Compostable Thermoplastic Starch/Biodegradable Polyester Polymer Blends

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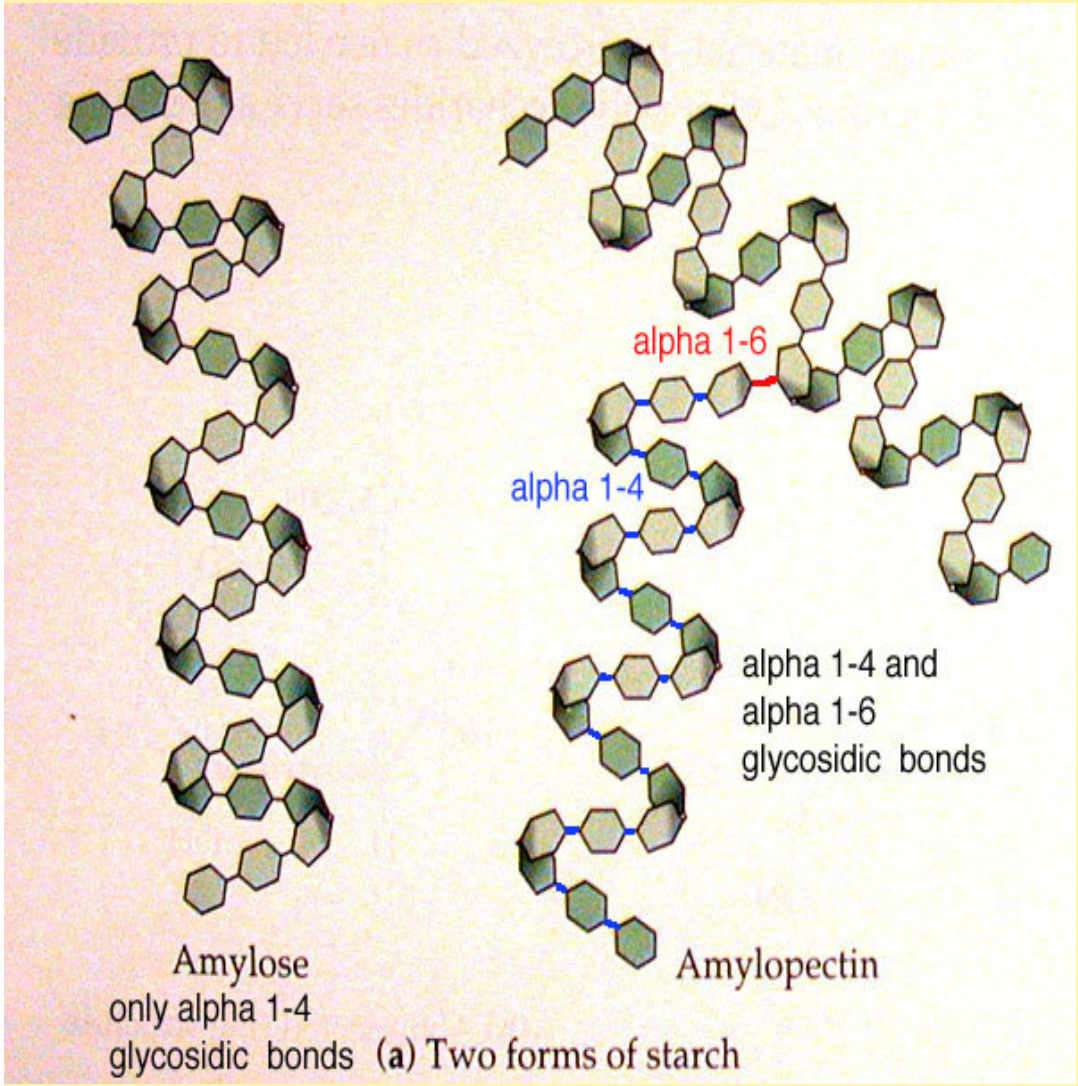
Outlines

- Starch and Thermoplastic Starch (TPS)
- TPS Process Technology
- Teknor Apex Terraloy™ vs Other Commercial Grades
  - Terraloy™ vs LDPE
  - Terraloy™ vs LLDPE
  - Terraloy™ vs PBAT
- ASTM D-6400
- Life Cycle Analysis
- Teknor Apex Terraloy Technology Value Proposition
- Typical Markets & Applications
- Summary

Starch

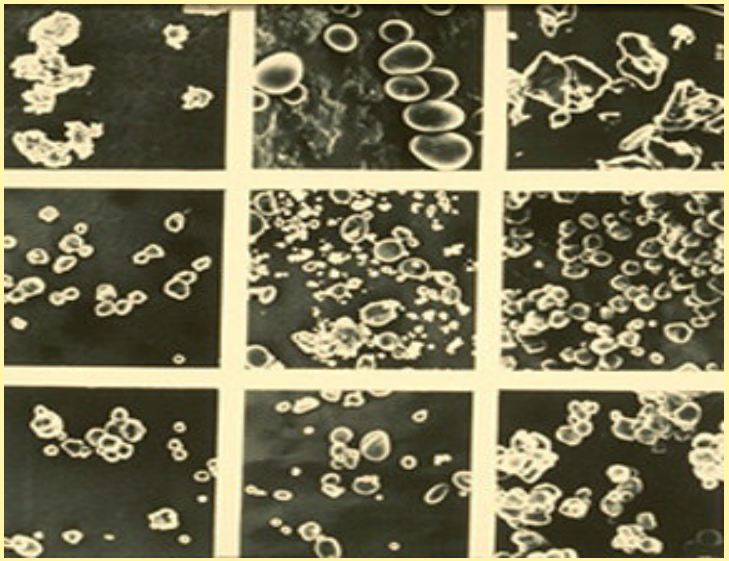


Starch is a polymer of repeating glucose units which is polar in nature.

The structure may be in two physical forms. Amylose the crystalline form, and Amylopectin the amorphous form.

Source: http://academic.brooklyn.cuny.edu

Starch



The granules are coarse and have filler like properties when blended with a polymer

Starch may be converted to a thermoplastic polymer by plasticizing with glycerol and water. On removal of the water, the resulting TPS may be added to polymers without significant change in physical properties.

Non-polar polymer blends require a compatibilizer for optimal performance.

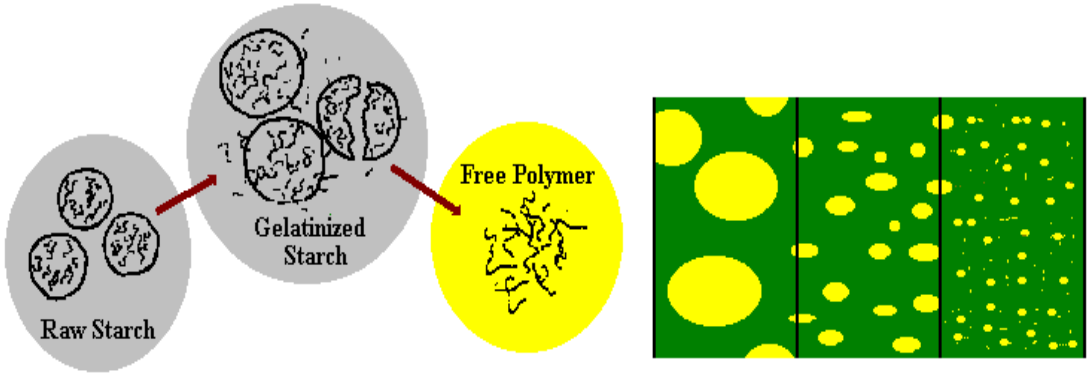
Source: Text from Keeling (©1998)

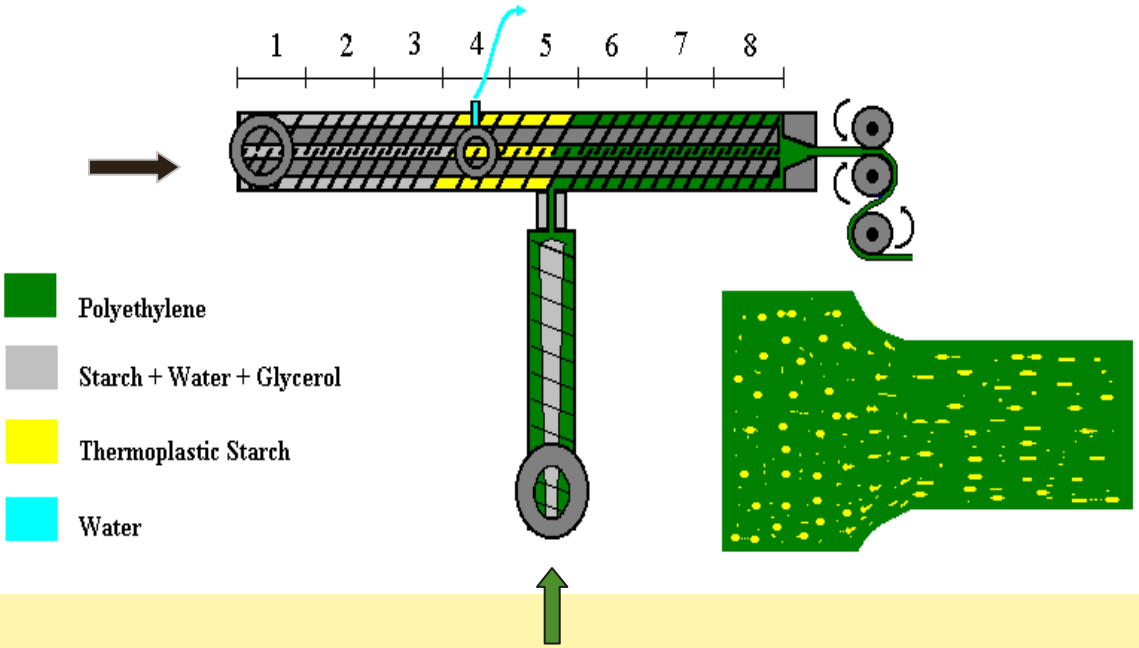
Thermoplastic Starch (TPS) Defined

- TPS: Starch which has been transformed from a coarse granule to a fluid similar to other thermoplastics using melt extrusion
- This is achieved with heat in the presence of water and/or plasticizer
- TPS on it's own, is susceptible to moisture uptake and has low mechanical properties. These failings may be overcome by blending polymers and/or additives with TPS
- The successful transformation into a plasticized starch/polymer blend is a complex operation requiring a balance of residence time and temperature in melt extrusion

Source: Li Gang et. al.

Producing a Useful TPS/Polymer Blend





Patented Process Technology

A slurry of starch, water, and glycerol are fed to a twin screw extruder.

A polymer melt is introduced after the starch is plasticized and the water driven-off.

The resulting compound is a co-continuous mixture of TPS & polymer.

Versatility of Terraloy TPS Technology

	Fossil-based	Bio-based = Renewable
Non-biodegradable	Commodity (PP, PE, PS..)	Biobased-PE Biobased-PVC Polytrimethyl terephthalate (PPT) Polyurethane (PU) Polyamide (PA 11) TPS- PE, PP or PS PLA- Engr Plastics
Biodegradable	PolycaproLactone (PCL) Polyvinyl Alcohol (PVA) Polyethylene Succinate (PES) Polybutylene Succinate (PBS) Polybutylene Succinate –co-Adipate (PBSA) Polybutylene adipate-co-terephthalate (PBAT)	Cellulose Acetate (CA) TPS-PLA Polylactic acid (PLA) Polybutylene Succinate-co-L-lactate (PBSL) Polyhydroxyalkanoates (PHA: PHB, PHBV…)

Terraloy™ TPS

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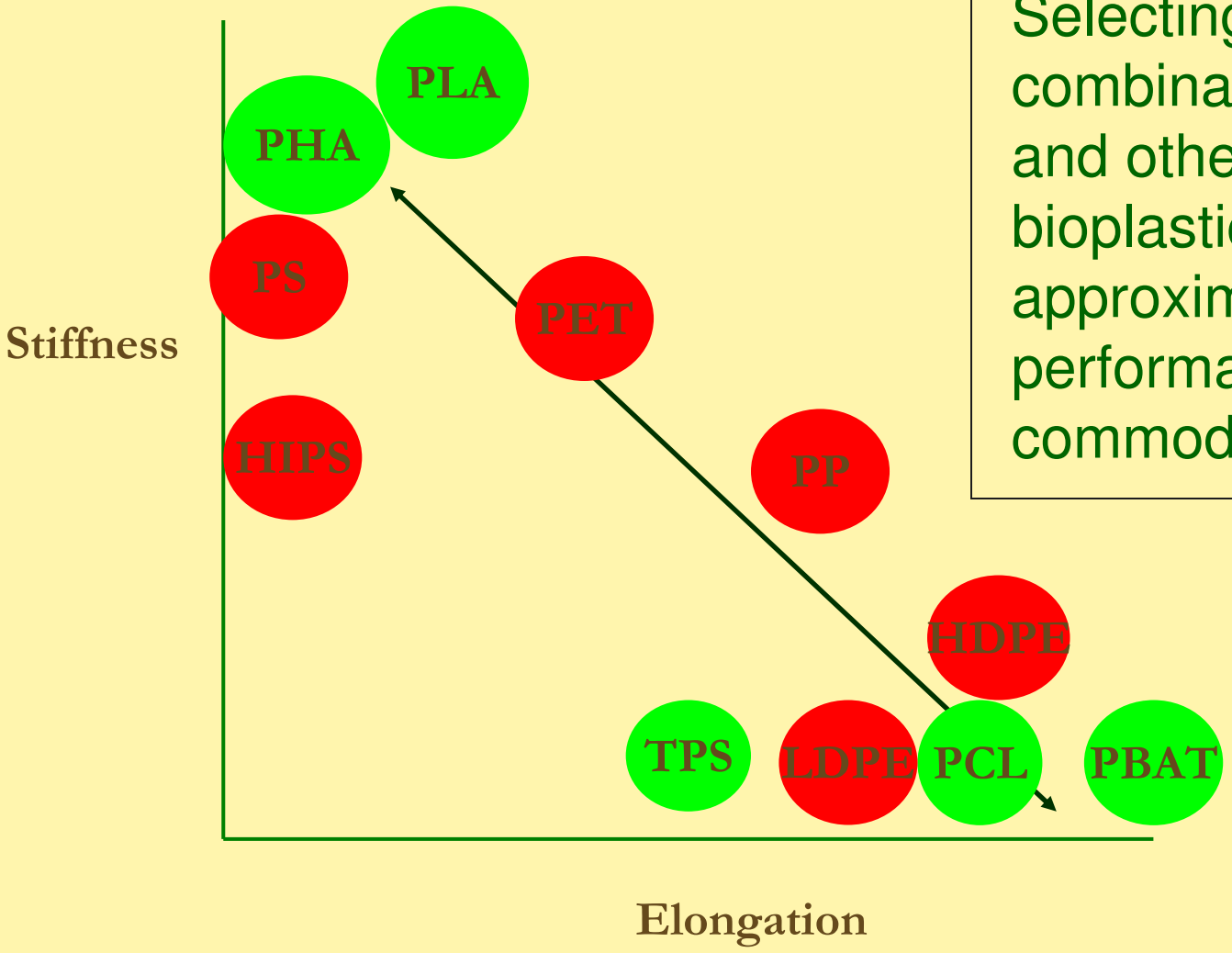
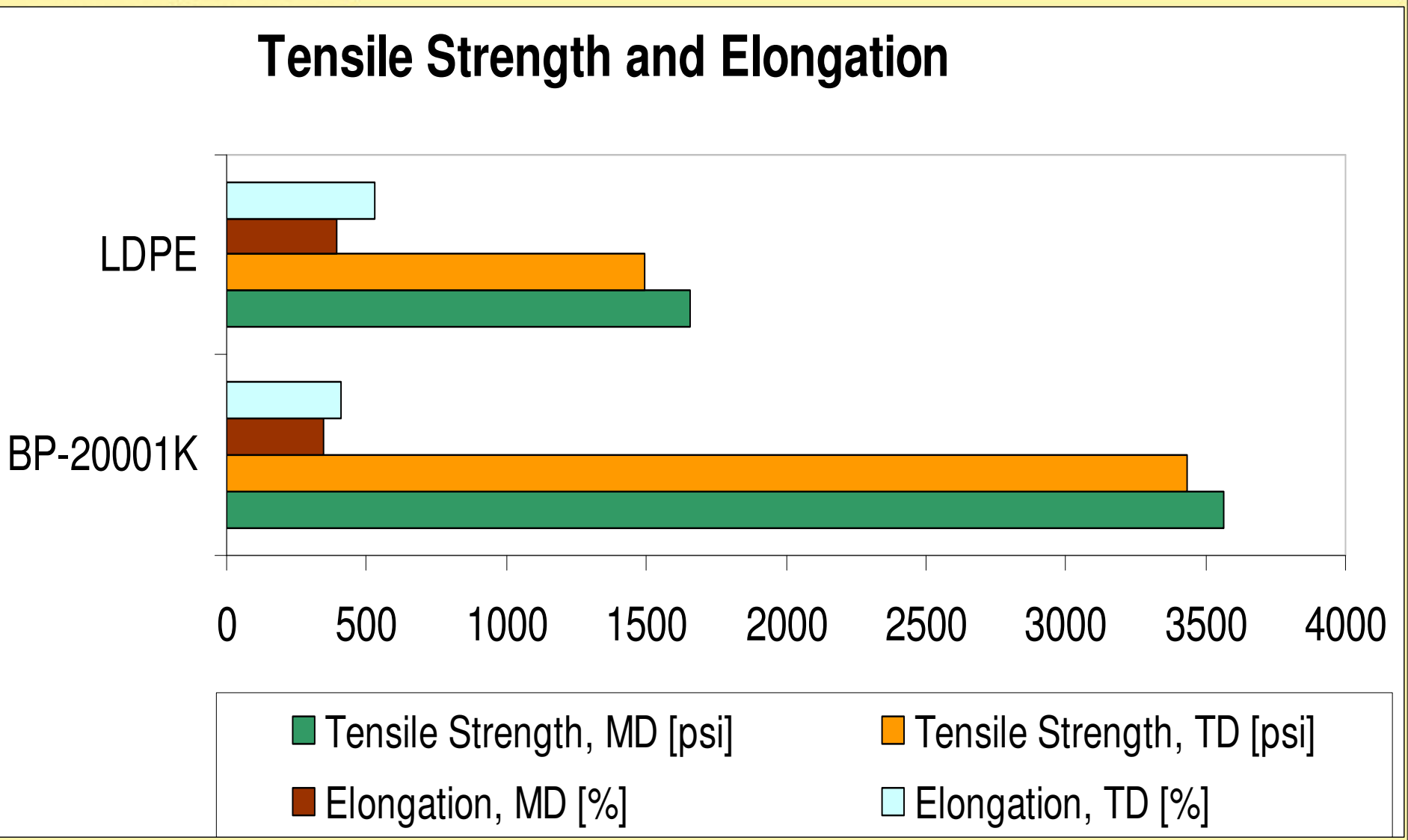
Bioplastisc and Commodity Plastics



Selecting the right combination of TPS and other polymers or bioplastics can approximate the performance commodity plastics

Terraloy™ BP-20001K vs. LDPE



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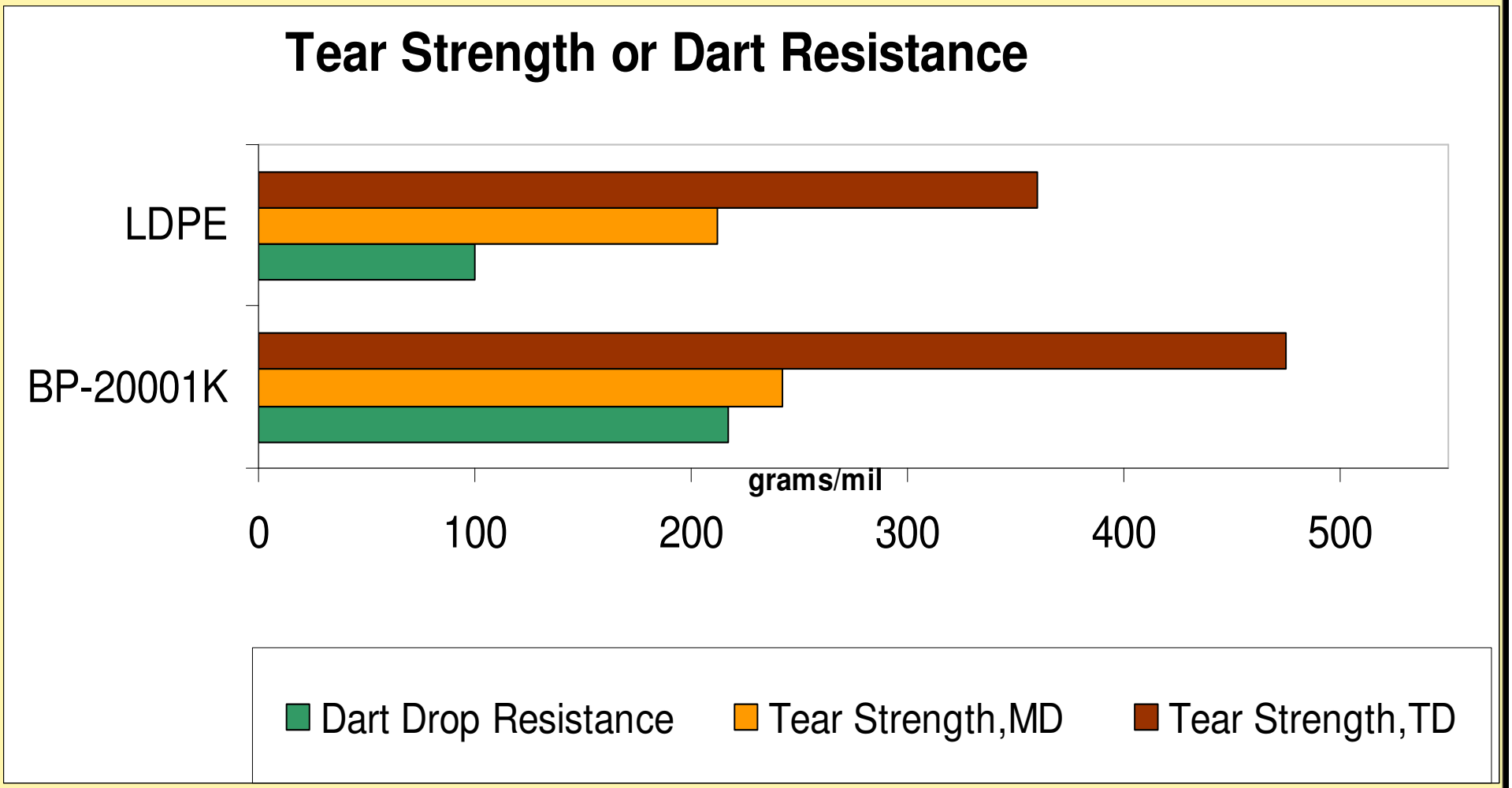
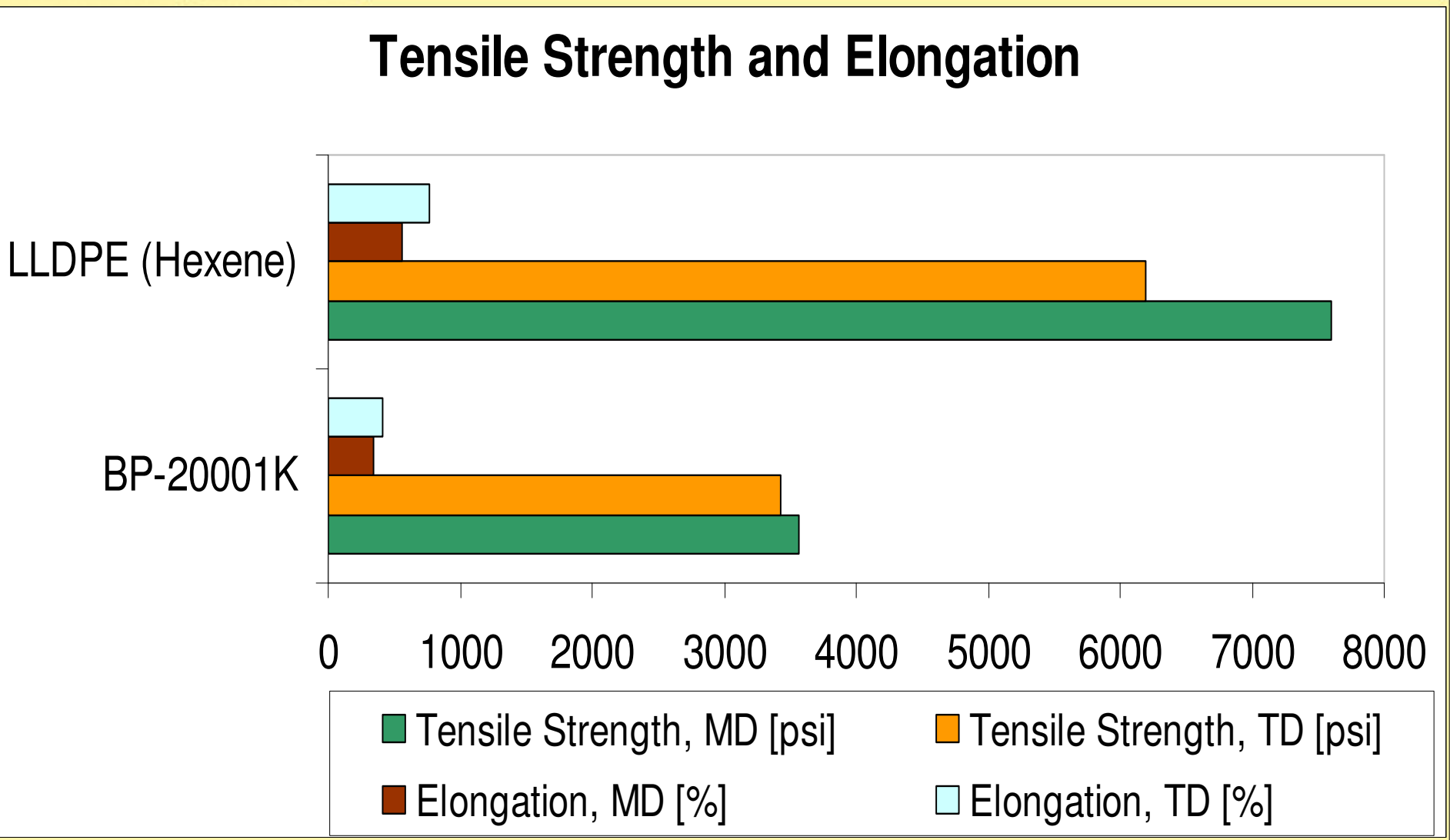
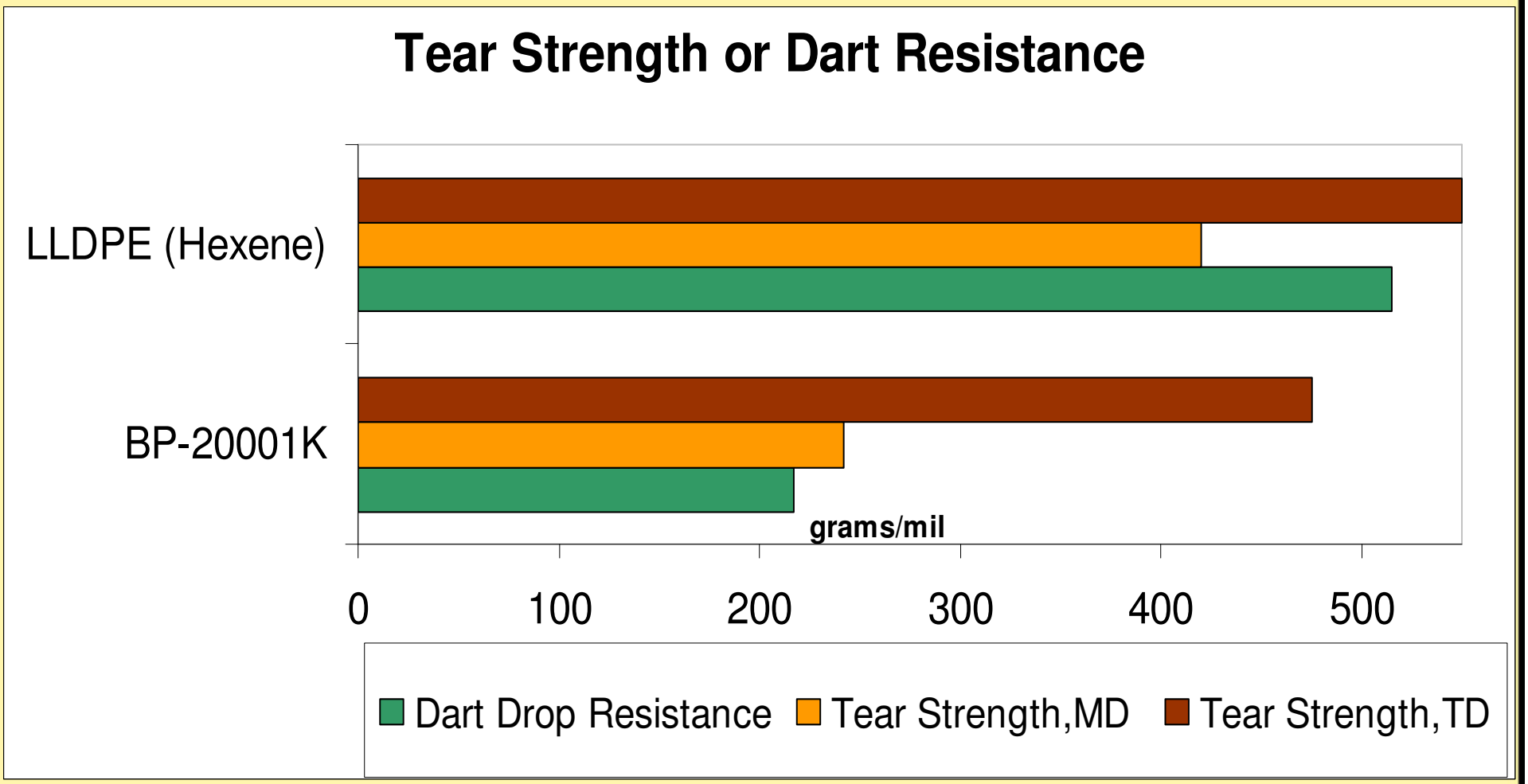


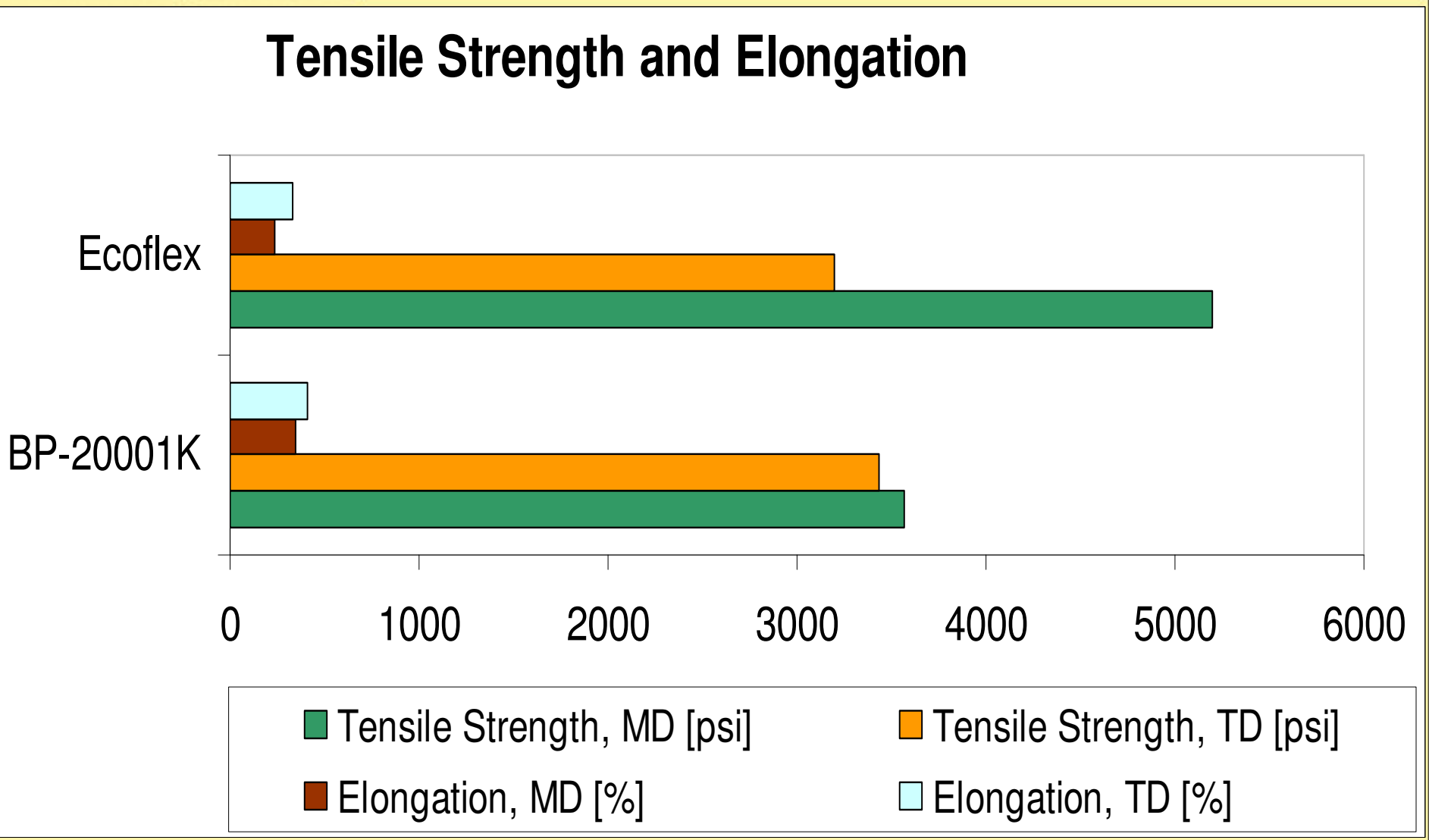
Terraloy™ BP-20001K vs. LLDPE



Terraloy™ BP-20001K vs. LLDPE



Terraloy™ BP-20001K vs. PBAT



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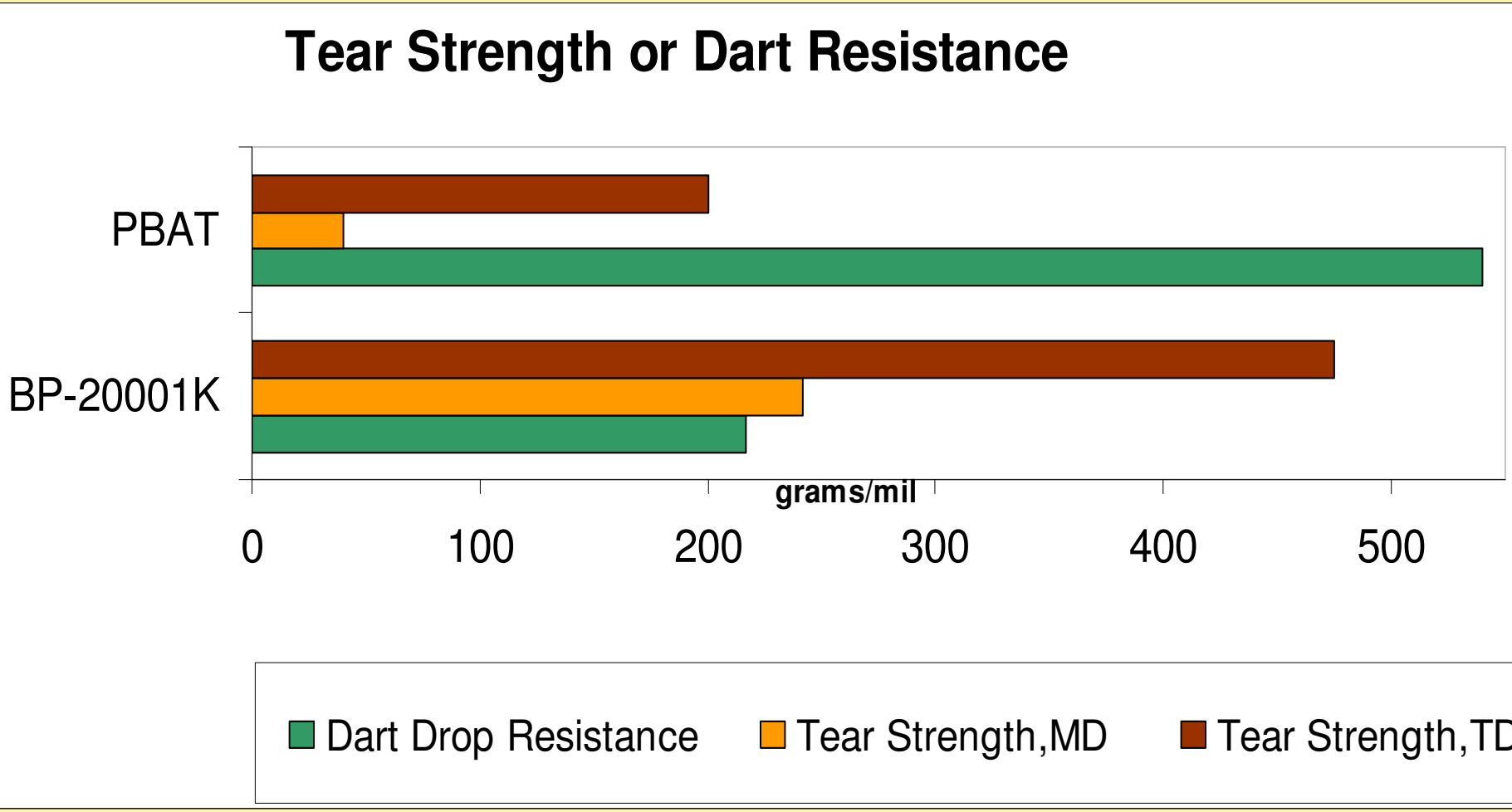

ASTM D6400 Test for Compostability

BIODEGRADABLE vs. COMPOSTABLE

BIODEGRADABLE
Plastics break down via the action of naturally occurring microorganisms such as bacteria and fungi

COMPOSTABLE
Plastics break down into CO2, H2O and biomass at the same rate as paper without leaving toxic residues.

Three Criteria for ASTM D6400

1. Biodegrades to CO2, H2O and biomass at the same rate as paper
2. Disintegrates, leaving no visible pieces
3. Eco-Toxicity – degradation does not product toxic materials and the compost can still support plant growth

COMPOSTABLE
Biodegradable Products Institute | US COMPOSTING COUNCIL

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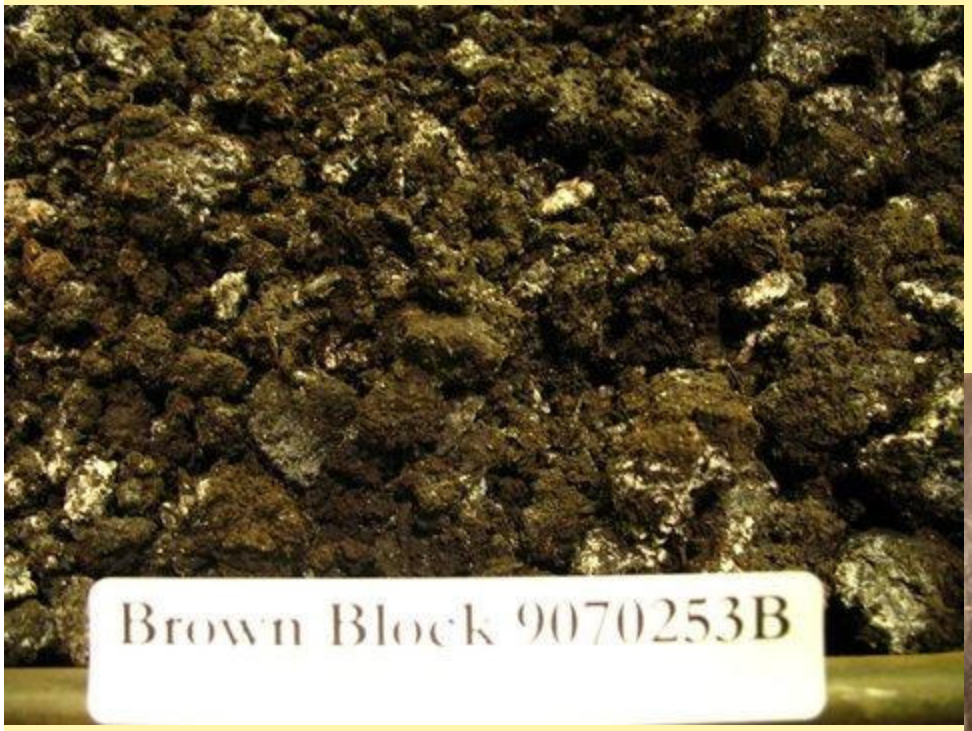
ASTM D6400- TPS

Environmental Benefit: Compostability

ASTM D6400- TPS



Environmental Benefit: Complete disintegration

ASTM D6400: TPS Compostability

Environmental Benefit:
Support plant growth

BPI Listed that meets ASTM D-6400

Teknor Apex Company
Terraloy Bioplastics
Compound BP-20001
meets ASTM D-6400
and listed at BPI

BPI Biodegradable Products Institute
promoting biodegradable products throughout the world

COMPOSTABLE
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Life Cycle Analysis

Determines product's environmental performance from cradle to gate or cradle to grave, including:

- Natural resource depletion
- Release of harmful substances and impact
- Local and global scale

Measured by total Greenhouse Gas Emissions, GHG.

Note:
GHG emissions are significantly lower with TPS versus petroleum-based resins and other bioplastics.

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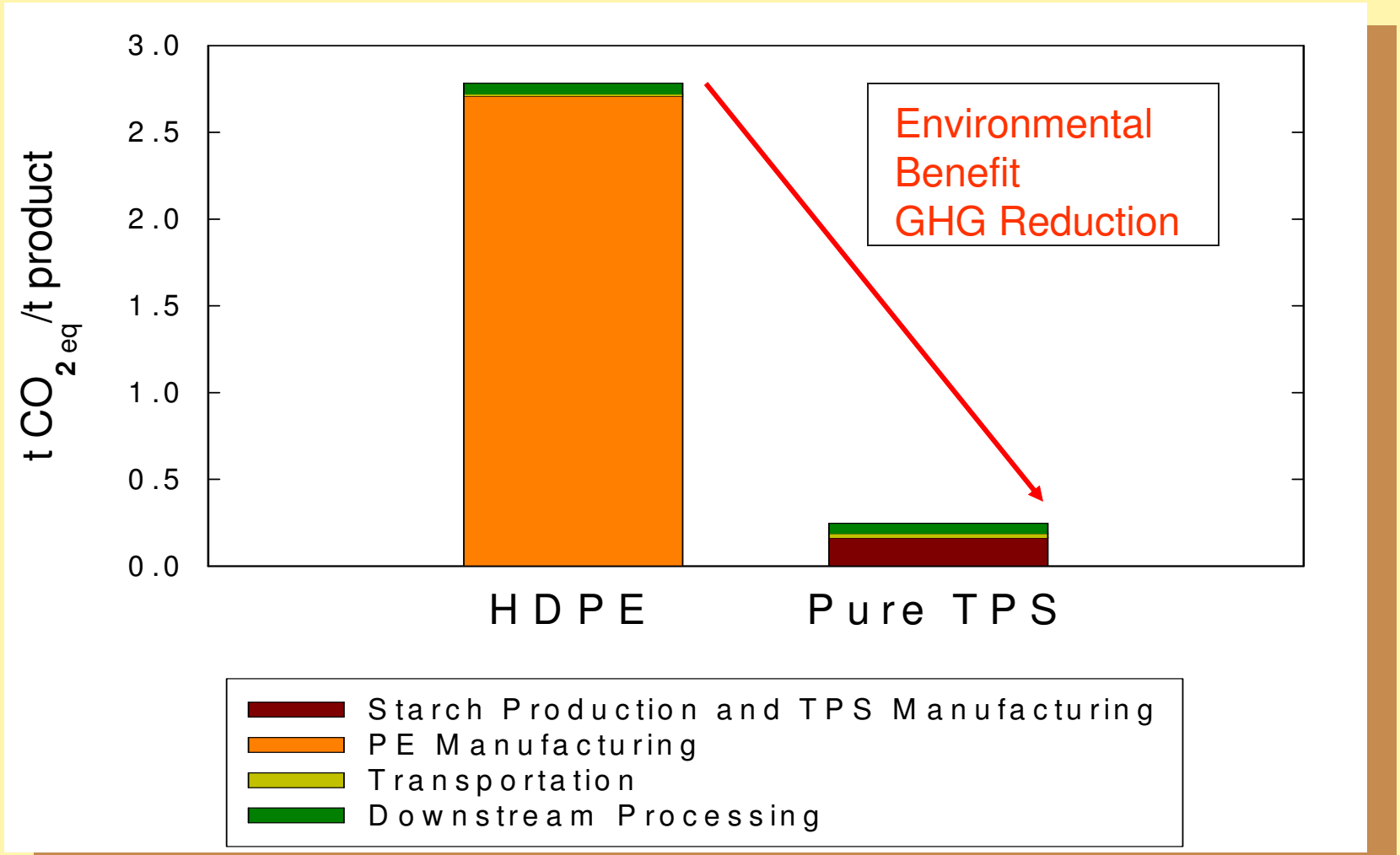
Green House Gas Reduction for HDPE



(1) GHGenius Feedstocks, Power, Fuels, Fertilizers and Materials p.25 Table 4.10
(2) Canadian Raw Materials Database, University of Waterloo, http://crmd.uwaterloo.ca/
(3) Canada's National Inventory Report 1990-2004, http://www.ec.gc.ca/pdb/ghg/inventory_report/2004_report/toc_e.cfm
(4) Canada's GHG Verification Center, 2004

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Teknor Apex's Value Proposition

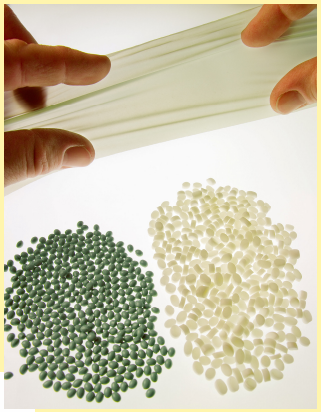
85 YEARS OF COMPOUNDING EXPERTISE

The ability to customize formulations to fit your end-use requirements.

We balance PRICE, PERFORMANCE, and PROCESSABILITY, to meet your *SUSTAINABILITY GOALS*.

Potential Applications of TPS/Blends

- Trash Bags
- Packaging
- Foam packaging
- Mulch Film
- Shopping Bags (a.k.a. T-Shirt bags)
- Disposable Cups and Utensils
- Horticulture (potting trays)



Disclaimer: pictures are for illustration only, they are not necessary made out of Teknor Apex Terraloy bioplastics Grades

Summary

- Thermoplastic Starch blend (TPS) is a versatile resin that be compounded with commodity thermoplastics such as LLDPE, LDPE, MDPE, HDPE, GPPS and HIPS
- TPS can also be compounded with other bioplastics such as PLA, PBAT and PHA
- TA's patented technology has better mechanical properties than other commercial TPS grades due to process technology and formulation optimization
- Terraloy™BP-20001 has excellent film properties such as tear strength and dart impact

Summary

- Terraloy BP-20001meets ASTM D-6400 and currently listed by BPI
- TPS has much lower GHG than petroleum resins
- Markets and applications are quite broad for TPS blends
    - Film
    - Packaging
    - Consumer products
    - Food services
    - Others

Presenter wants to thank:

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Cerestech Company

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Questions and Comments

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TERRALOY™ TEKNOR APEX BIOPLASTICS DIVISION

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Footnotes:

Terraloy™ trademark of Teknor Apex Company
www.teknorapex.com