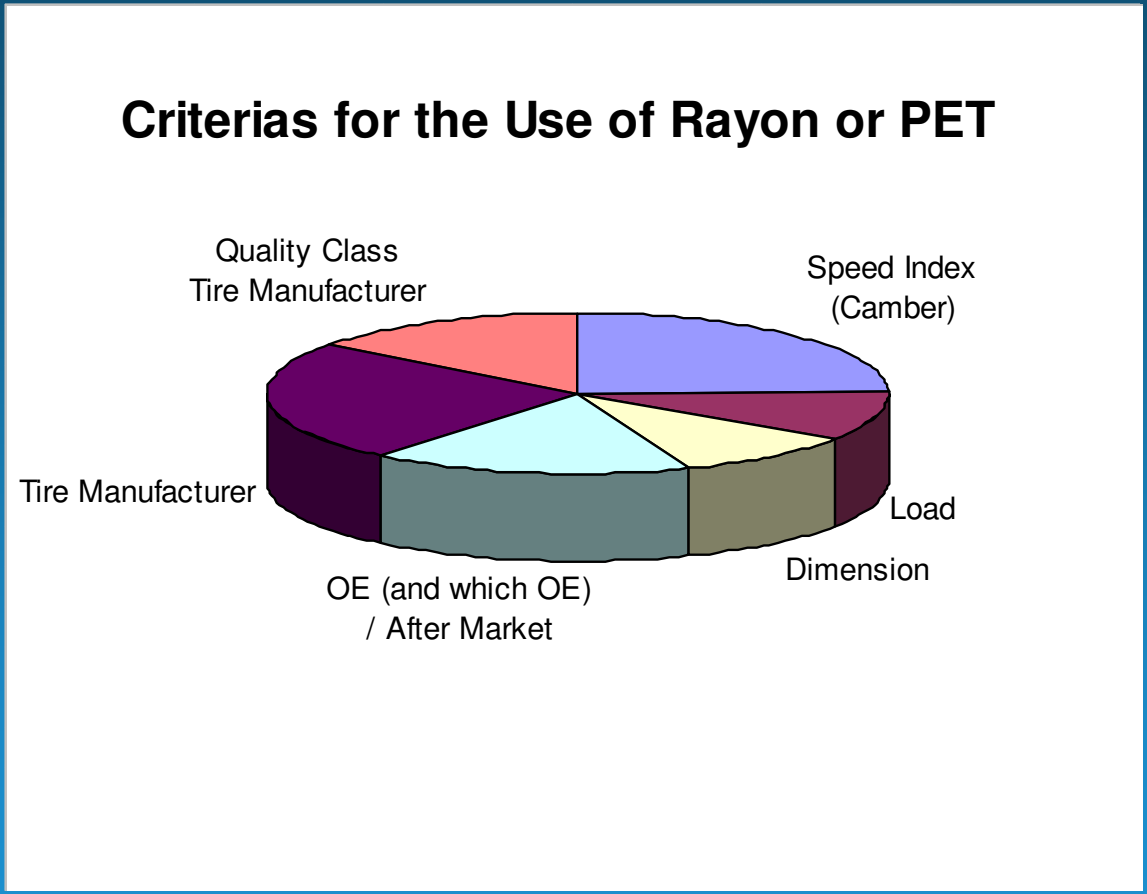
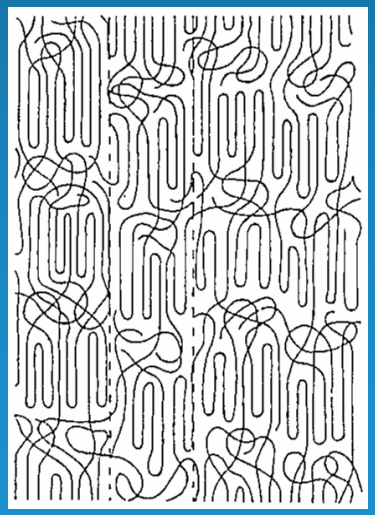
Rayon or PET ?

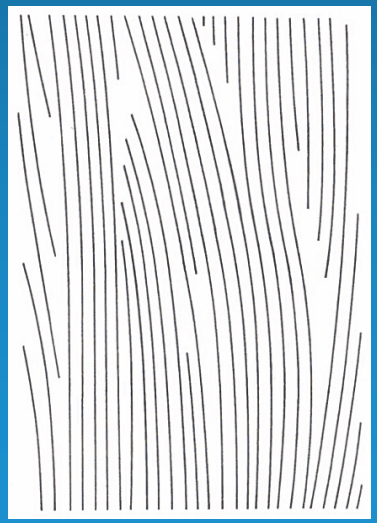

Criterias for the Use of Rayon or PET
Quality Class
Tire Manufacturer
Speed Index
(Camber)
Tire Manufacturer
Load
Dimension
OE (and which OE)
/ After Market

Alternatives

Semicrystalline
(meltspun)
PEN
Rayon-like PET
PA4.6

Paracrystalline
(wetspun)
Lyocell
POK





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Alternatives: Rayon – like - Polyester

- Stiffness significantly higher than standard HMLS PET

- Hot Air Shrinkage better, but close to standard HMLS PET

- FASE higher, but close to standard HMLS PET

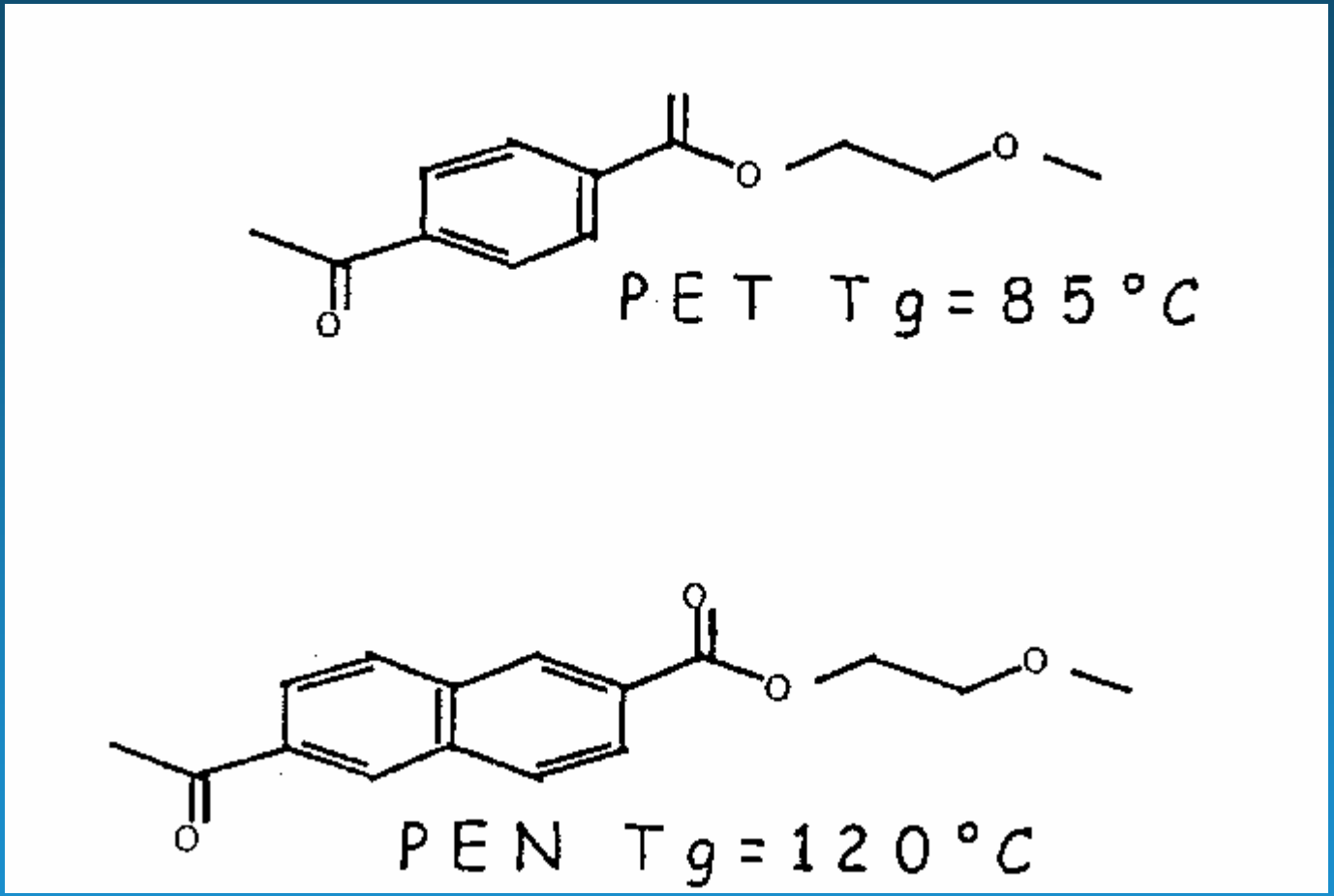
- Breaking Strength lower, but close to HMLS PET

-Temperature dependence of properties like Polyester

- linear density like Rayon

Conclusion: Polyester like Polyester with the linear density of Rayon

Alternatives: Polyethylene Naphtalate (PEN)



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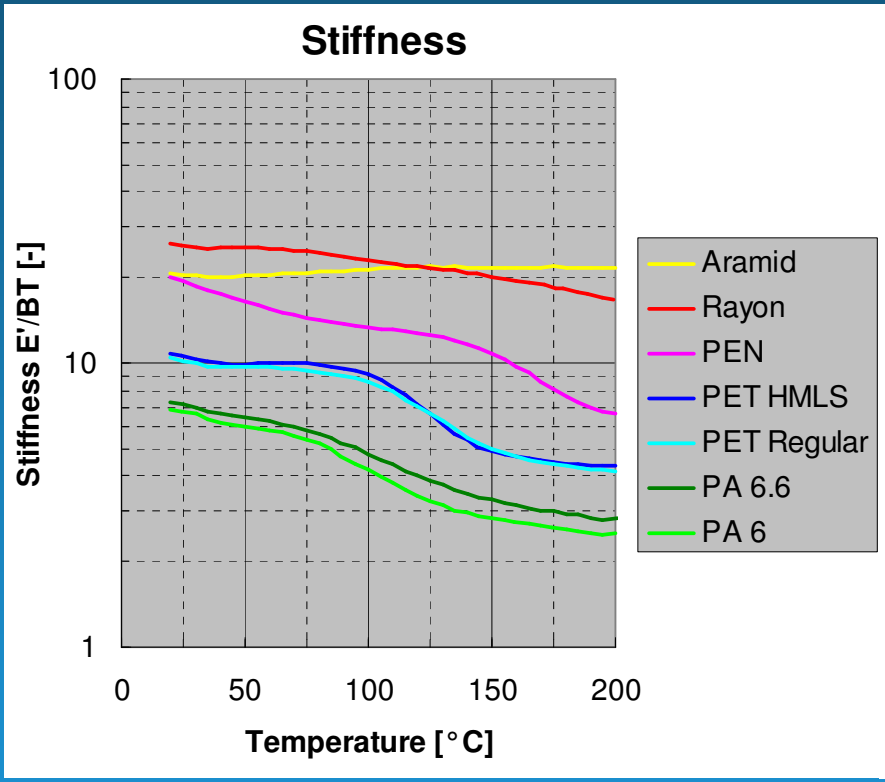
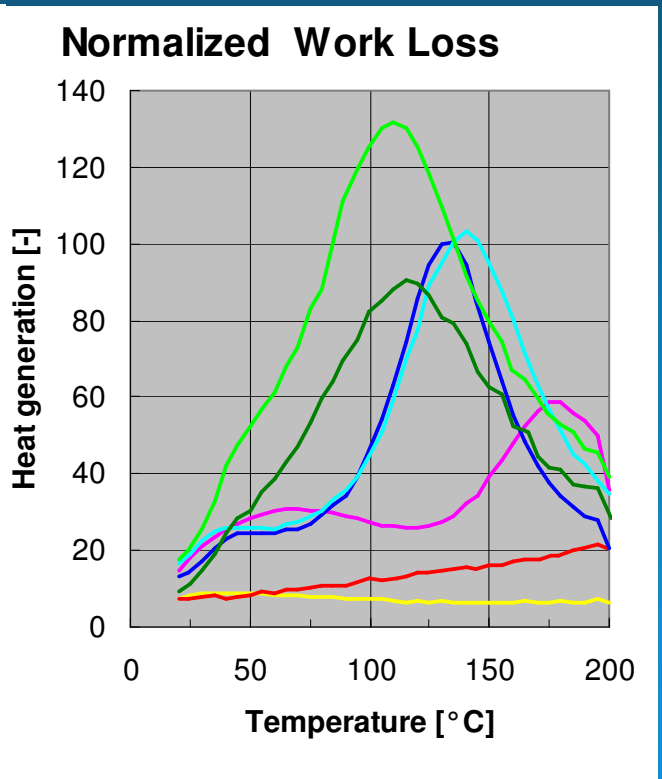
Alternatives: PEN

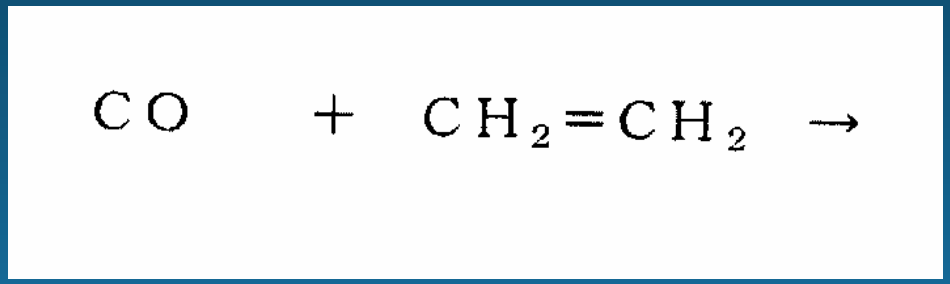
Dynamic Modulus

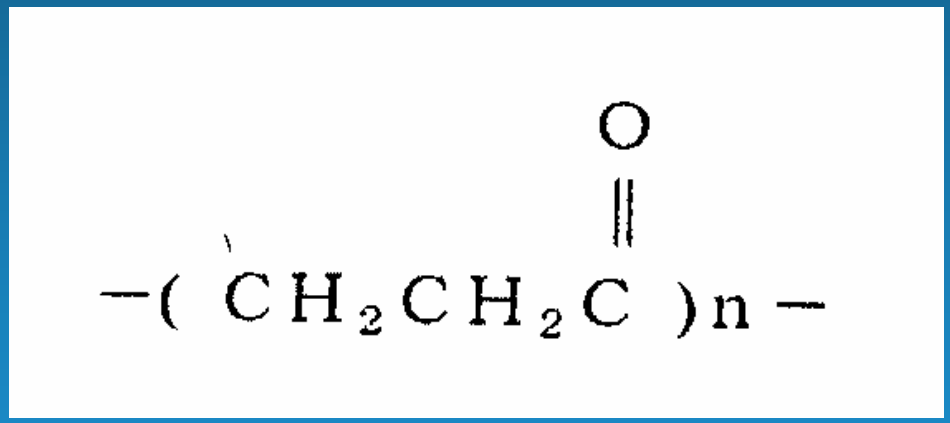


Work Loss / Heat generation



Alternatives: Polyketone (PK)





Poly-(1-oxotrimethylene)

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Alternatives: Polyketone (PK)

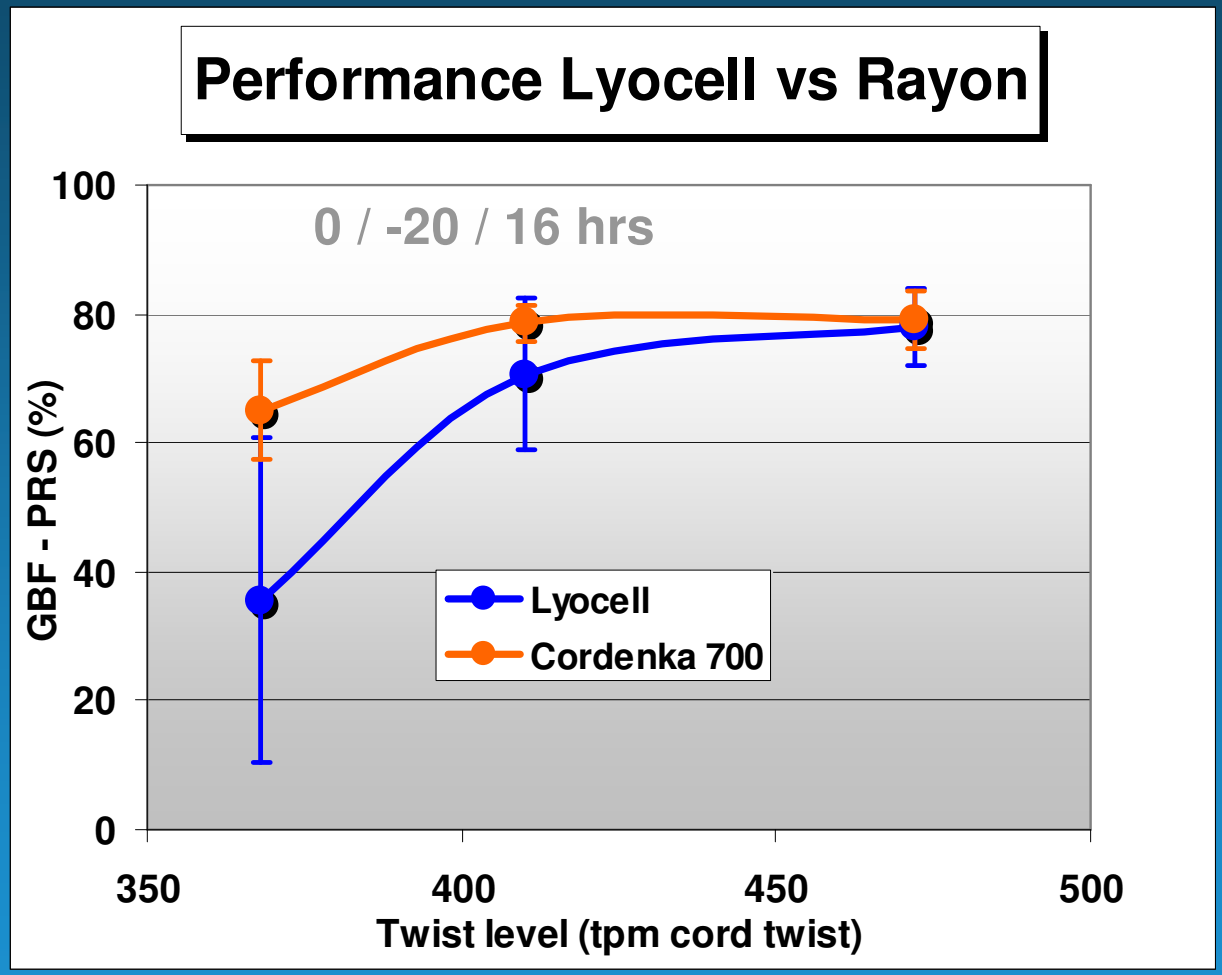
Treated Cord Properties

- Modulus: closer to Rayon than to Polyester
- Hot Air Shrinkage: between PET and Rayon
- Adhesion: between Rayon and PET
- Strength: higher than Rayon and PET
- elongation at break: about 50% of Rayon and PET

Alternatives: Lyocell

- **Comparable tenacity to Rayon Super 2 tire cord**
- **Higher modulus**
- **Significantly lower elongation at break** (EAB only 50 %)
- **Lower fatigue resistance especially for alternating load** (stress / compression)

Alternatives: Lyocell



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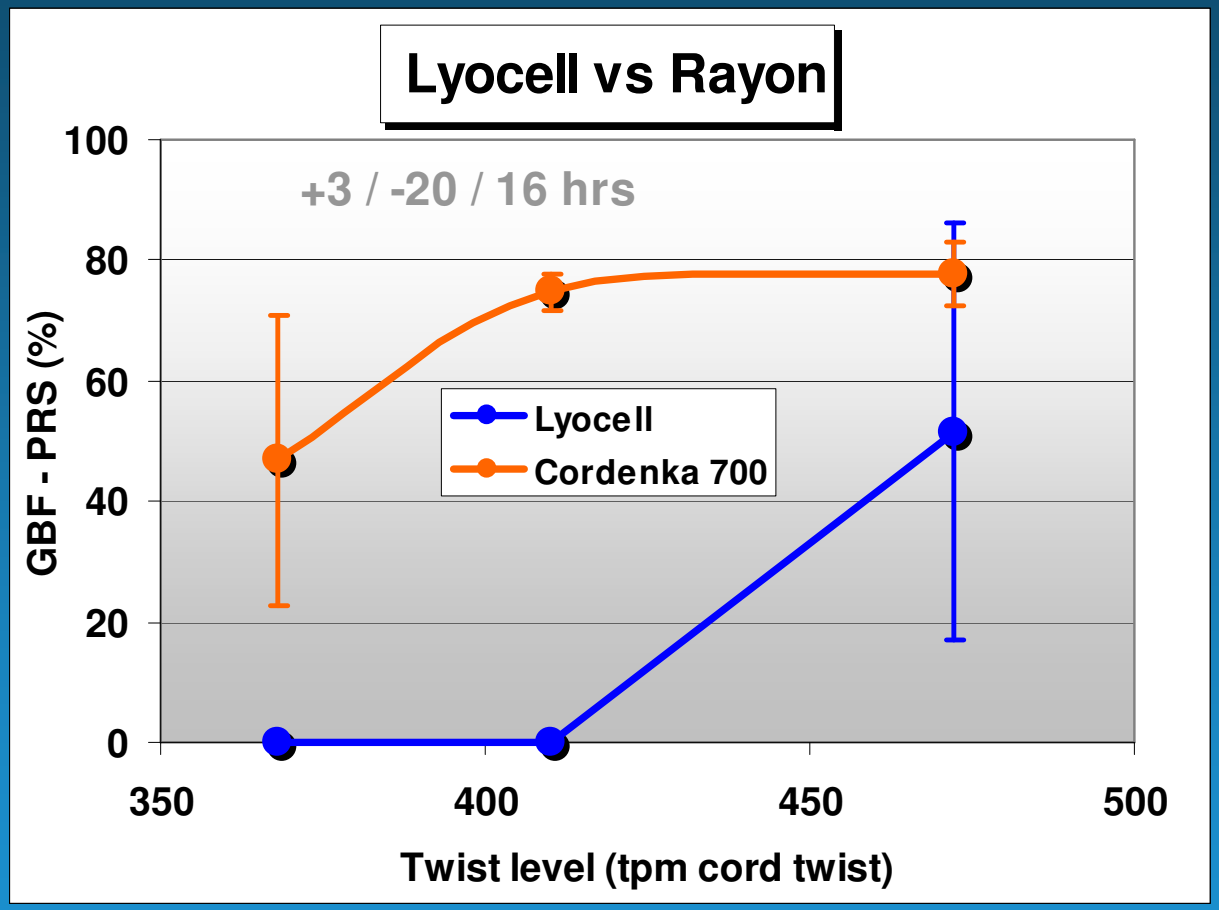
Alternatives: Lyocell



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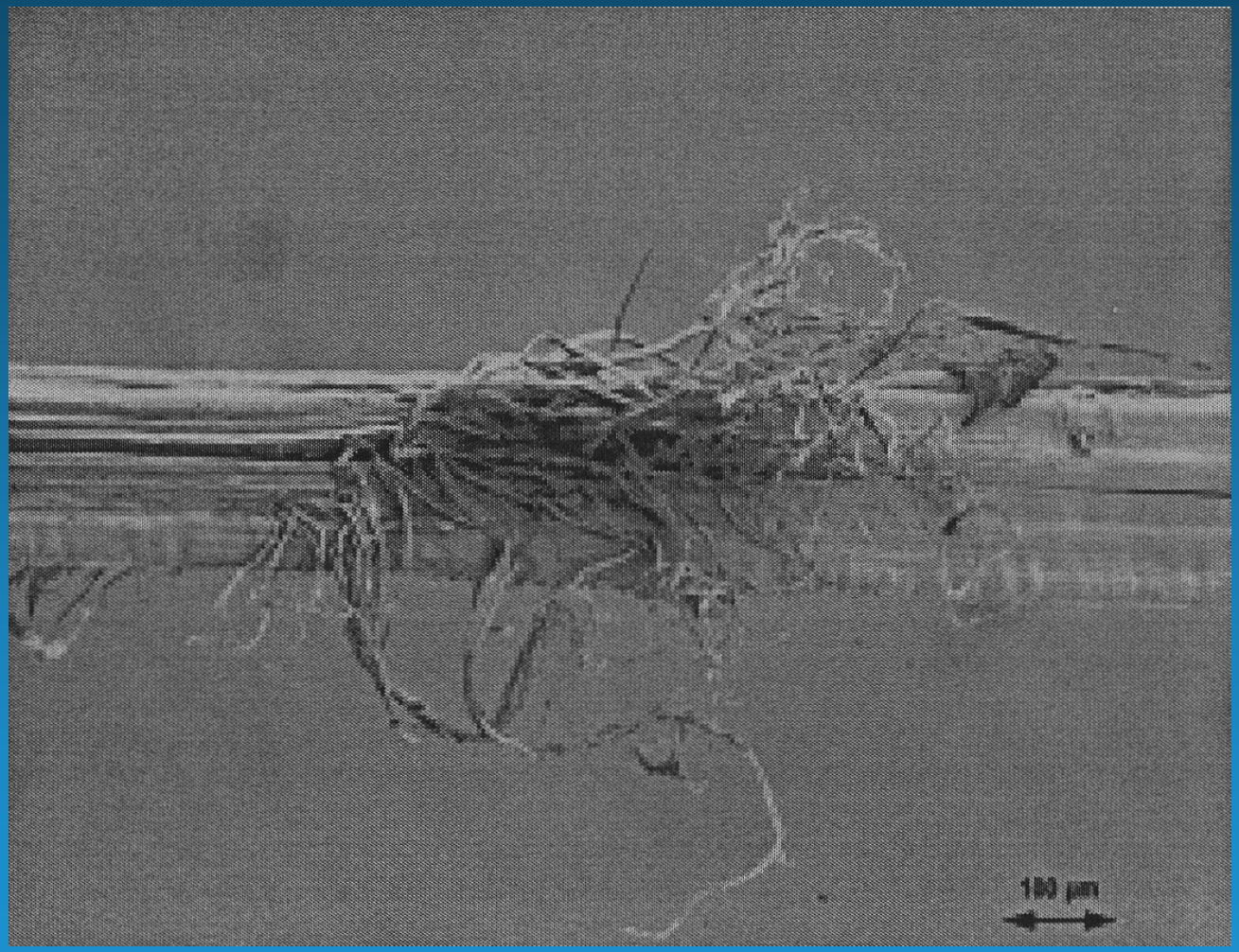
Alternatives: Lyocell (Fibrillation)



Conclusion

- Rayon is the material of choice for highest performance (incl. Run Flat Tires) at acceptable costs

- PET is the material of choice for acceptable performance and lowest costs

- Alternatives: Not better than Rayon and not cheaper than PET, might find some niches