

# **PHACT Amorphous PHA Enables Unique Bio-based and Compostable Products for Flexible Packaging Applications**

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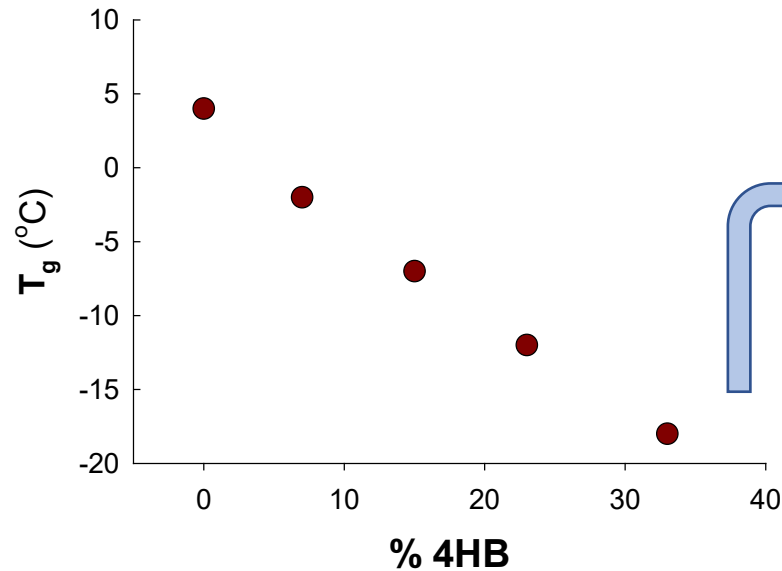
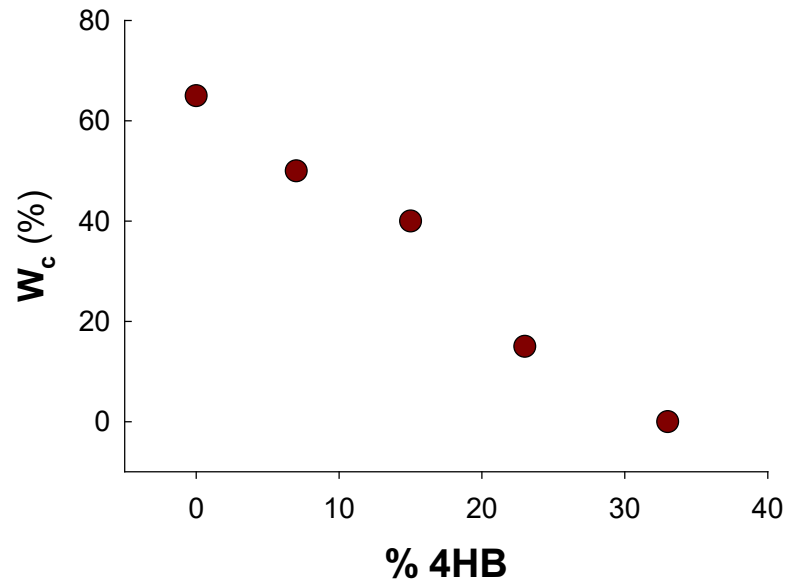
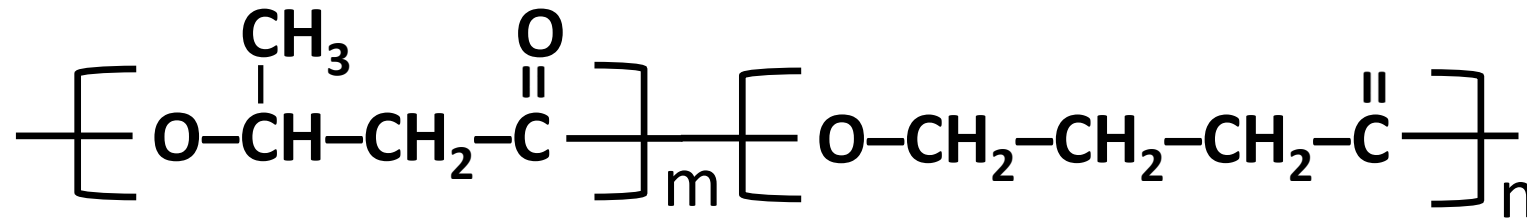
Bring a New Wave

**PHACT**

*By controlling polymer composition, we can create unique PHAs with a broad range of performance*

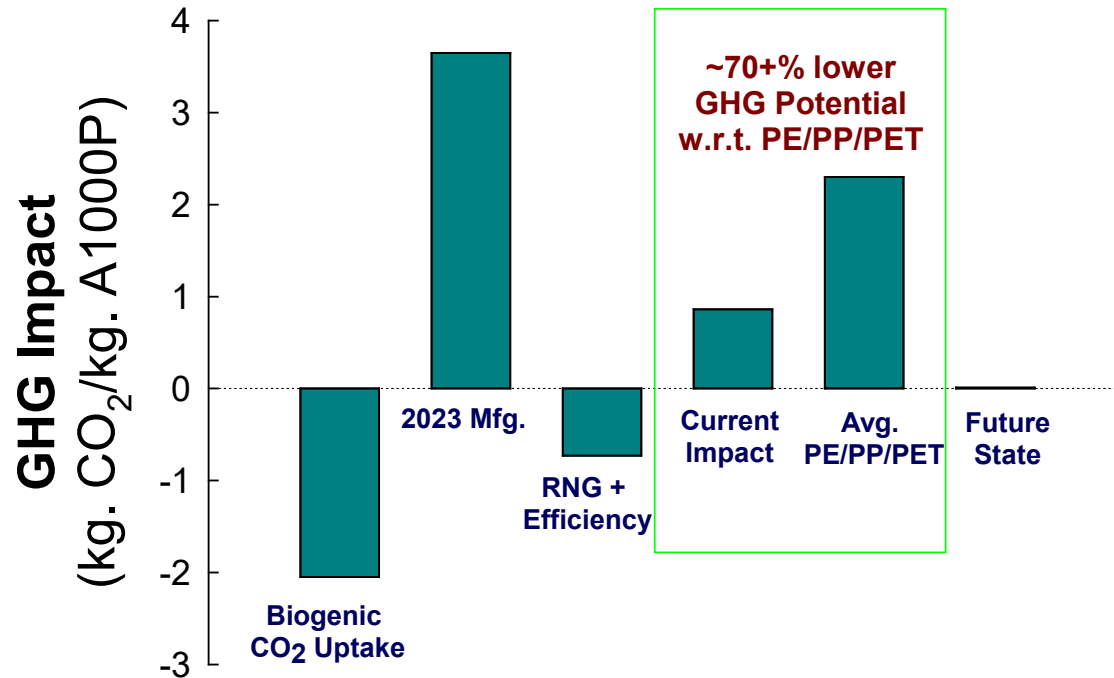
## P(3HB-co-4HB)

Poly(3-hydroxybutyrate-co-4-hydroxybutyrate)



Amorphous PHA  
**PHACT A1000P**

## A1000P Global Warming Potential



- Current State ~ 70+% GHG advantage relative to conventional polymers.
- Future - planned production plant will produce carbon neutral polymer.

## Certified Biodegradable

- Soil (Ambient)
- Home Compost
- Industrial Compost
- Fresh Water
- Marine Water
- Anaerobic

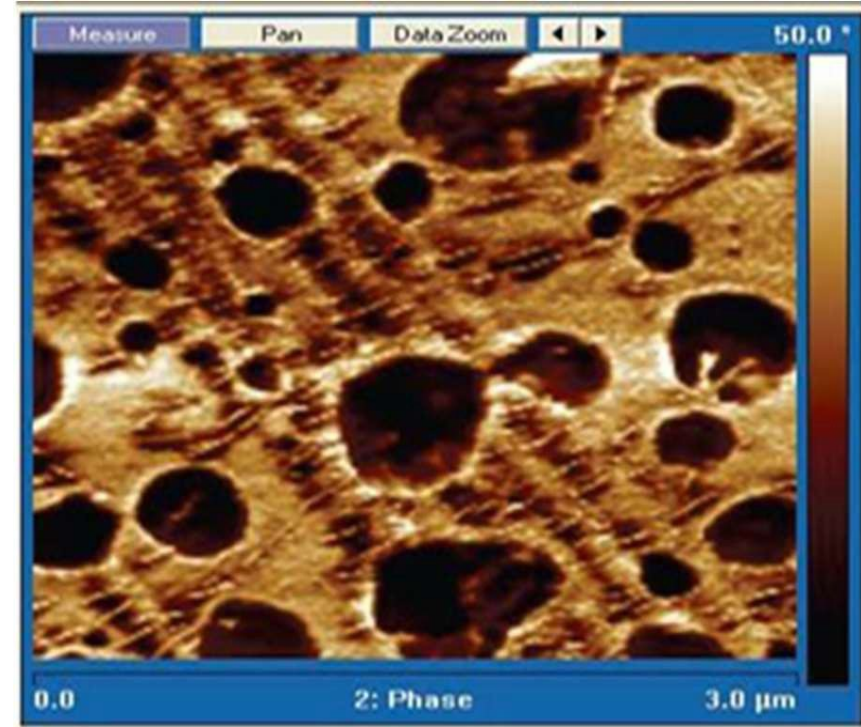
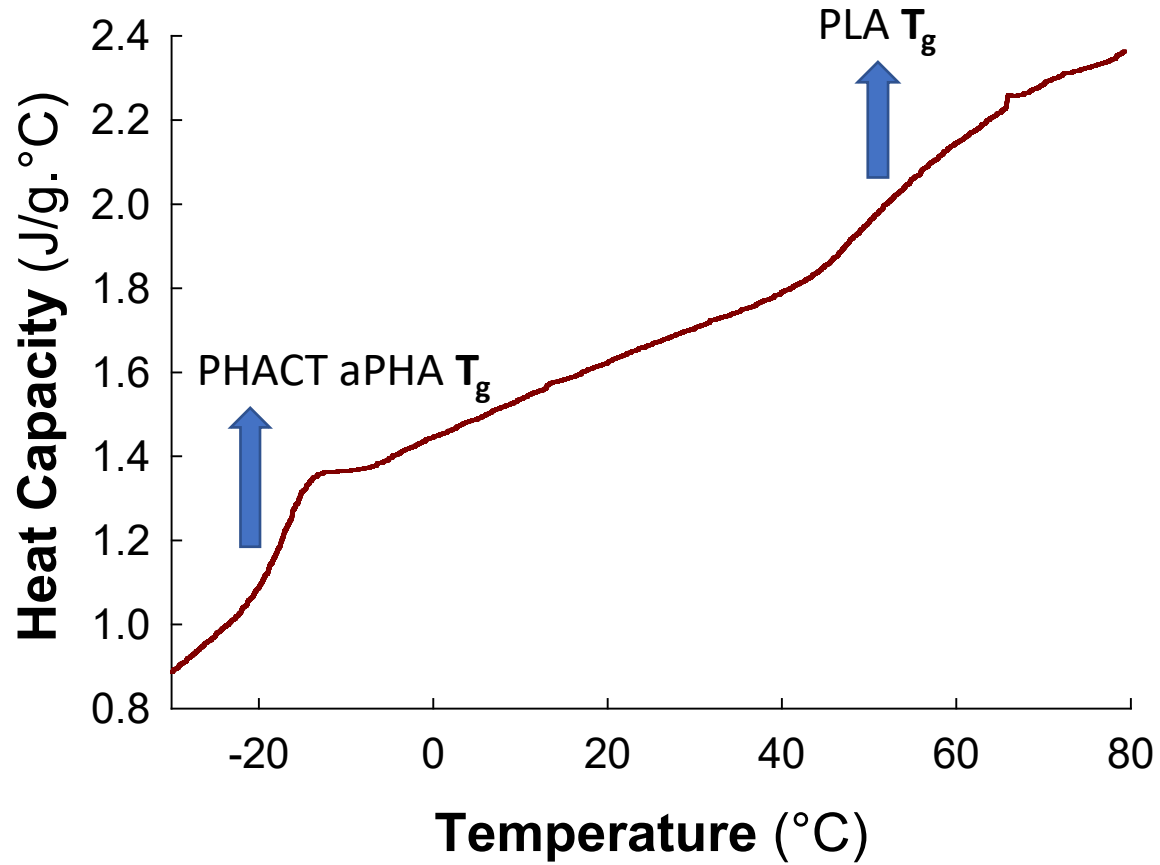
*Also promotes composting and biodegradation of other polymers such as PLA, PBS,...*



Our strategy is to use **PHACT A1000P** (amorphous PHA) to enable easier processing and superior performance of PLA-based **blown/cast/biax** films.

- Ingeo 4043D [PLA control]
- **CA1270P** and **CA1240PF** [clear and mineral-filled film products]

*Data for Ecovio C2224 blend are included for purposes of comparison [from data sheet]*

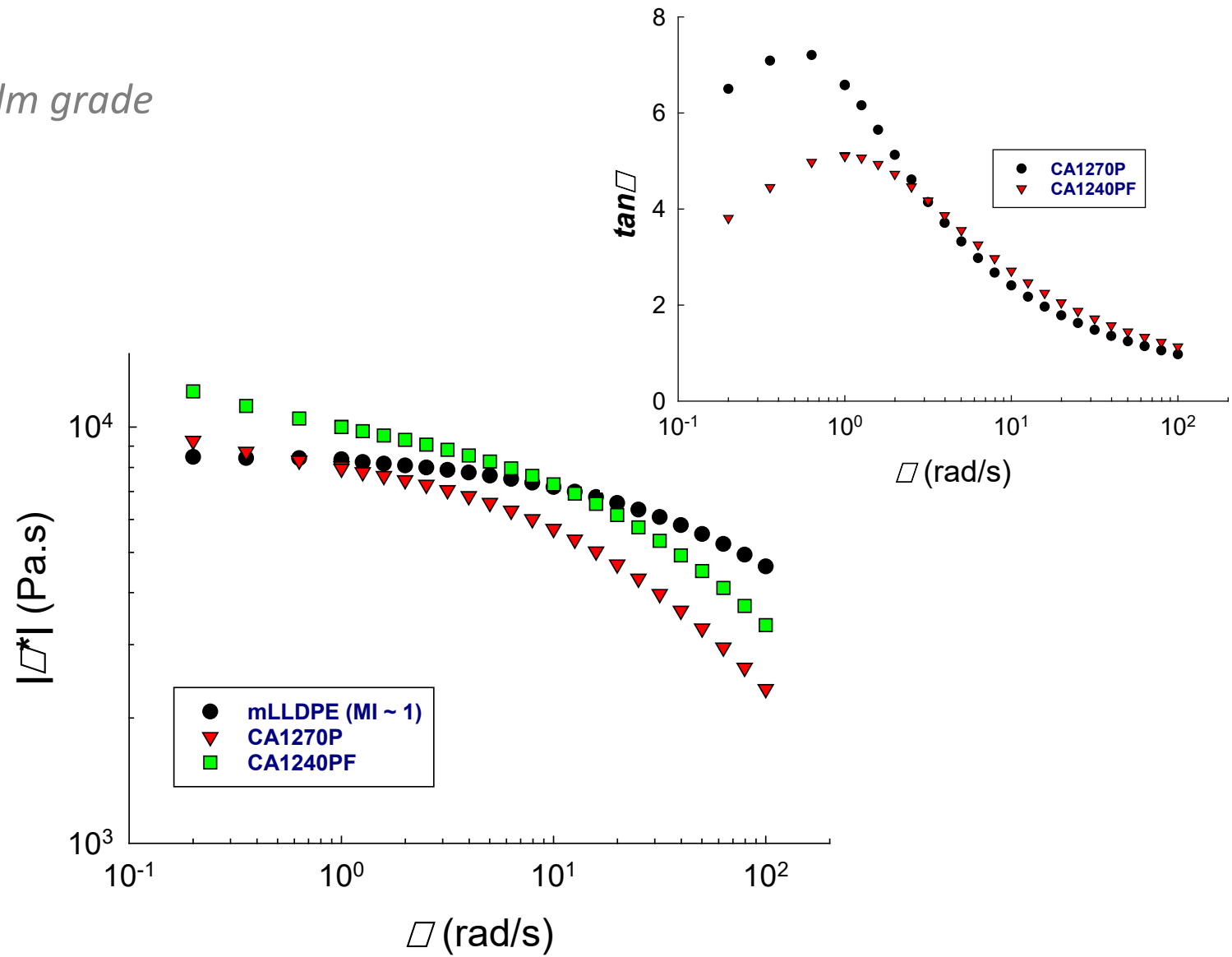


- ➔ Significant reduction in torque and pressure relative to PLA control
  - Ease of extrusion (lower torque)
  - Significantly improved downstream web handling
  
- ➔ Higher specific output rate
  - 10-20% higher output rate relative to PLA control for any given screw speed
  - Early plastication of A1000P appears to promote faster solids-melt transition of PLA [confirmed @ **Davis Standard**]

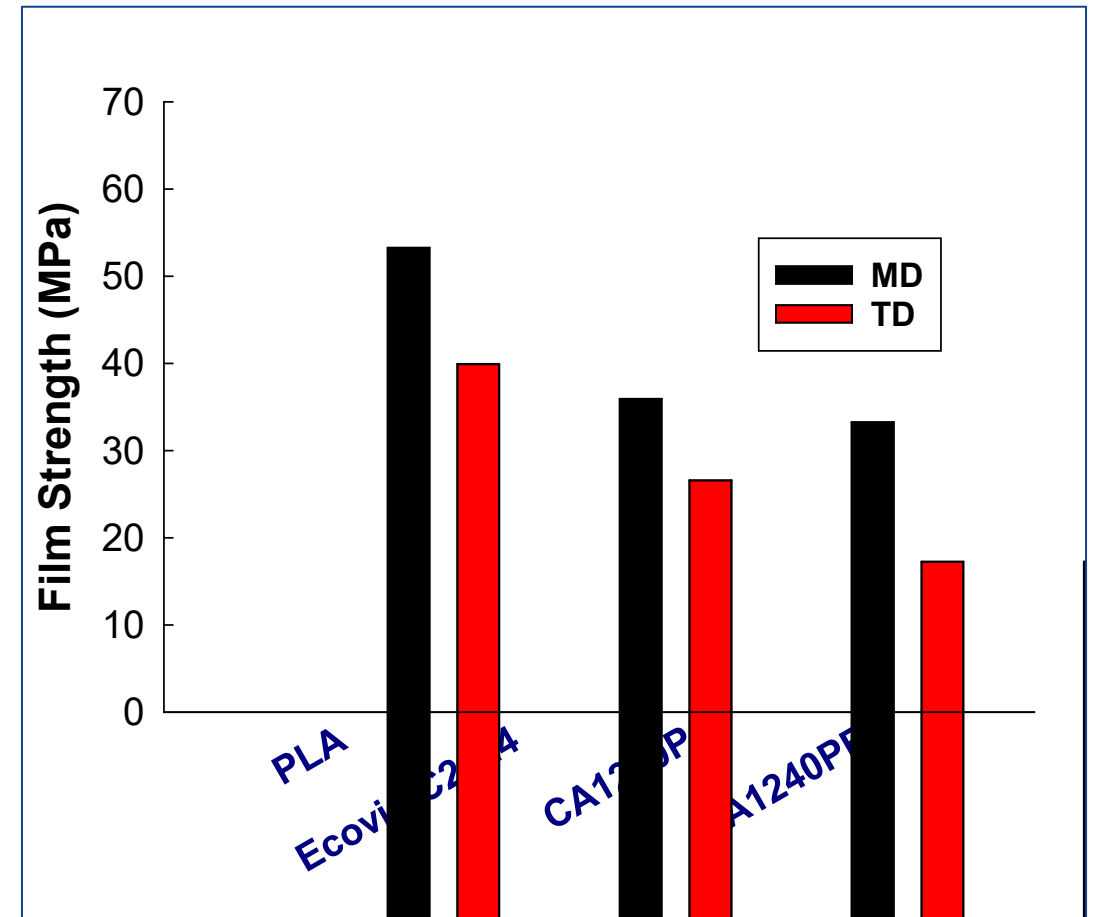
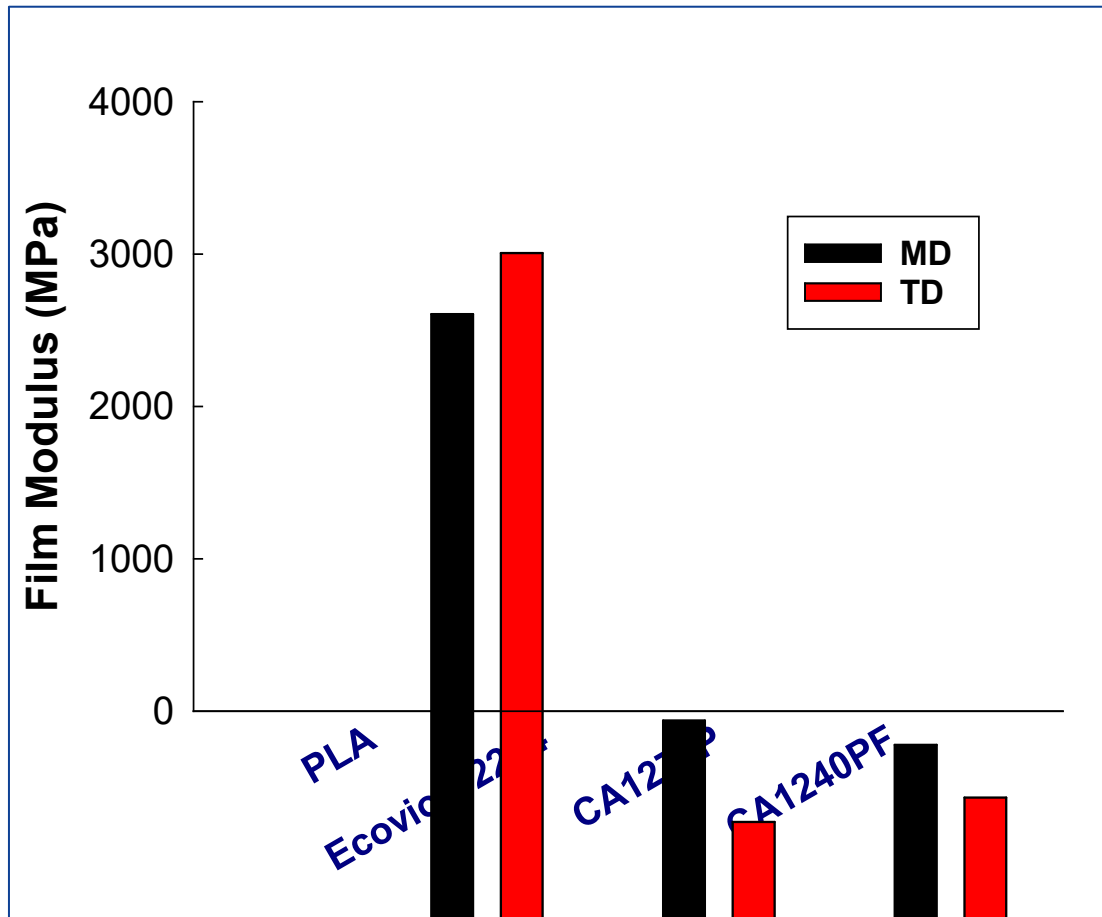


## Melt Rheology (@ 180 °C)

*relative to a 1 MI mLLDPE blown film grade*

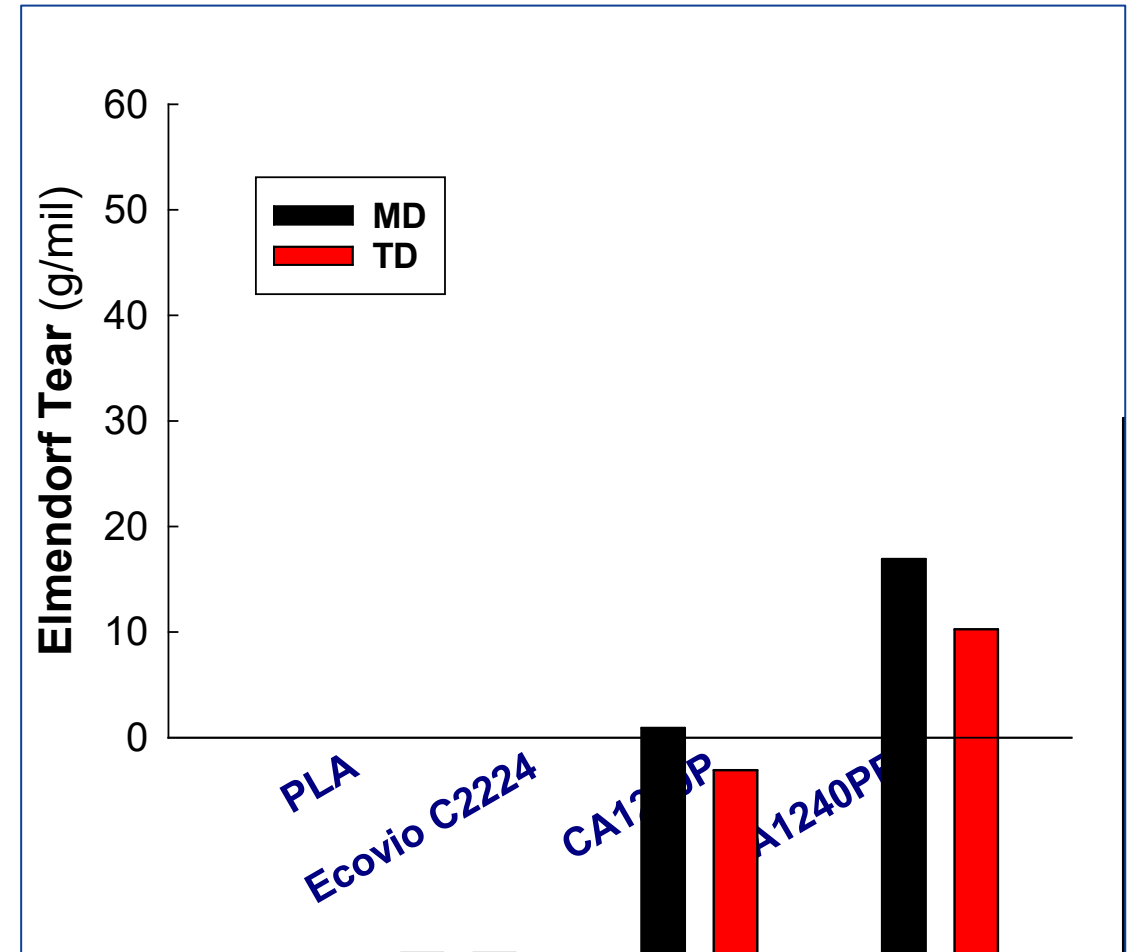
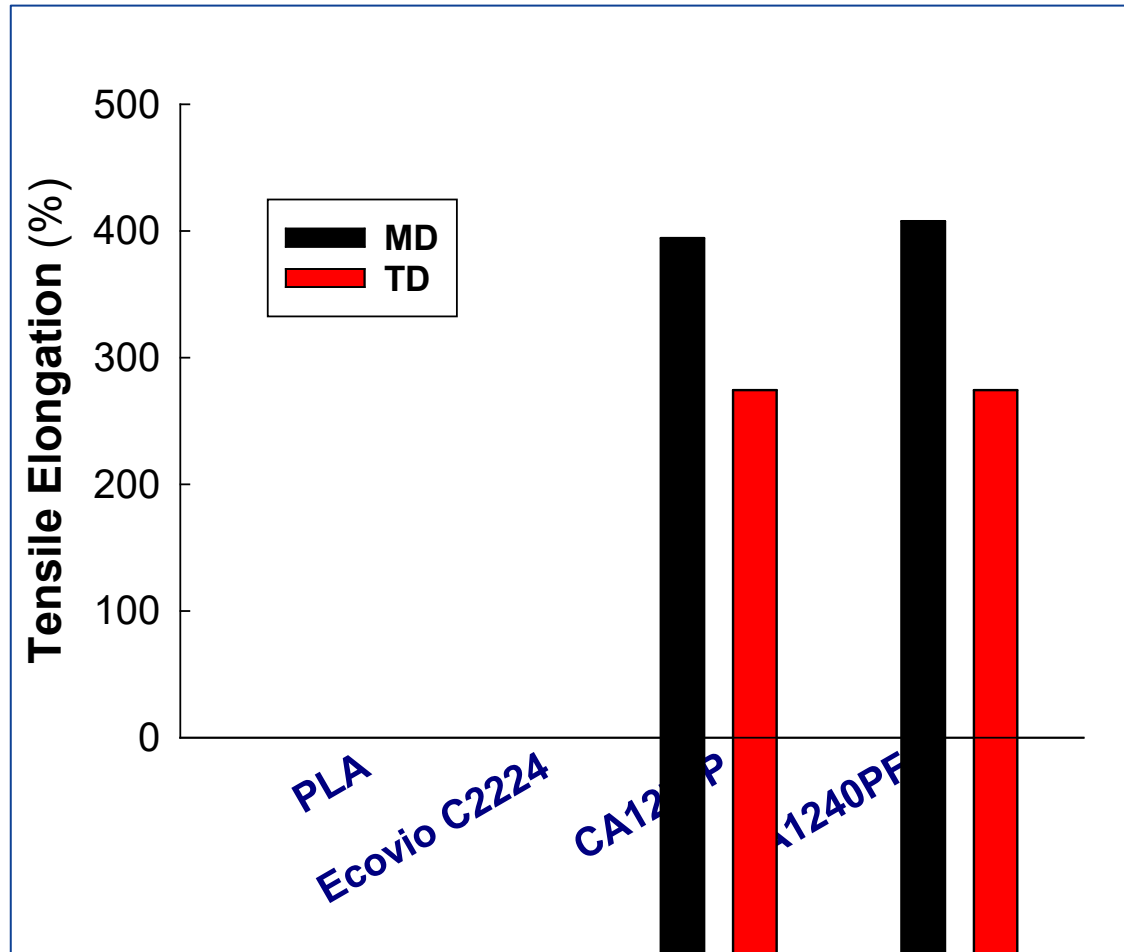


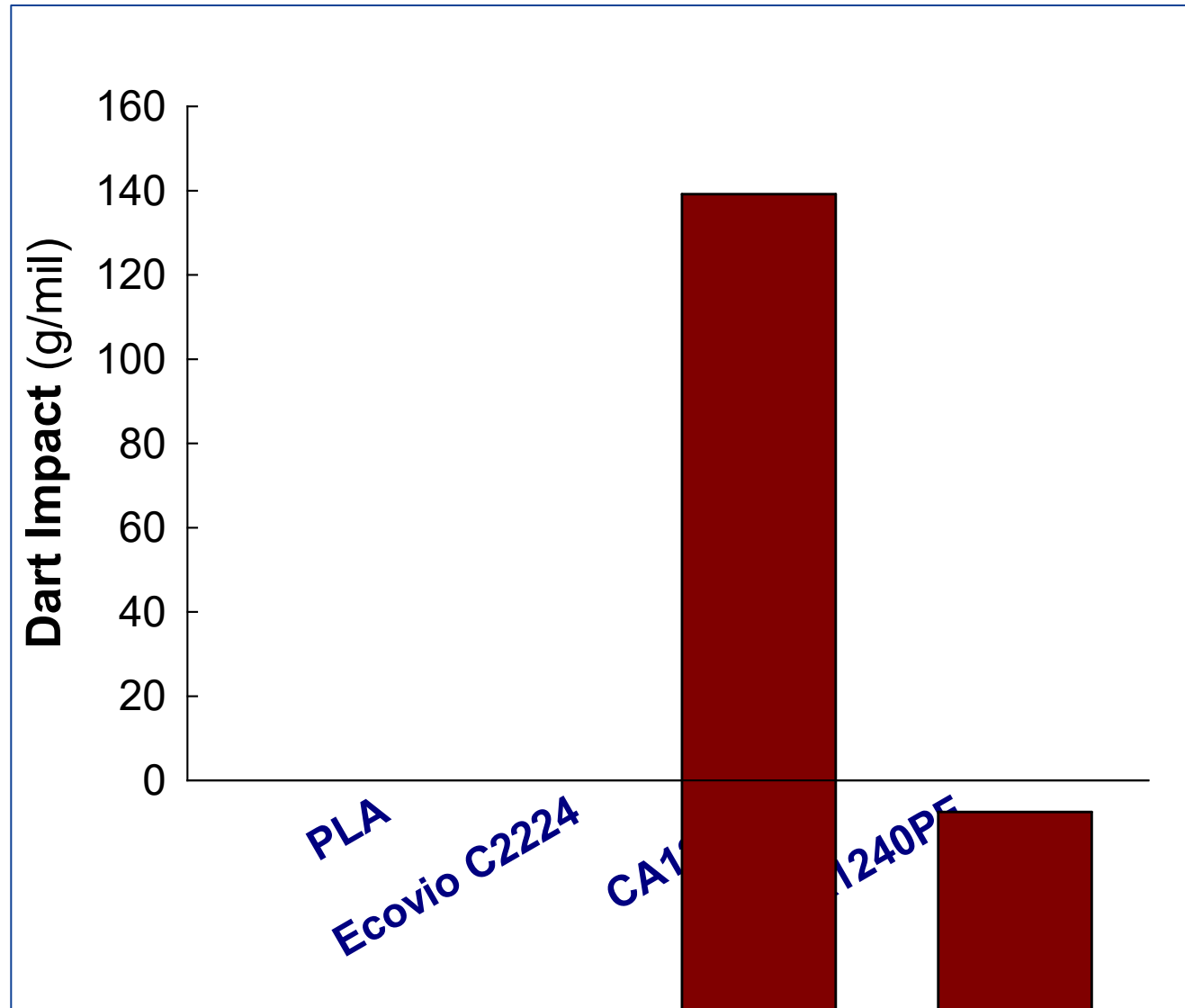
*CA1270P and CA1240PF modulus and strength higher than that of LDPE/LLDPE blown films*



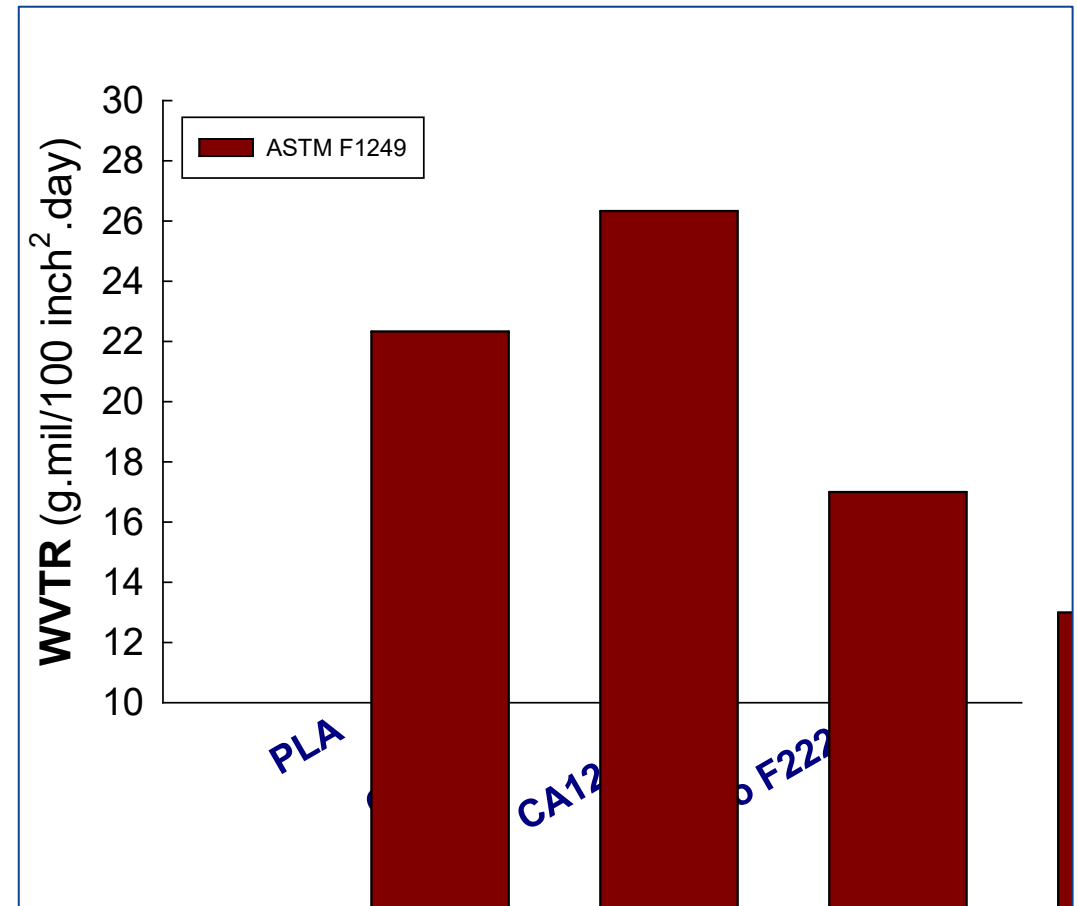
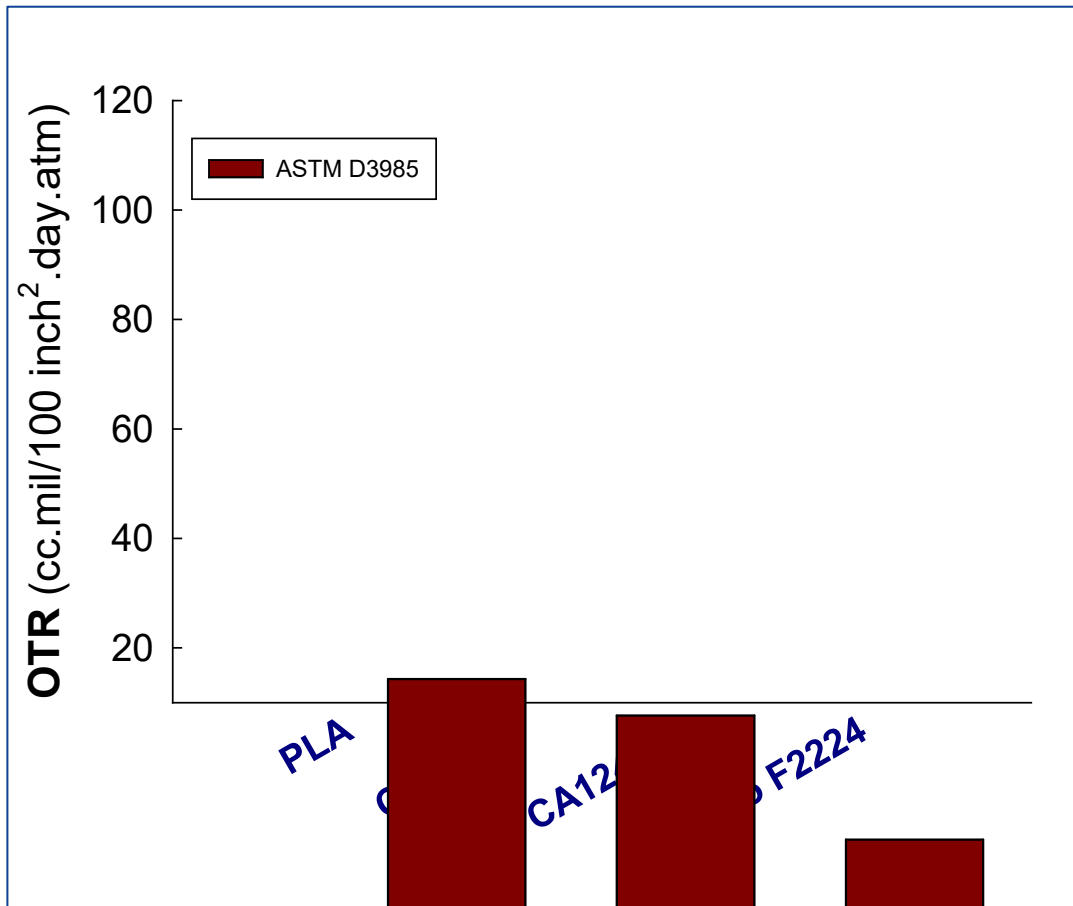


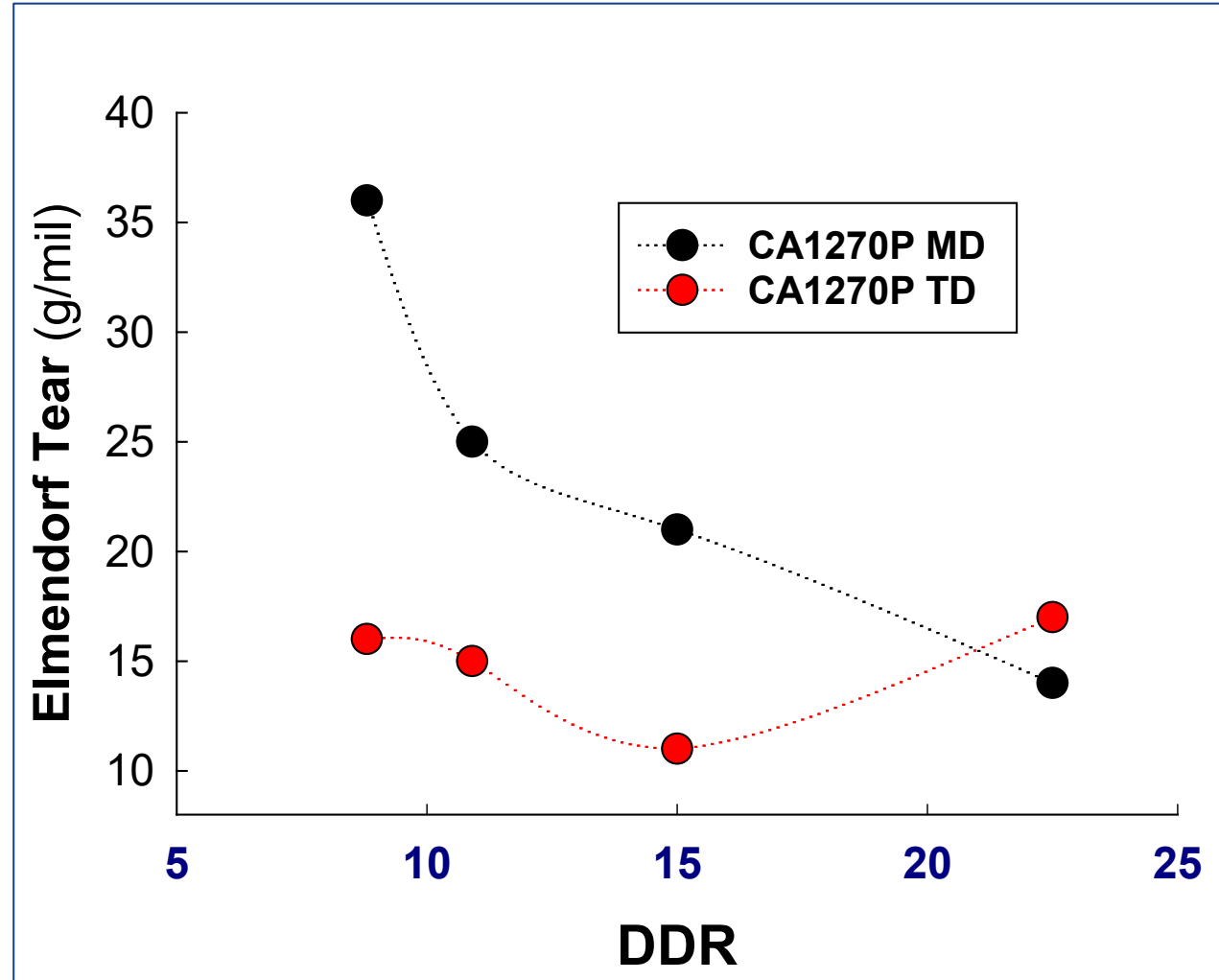
*CA1270P and CA1240PF films show higher tear and similar elongation compared to Ecovio*

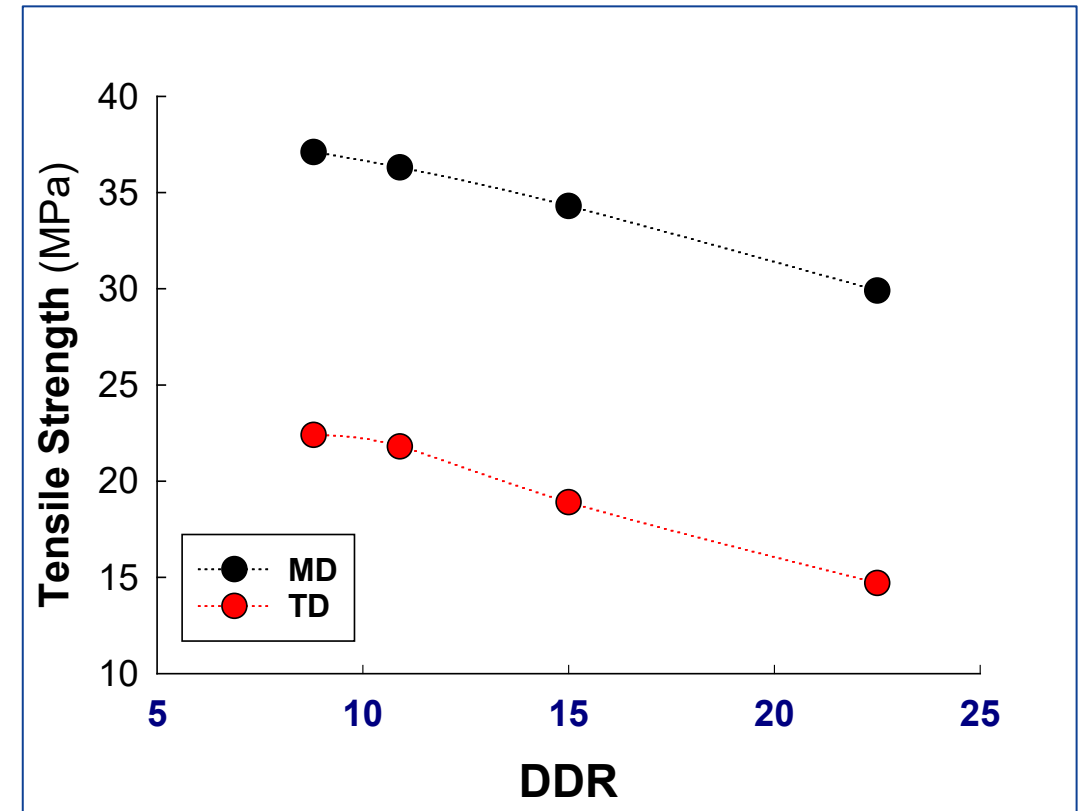
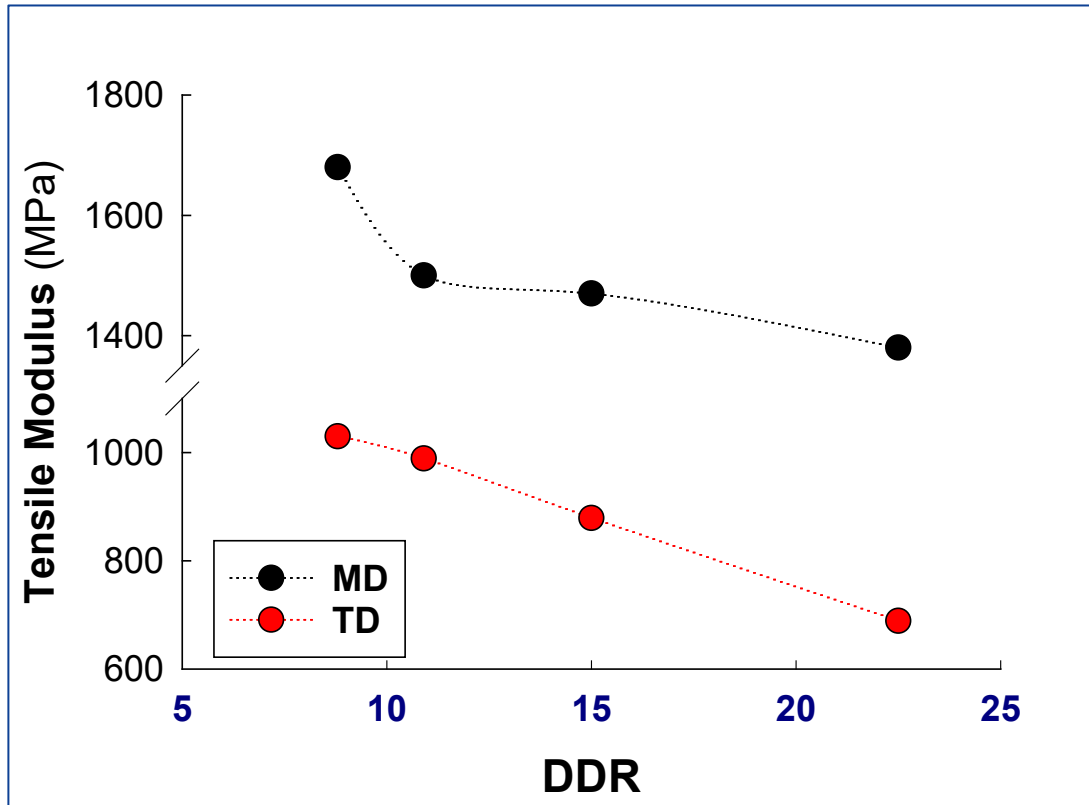


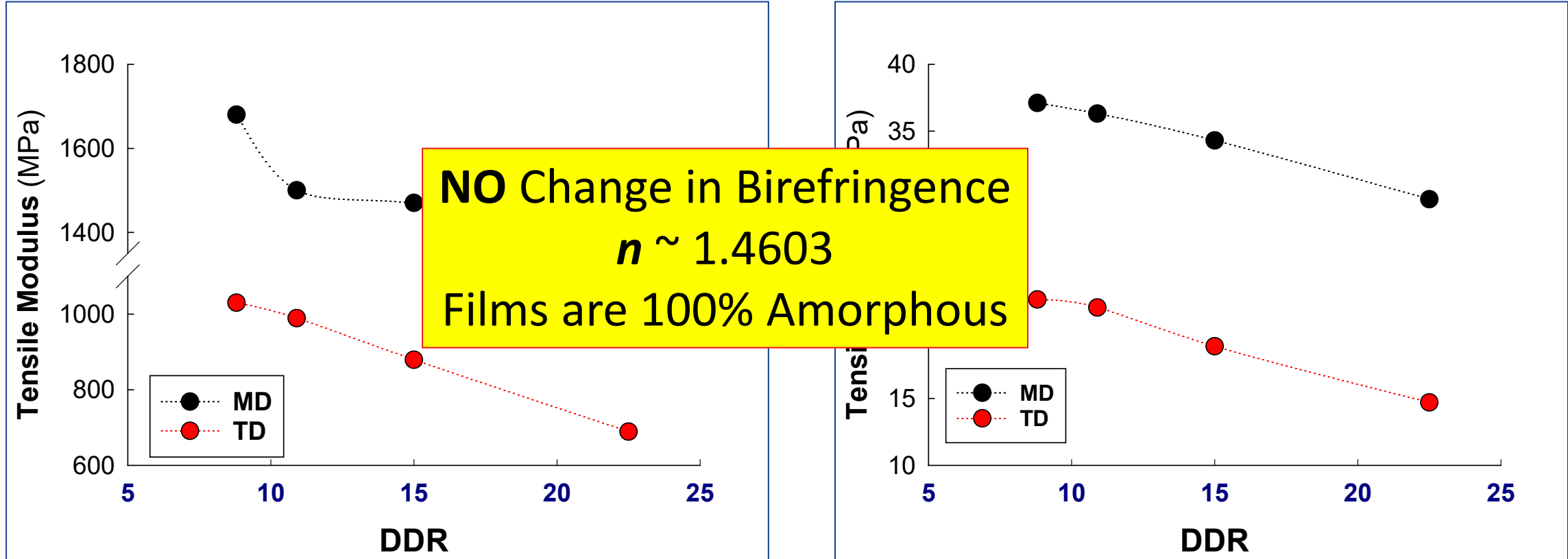


## Oxygen & Water Vapor

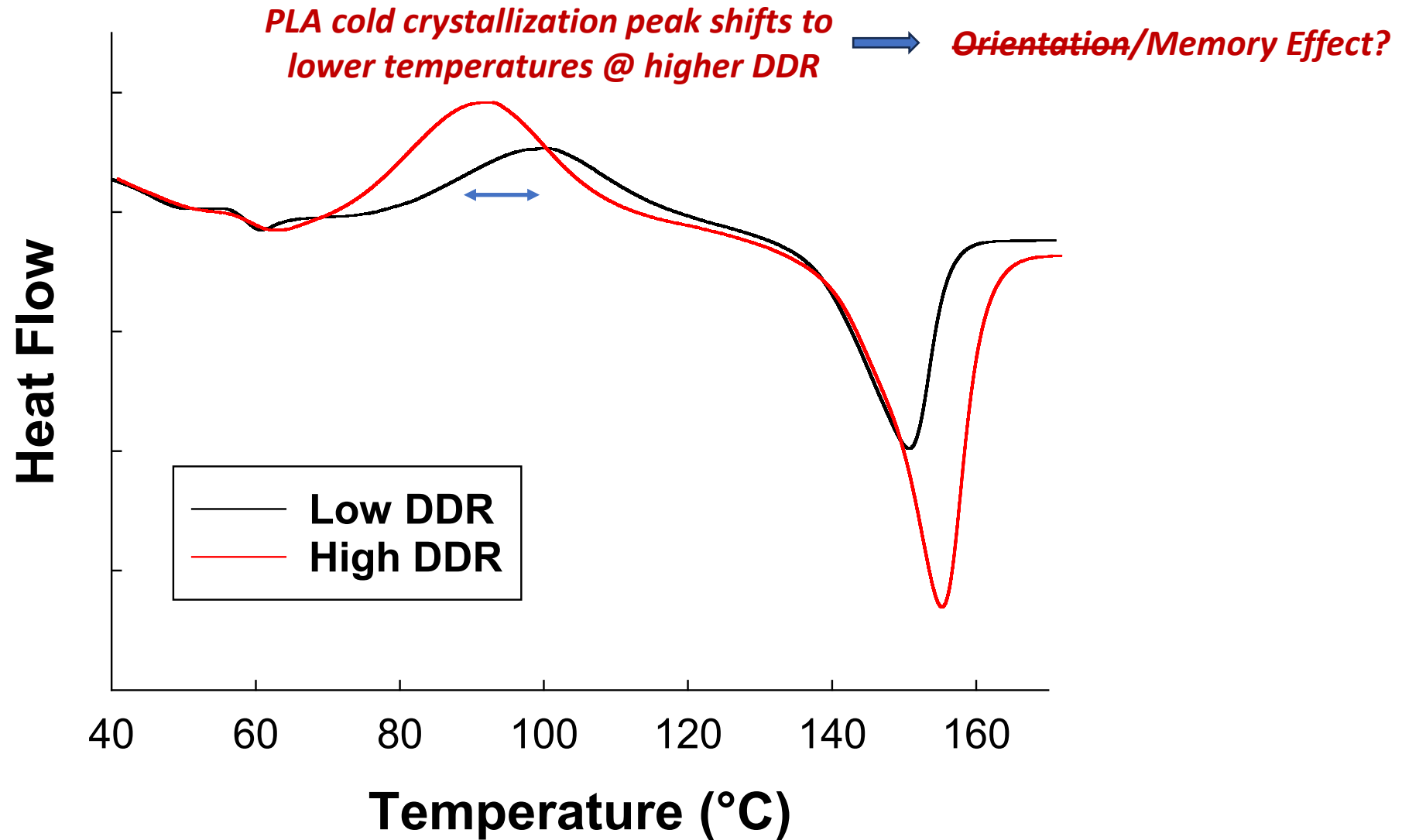


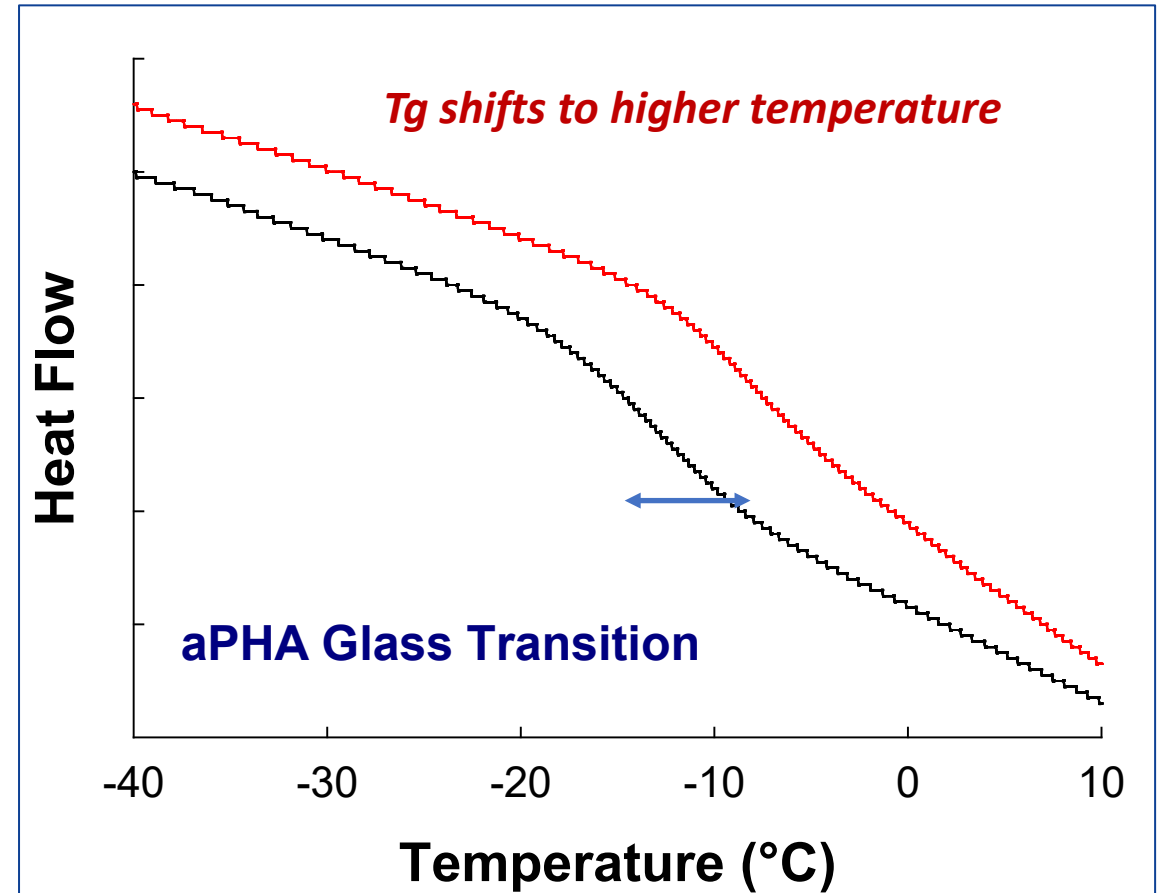
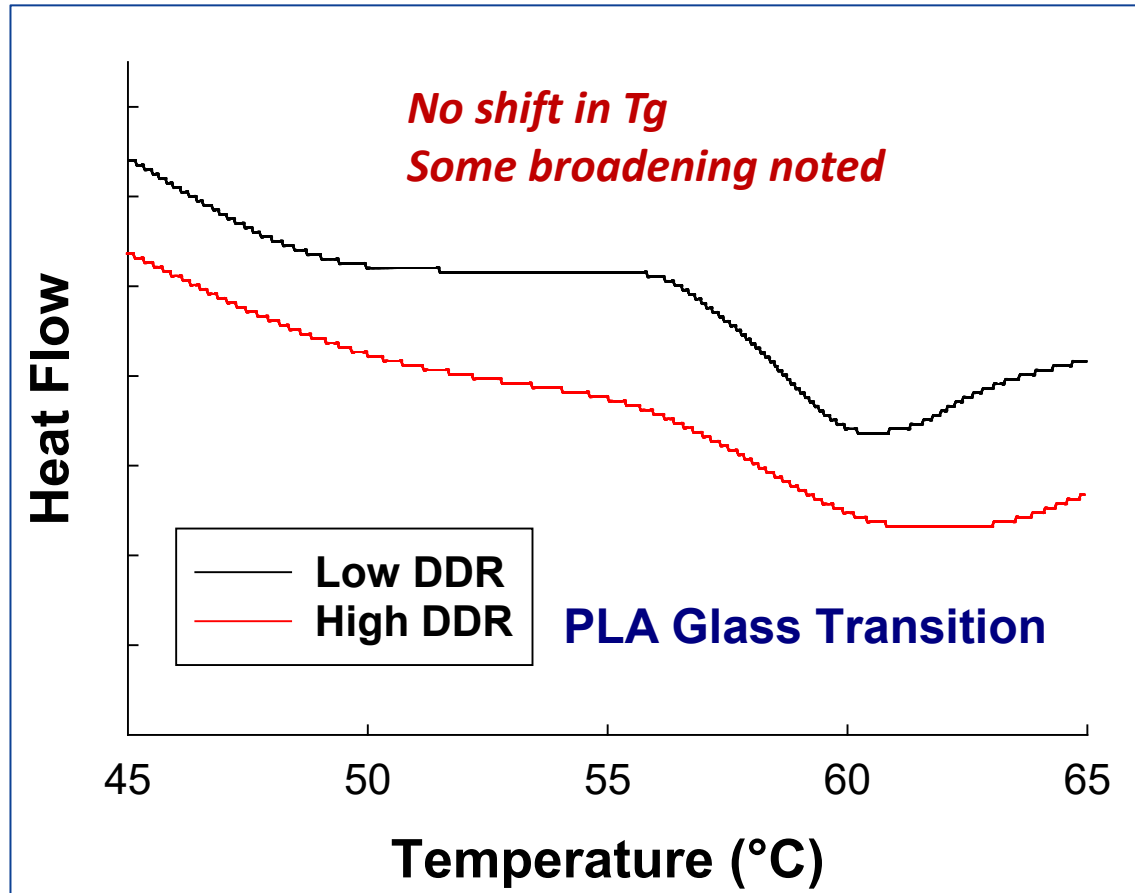




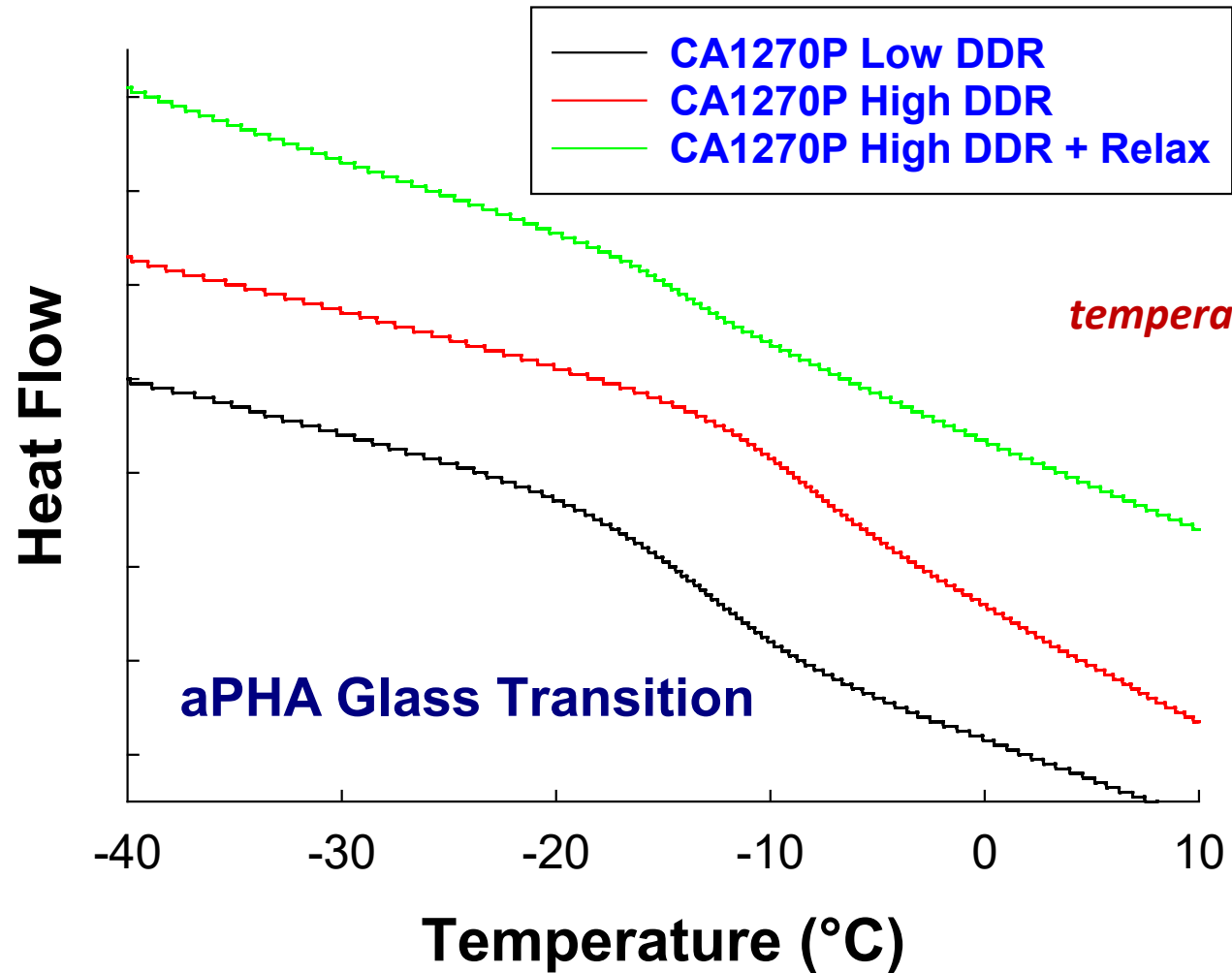








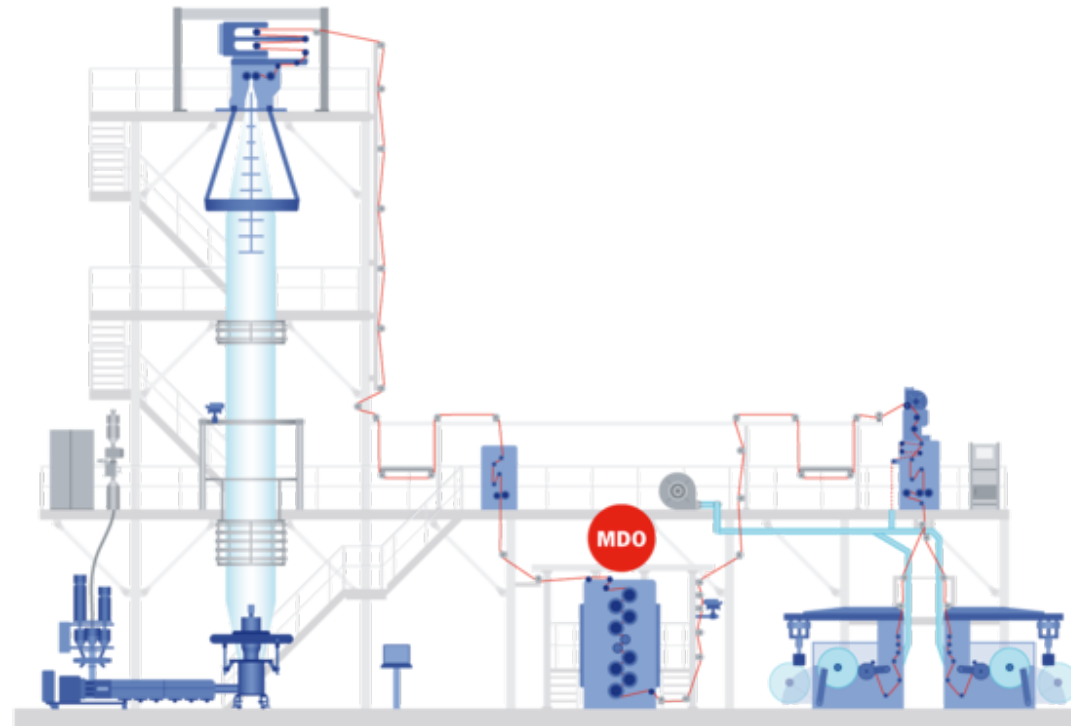
## A1000P Glass Transition



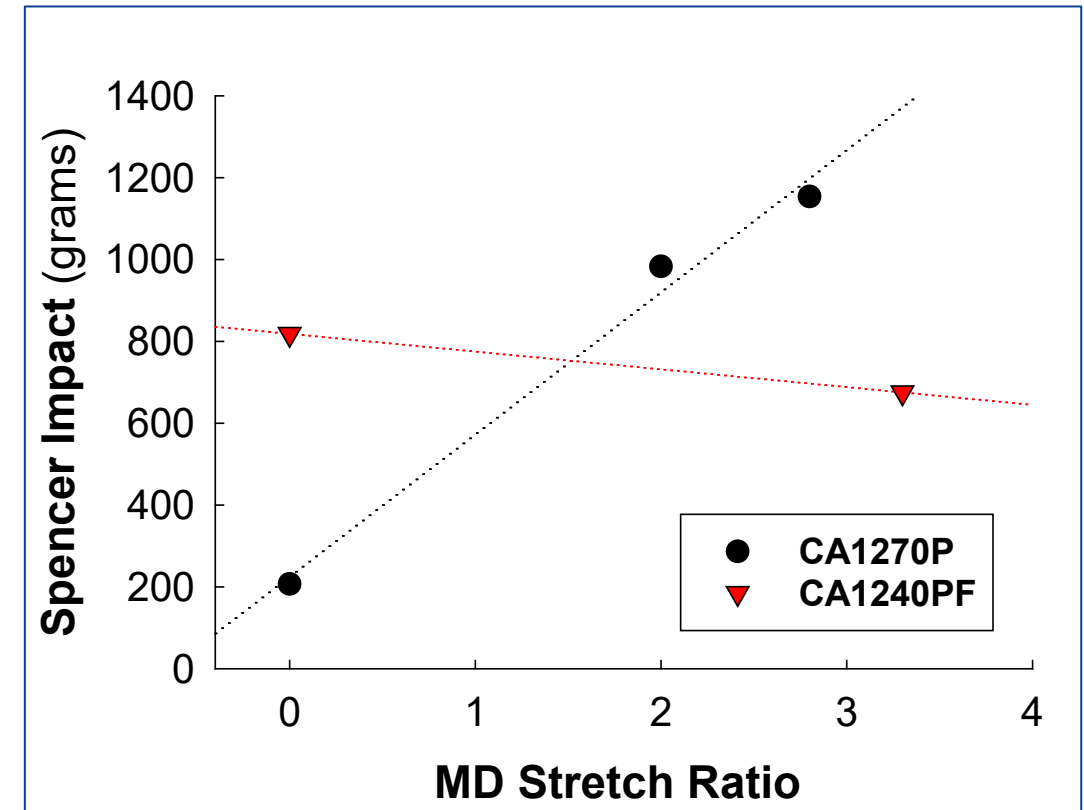
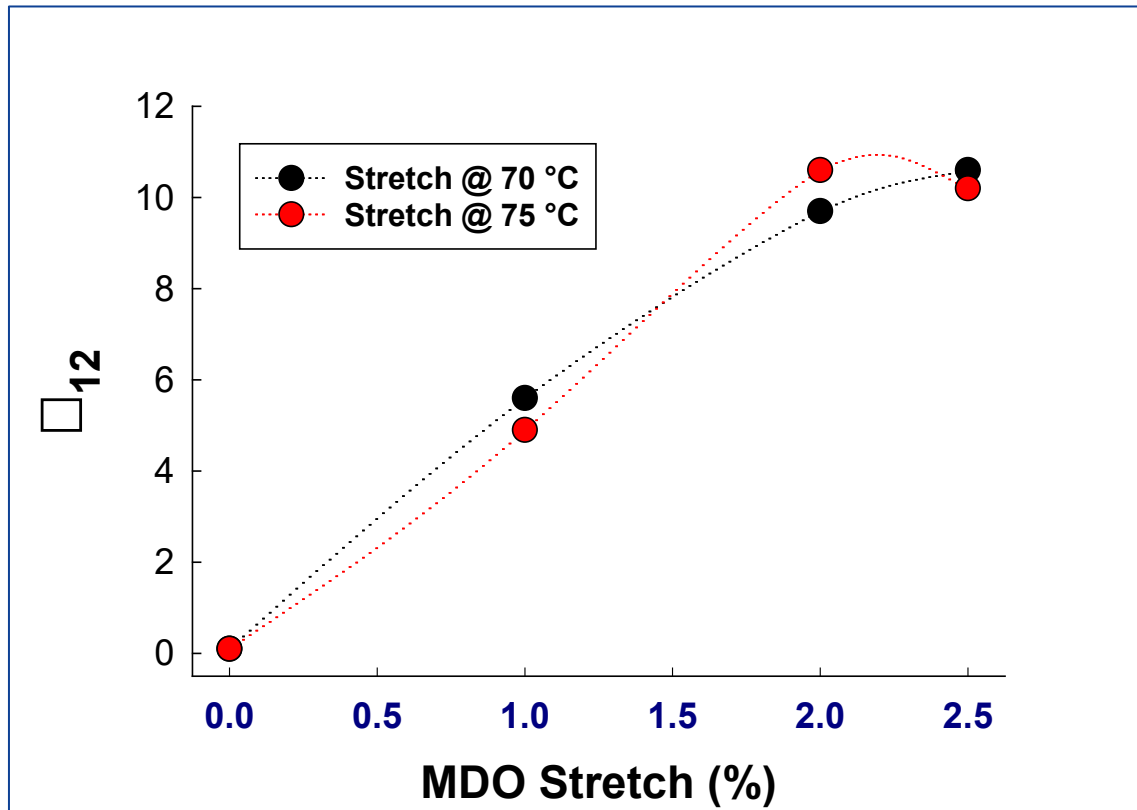
## When CA1270P is oriented (drawdown @ fixed BUR) in a blown film process

- PLA phase remained amorphous across the conditions explored
- No orientation (birefringence) evident in the PLA phase
- The amorphous PHA domains appear to orient along the MD
  - ***Higher  $M_w$  – longer relaxation times of aPHA supports that hypothesis***
- Orientation of the aPHA domains appears to constrain the mobility of the molecular segments resulting in higher  $T_g$
- Mobility constraints are minimized/relaxed when annealed at temperatures above the  $T_g$  of PLA

Both CA1270P and CA1240PF have been subject to blown-MDO processing (Up to 4.0X stretch achieved).

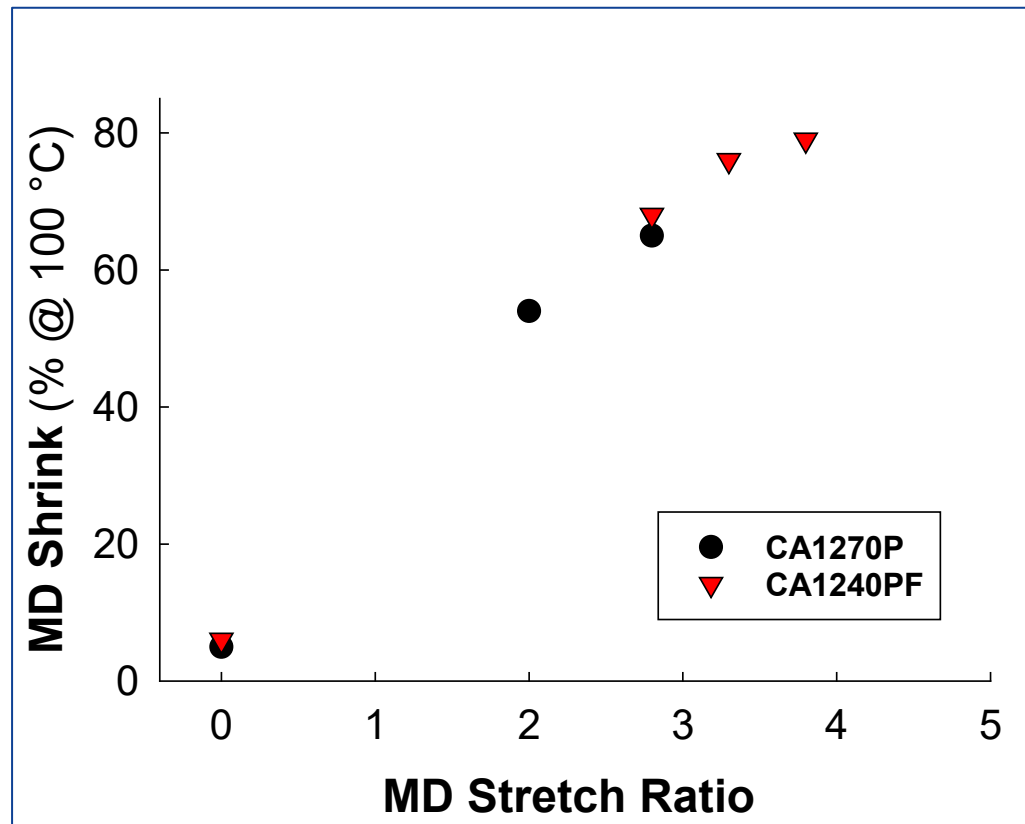


*MDO films reveal orientation (birefringence) and much improved puncture toughness*

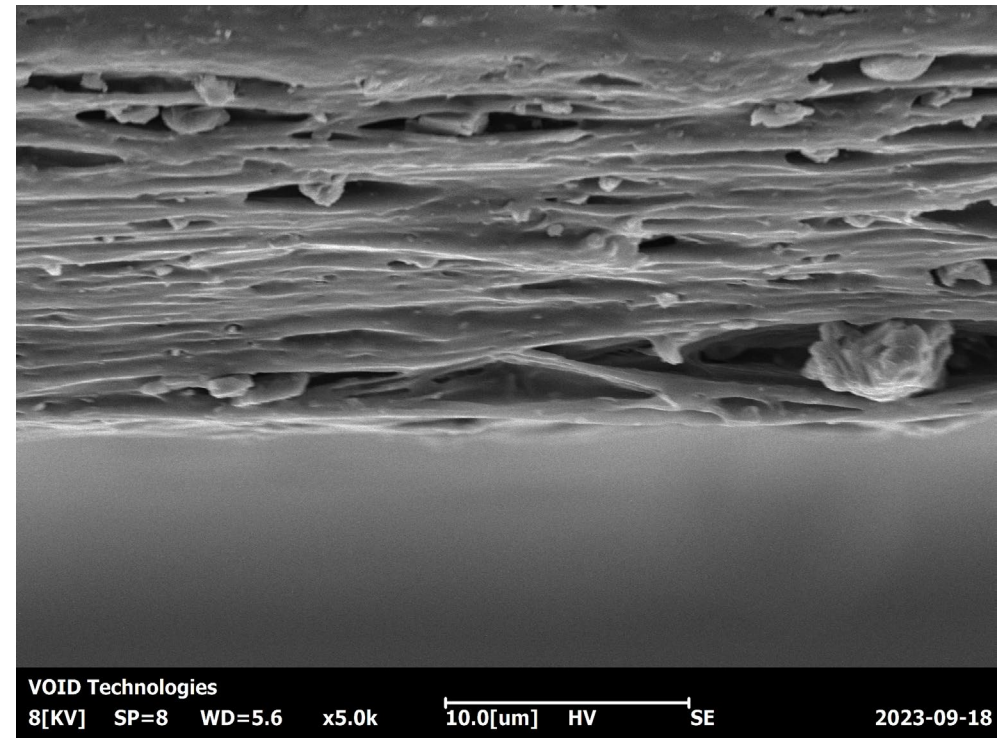
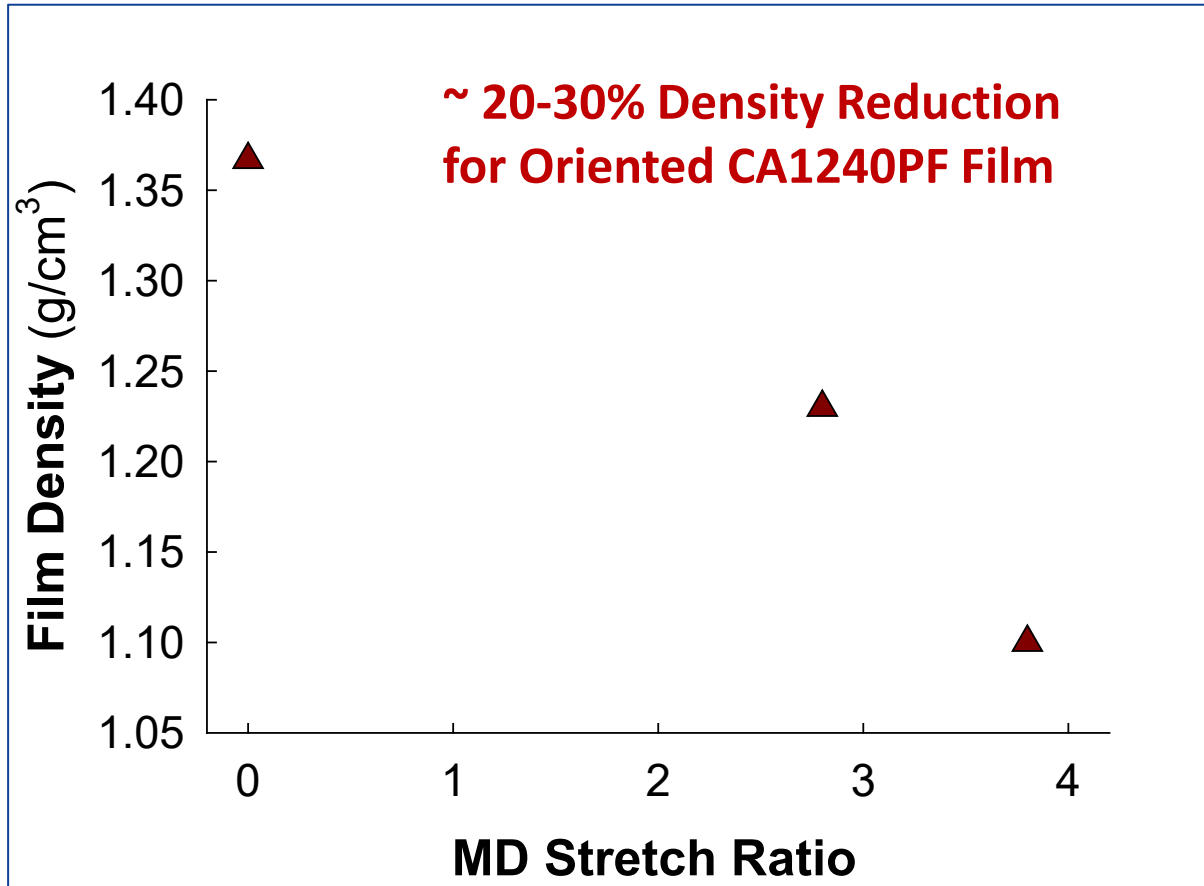




## Shrink Film Applications



## Micro-Void/Cavitated Film



- We have developed two products for blown, cast and MDO film applications. These grades are **CA1270P** and **CA1240PF** (CA1240PF has CaCO<sub>3</sub> included in product)
- Both products are **100% bio-based** and show an excellent balance between stiffness, strength, tear and puncture.
  - CA1270P film is transparent.
  - CA1270P and CA1240PF show excellent bubble and drawdown stability.
  - **CA1270P & CA1240PF are industrially compostable.**  
CA1240PF has good potential to be home compostable (tests are ongoing).
- Both products are also processable using the MDO process to create oriented films for shrink wrap applications.
  - MDO films with CA1240PF results in microporous films.

## Opportunities

- Snack food and produce packaging
- Frozen food bags
- Shopping bags
- Shrink wrap and labels
- Labels
- Hygiene backing films (breathable)
- Organic waste diversion bags
- Agricultural mulch films



CA1240PF is a 100% bio-based option at similar cost position to Ecovio with a clear pathway to home composting and soil biodegradation



THANK YOU!

[www.CJbiomaterials.com](http://www.CJbiomaterials.com)

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