



2024 FlexPack PLACE Conference

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Solutions to enhance performance of PLA-based flexible packaging films

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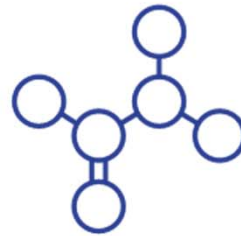
Renewably-sourced Virgin Materials



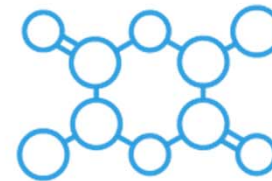
Greenhouse
Gases



Plant Sugar
(Dextrose)



Lactic Acid



Lactide



Ingeo
(polylactic acid
or PLA)

Carbon source is greenhouses gases, not petrochemicals

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Compostable flexible packaging

Lidding

- Peelable/sealable films for meat tray & ready meals
- Single-use for coffee-capsules

Snacks/ dry foods

- Chip bags
- Candy wrap
- Pet foods

Produce stickers

Fruit/veg labels

Fresh veg bags

- Salad bags
- Greens, etc.

For food-packaging applications, composting is an effective method to divert food-waste from landfills



Flexible packaging, common conversion processes

Biax

Blown

Cast

**Extrusion
Coating**

on film substrate

**Dispersion
Coating**

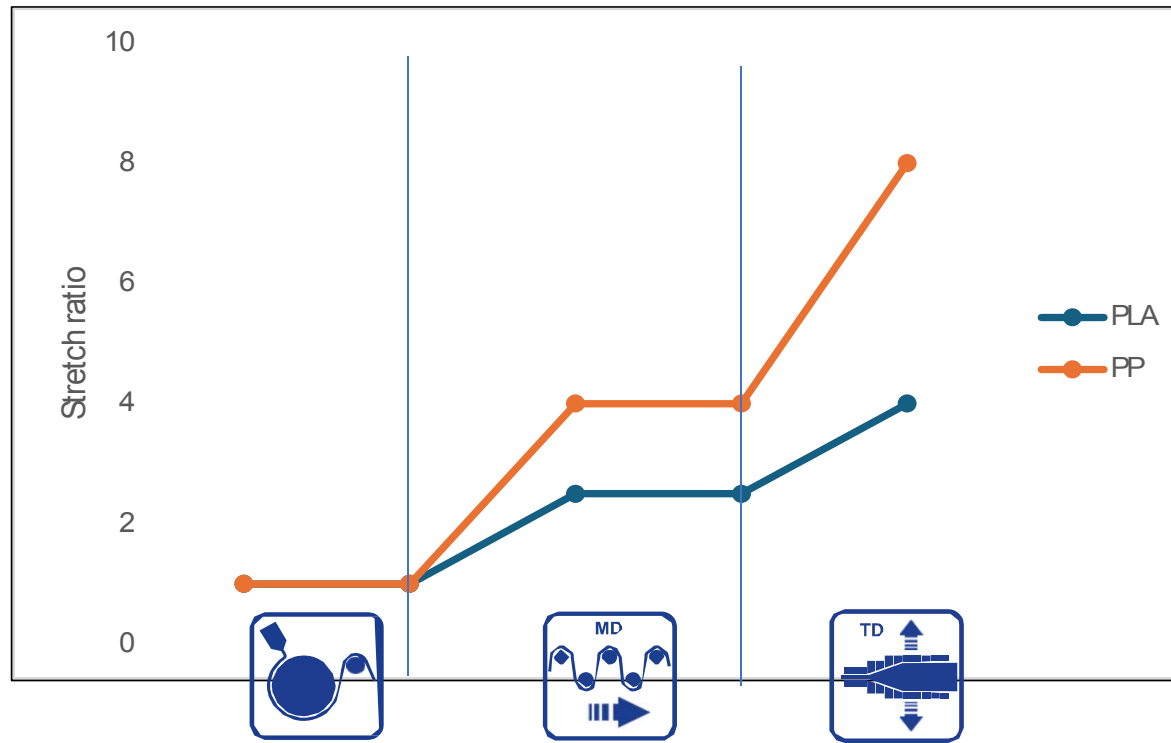


Biaxially oriented PLA (BOPLA) films

- Orienting & heat setting PLA is an effective process to produce films with;
 - High clarity/transparency
 - Improved mechanical properties
 - Increased thermal properties
 - Tunable levels of shrink
- Large number of biax-orientation lines are designed for polypropylene (BOPP)



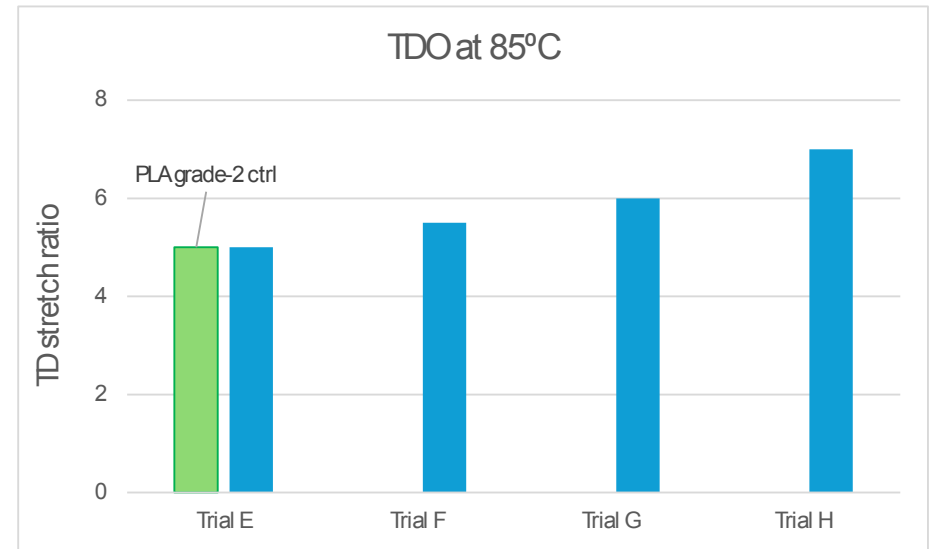
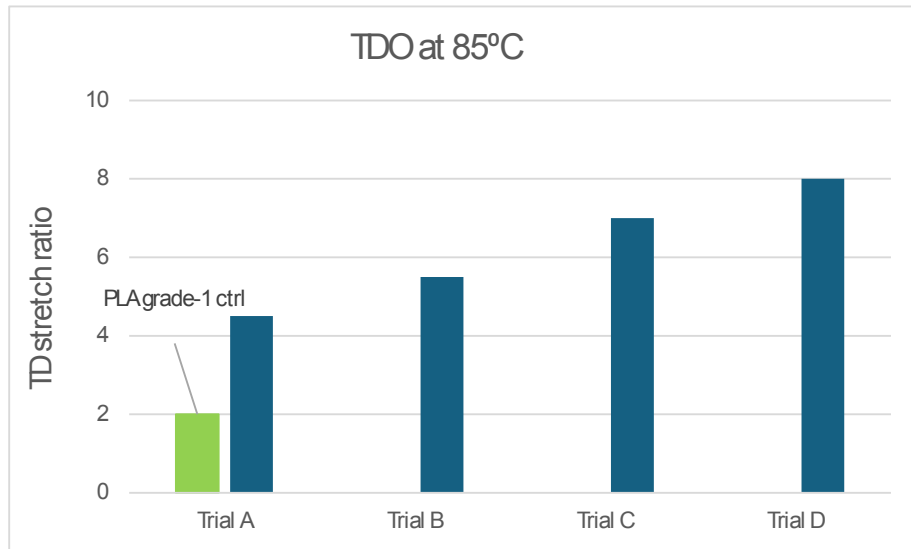
Typical stretch ratios for BOPLA and BOPP



Wide gap in stretch ratios between current BOPLA systems & BOPP



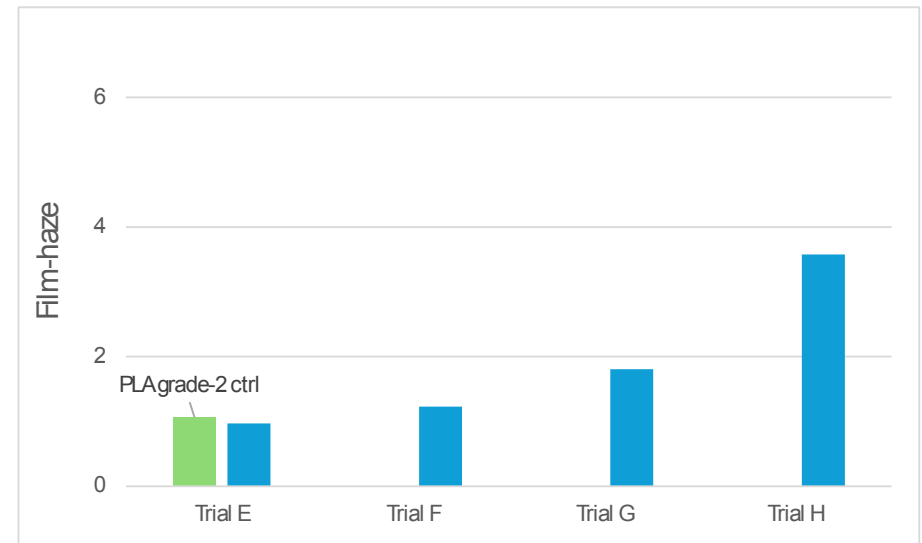
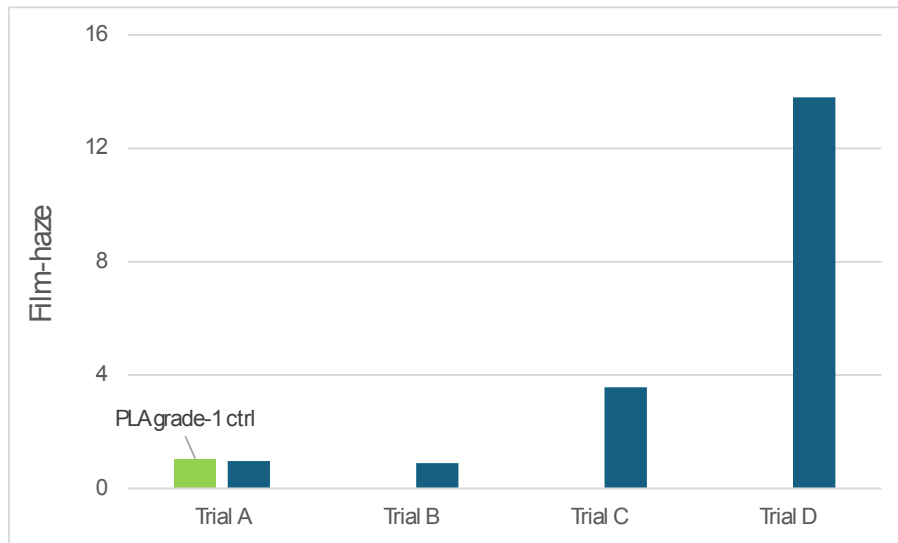
Lab-line film stretching results (Sequential stretch)



- Above trial formulations are fully PLA based
- MD ratio held at ~3.5X
- Film thickness ~1.5mil
- Shrink at 100°C was ~5-8%



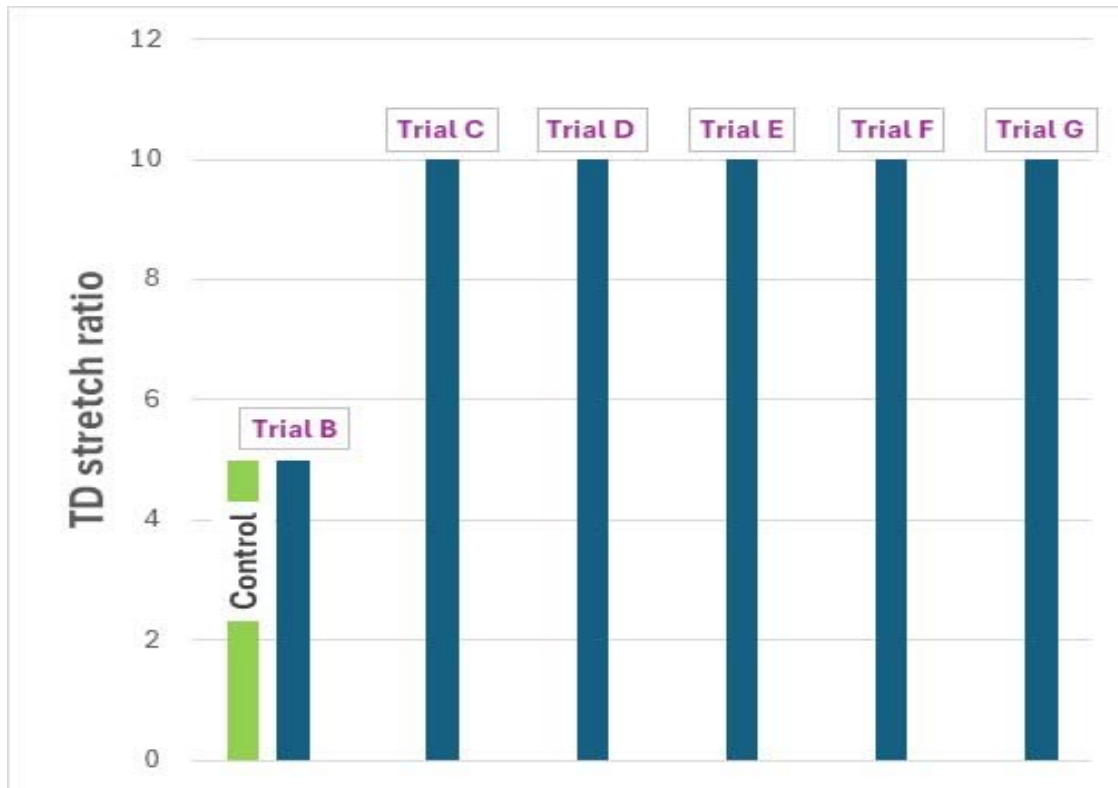
BOPLA film surface-haze results (Sequential stretch)



*MD ratio held at ~3.5X
Film thickness ~1.5mil*



Pilot-line film stretching results (Sequential stretch)



- Max TDO for control was ~5-5.5X
- Expt. samples all achieved TDO of 10X
- TD-shrink for the expt. samples did increase by 2-4X
 - *Heat set process not optimized during trial*



Crystallinity in BOPLA films



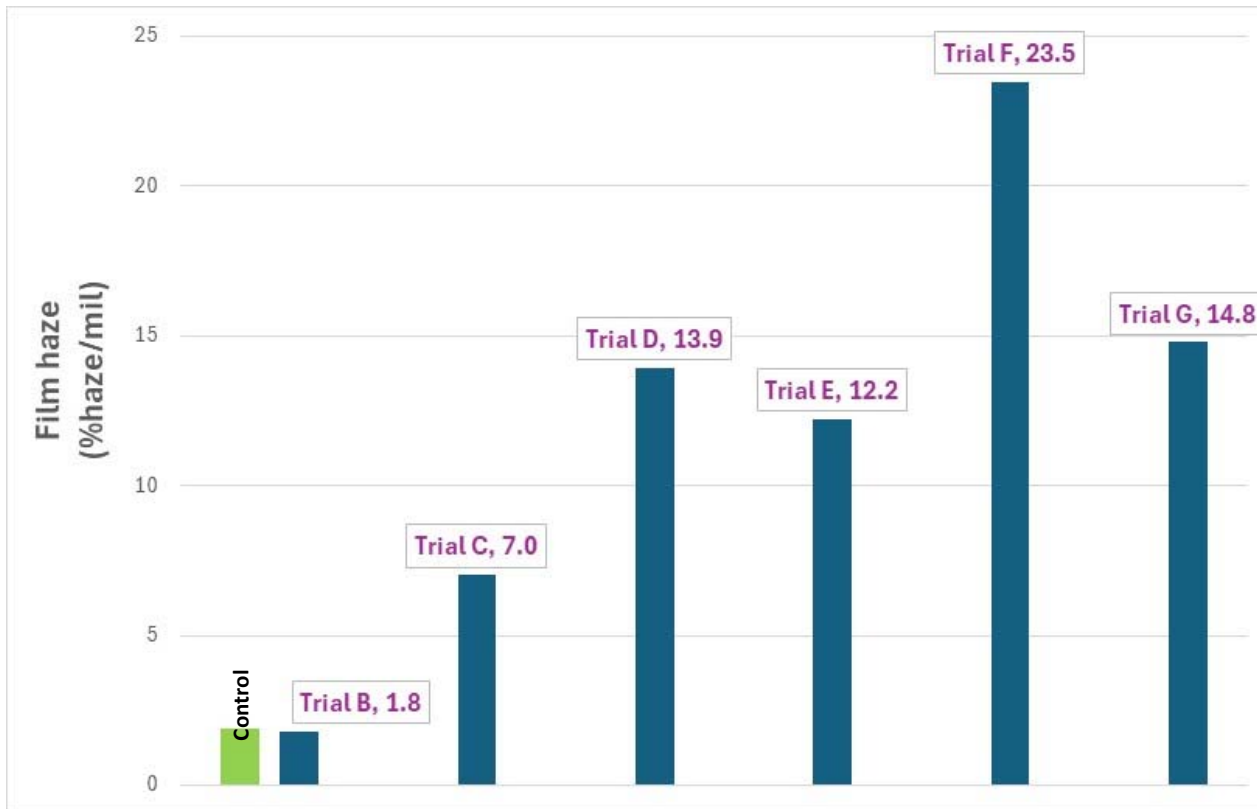
0.7-1mil BOPLA films, MDO ~2.75-3.5X

DSC method:

- All BOPLA films achieved acceptable levels of crystallinity
- Slightly lower (10-15%) level of crystallinity observed for control
 - Likely related to lower levels of orientation



Haze of BOPLA films



0.7-1mil BOPLA films, MDO ~2.75-3.5X
Haze values are average (n=5)

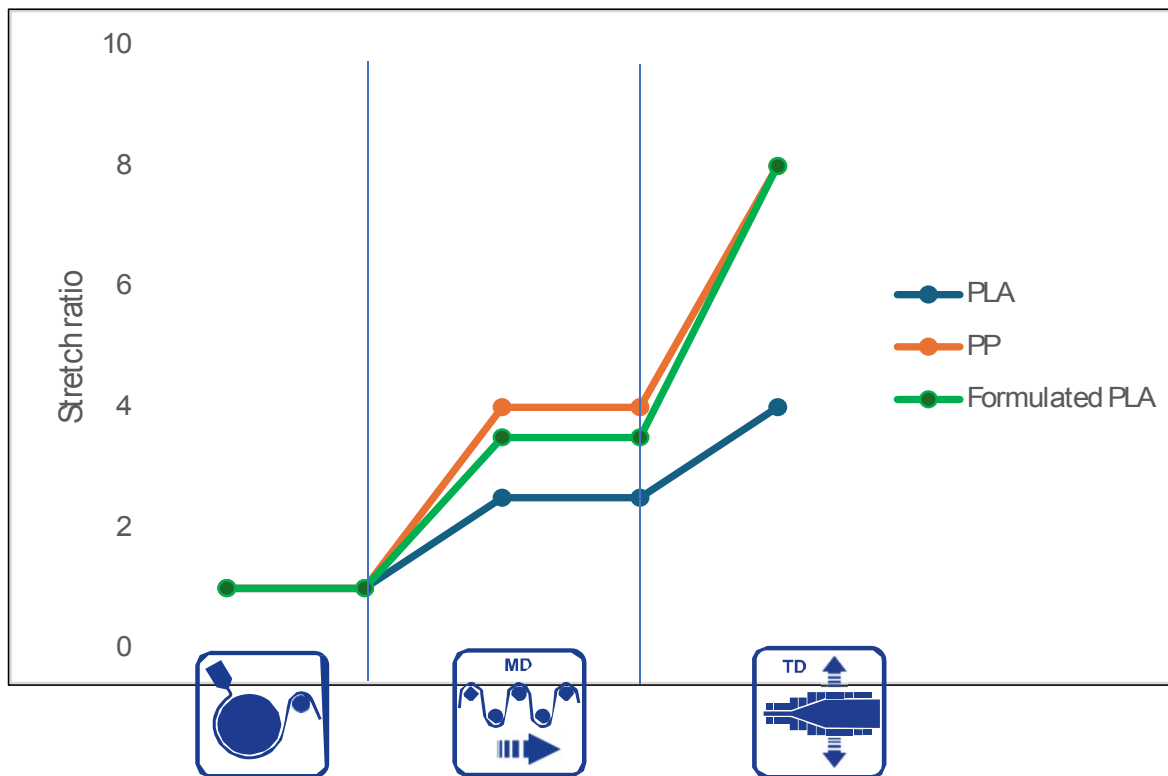
- Haze did increase w/higher TDO
- Reason for this currently unknown
 - *Could be the result of surface defects caused by unoptimized TDO process*

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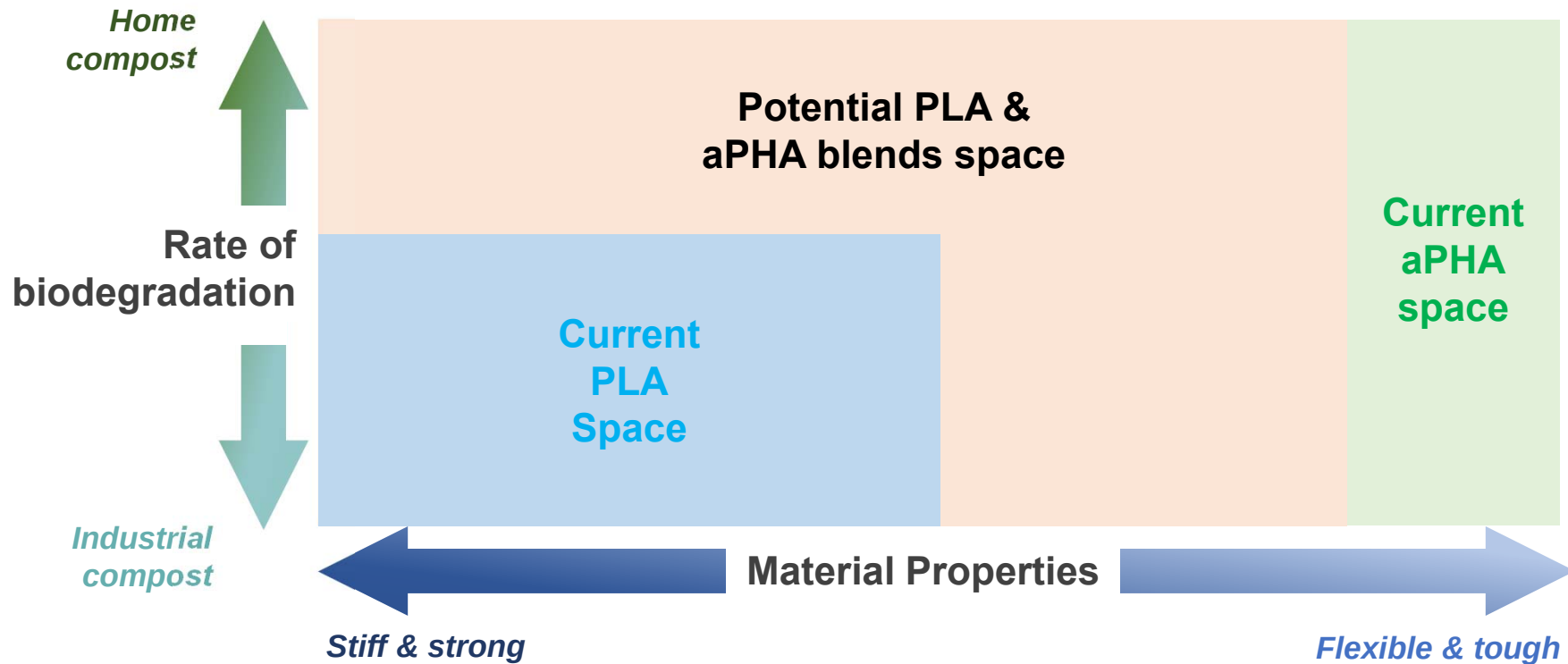
Comparing stretch ratios for BOPLA and BOPP



- New PLA formulation closes stretch-ratio gap
- Being able to run on existing BOPP assets could enable faster growth/adoption of BOPLA films by:
 - *Not requiring dedicated/modified PLA lines (i.e.- lower barrier to entry)*
 - *Potential for improved productivity/yield via increased stretch-ratio*

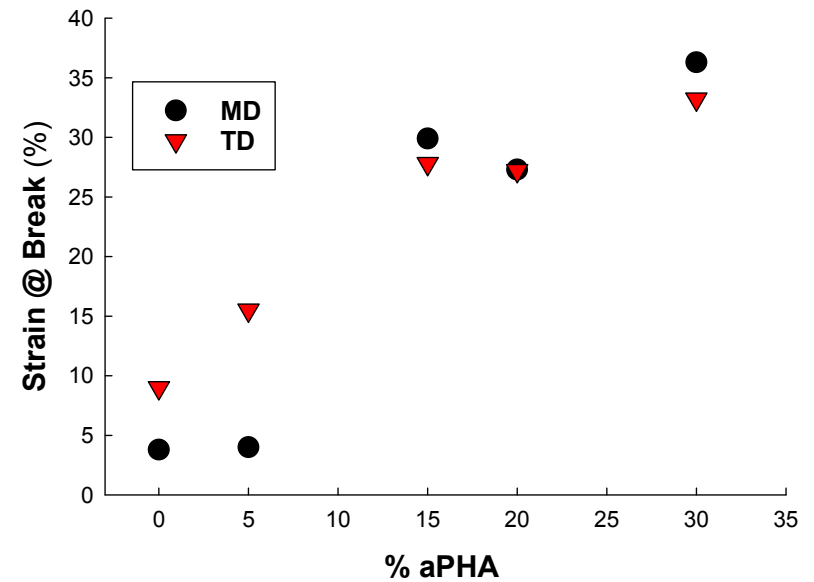
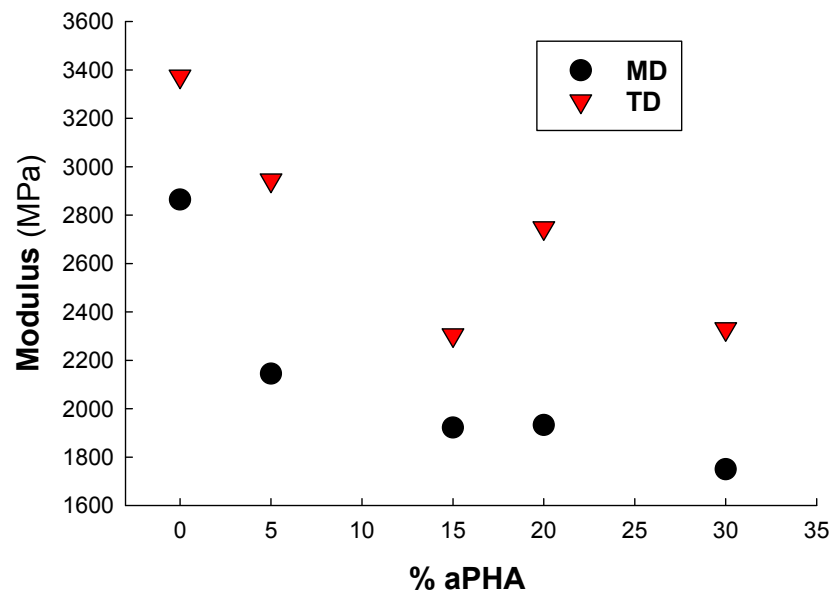


Broadening properties with PLA/amorphous PHA (aPHA) blends





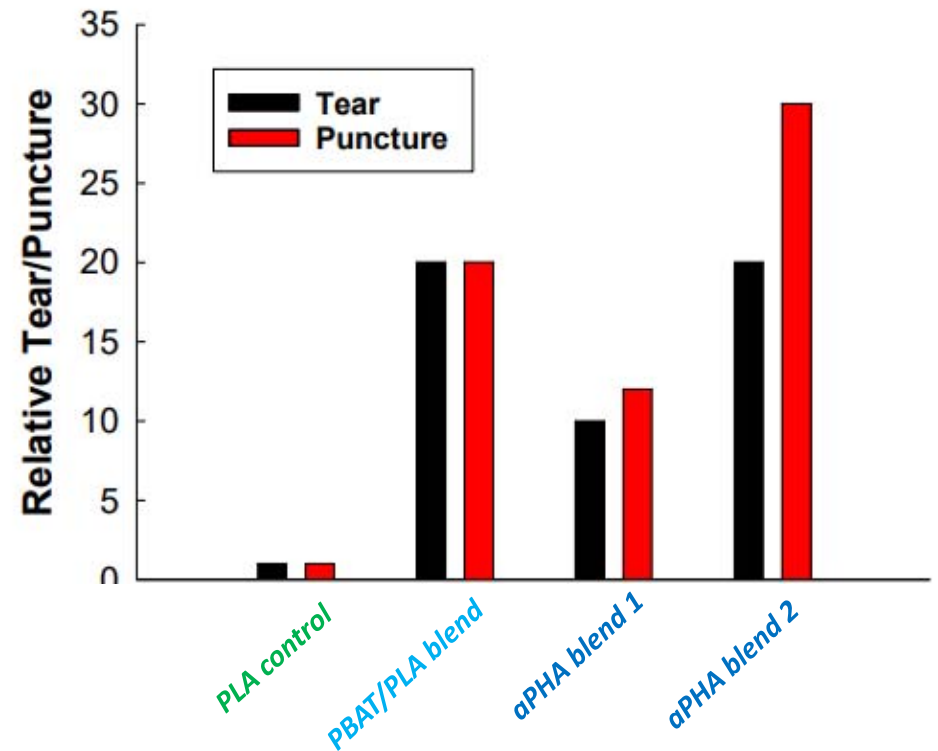
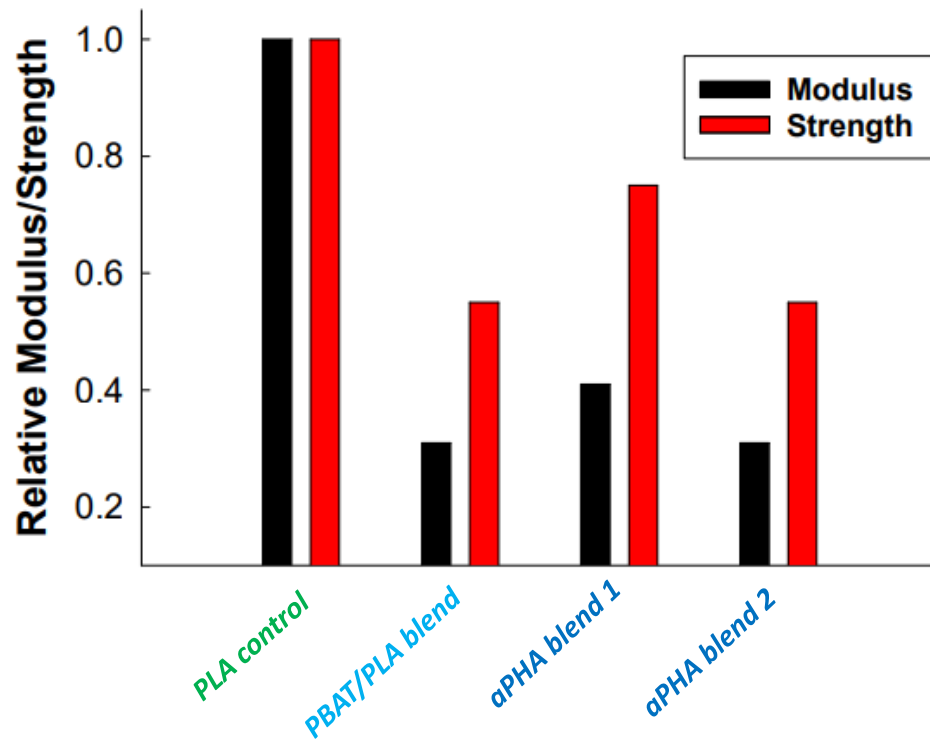
PLA tensile modulus as a function of aPHA loading



Film thickness ~1mil



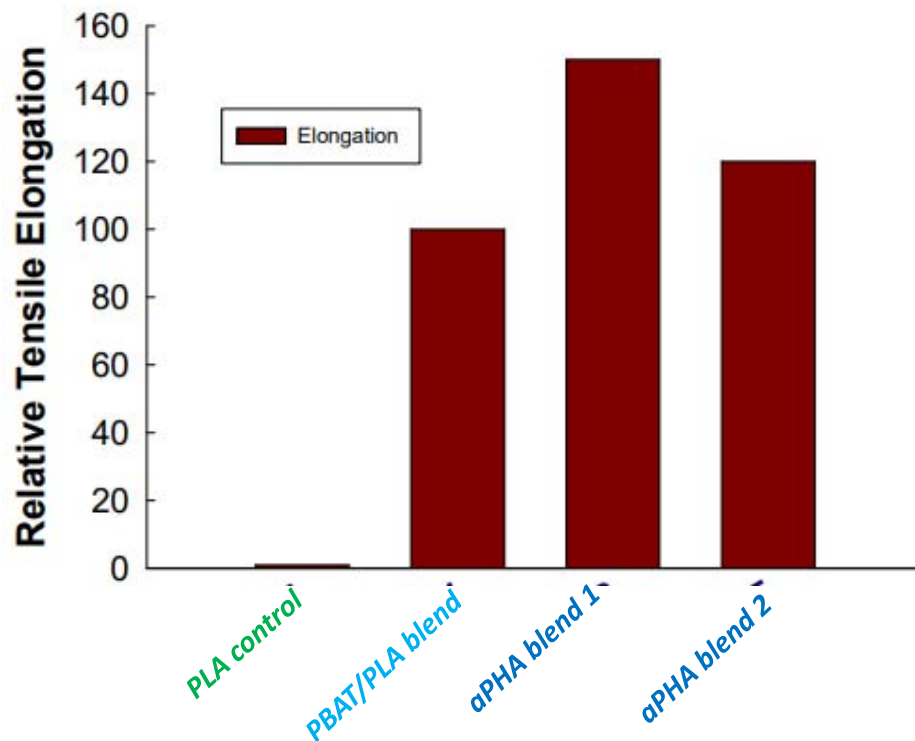
PLA/aPHA blown-film properties



Film thickness ~1.5mil



PLA/aPHA blown-film properties



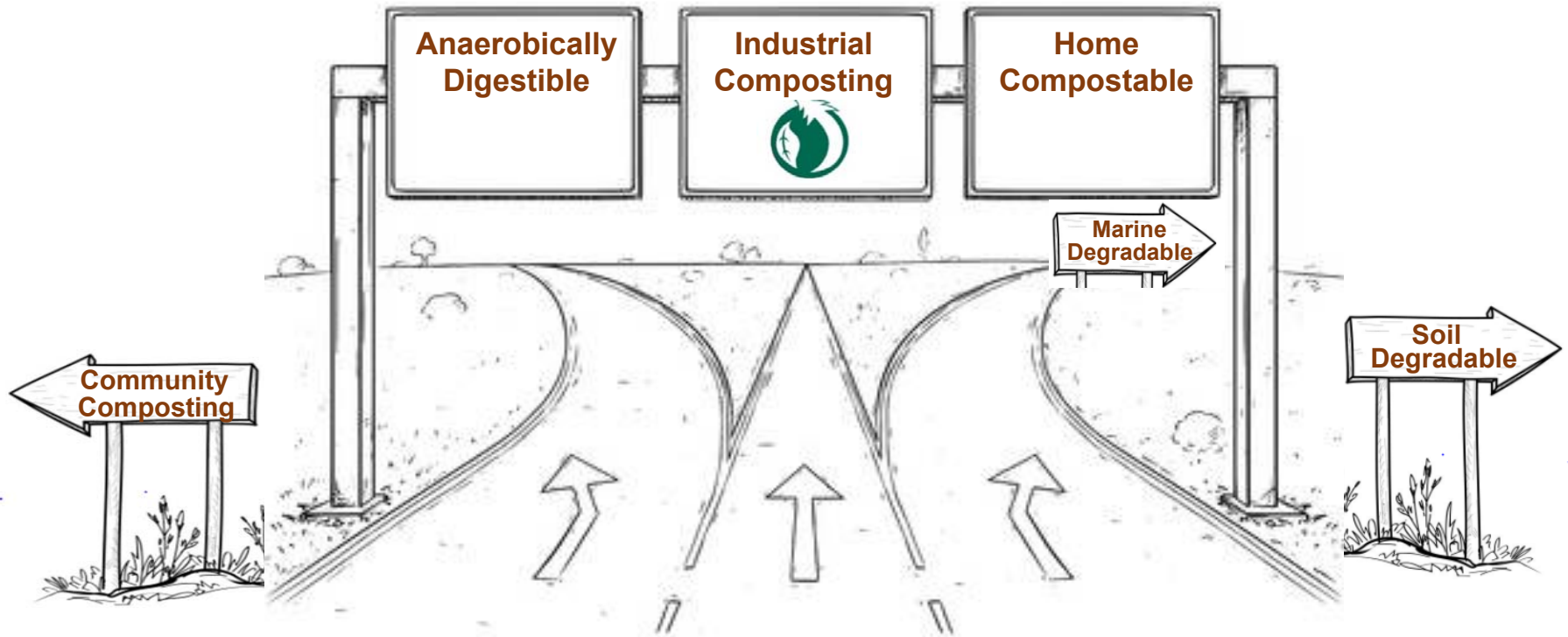
Fully biobased solutions to significantly improve mechanical properties of PLA based films

- *Formulations balance stiffness, tear and puncture*
- *Potential to achieve faster industrial or home-compostable films*

Film thickness ~1.5mil

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Differing market asks from a variety of single-use end markets

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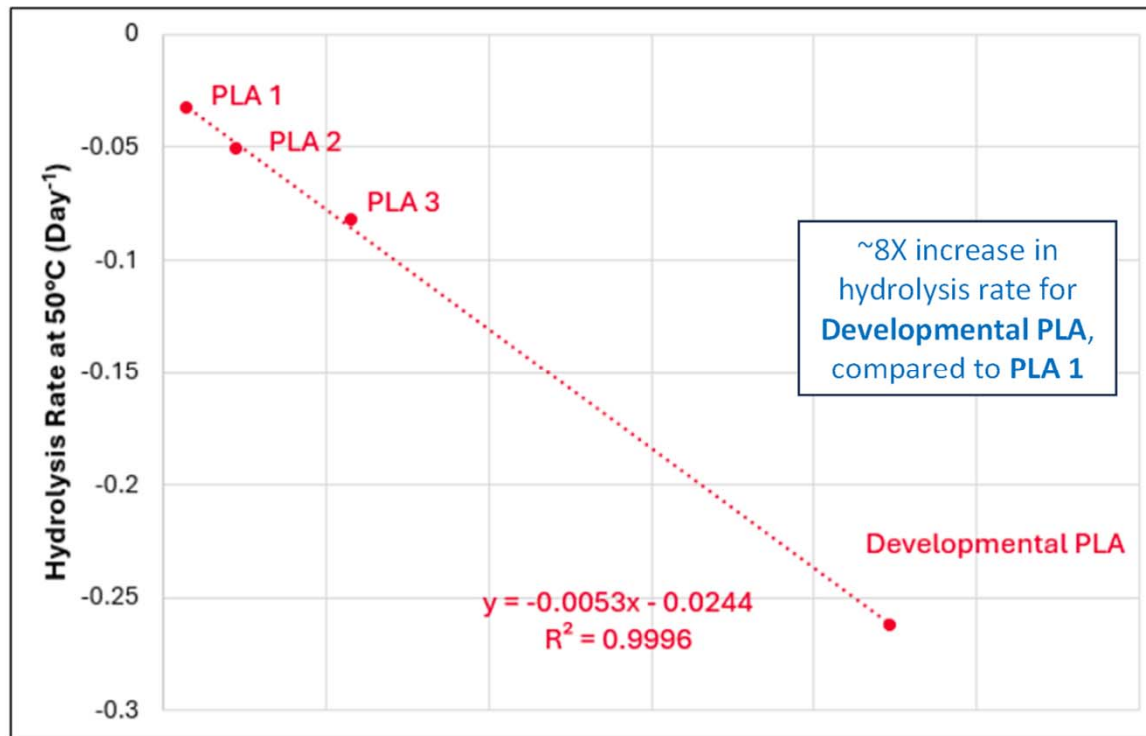
We look at degradability as a continuum



And we're investing significantly in tailoring polymer grade design to vary degradability in appropriate end environments ...



Tuning hydrolysis rates of PLA

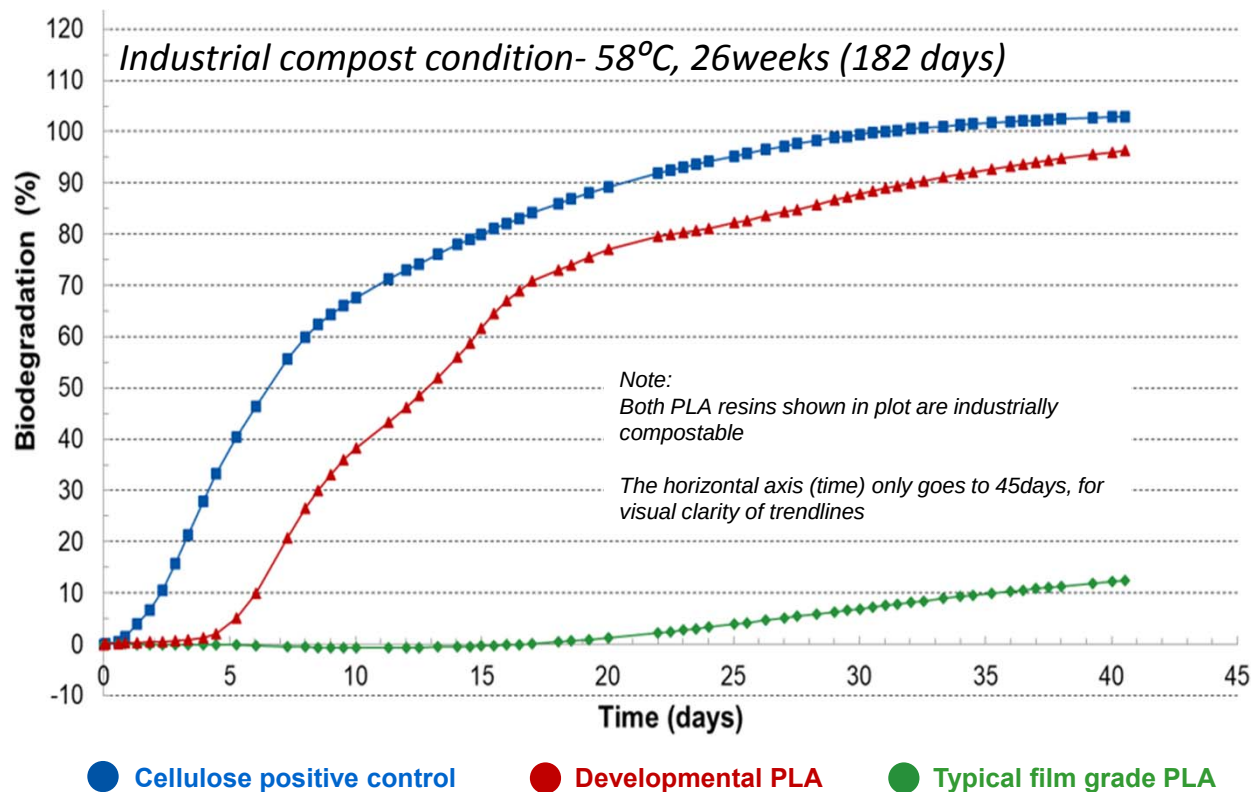


Opportunities exist to blend the new developmental PLA with slower hydrolyzing PLA grades (or other polyesters), to manipulate the rate of hydrolysis of the blend

Hydrolysis experiments conducted with pellets submersed in *deionized* water



Biodegradation rate of PLA

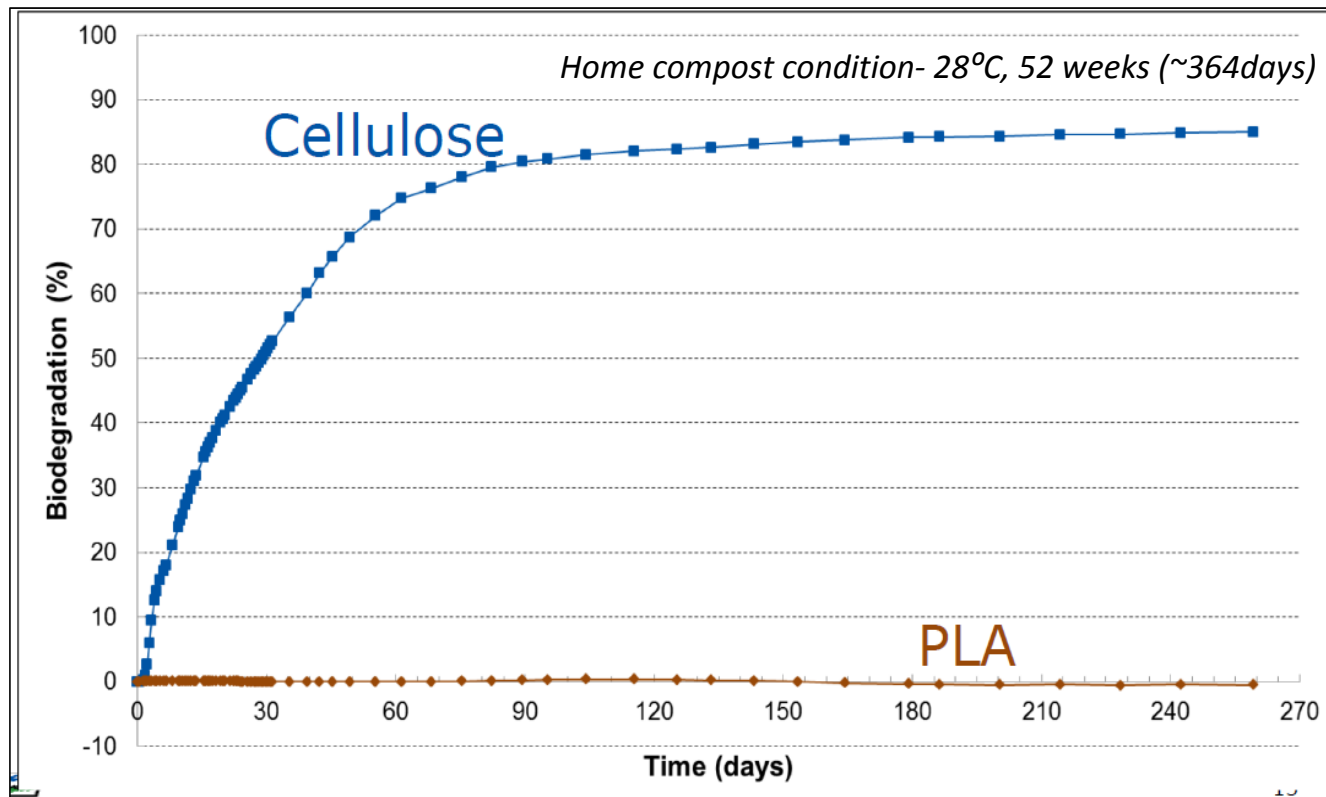


Rate limiting step in PLA degradation is the chain hydrolysis step

Faster hydrolysis rates translates to faster rate of biodegradation



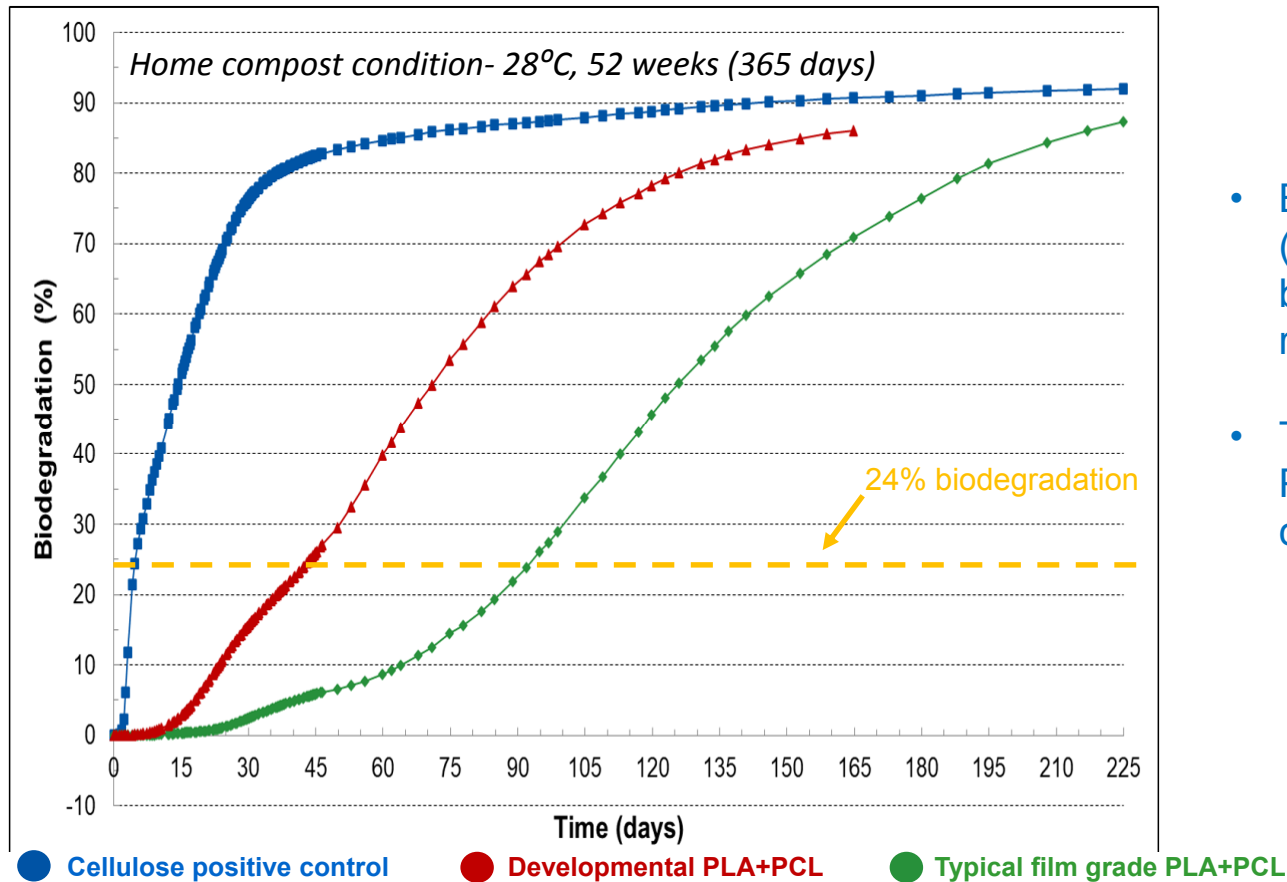
Manipulating biodegradation rate of PLA



Unmodified PLA does not biodegrade quickly under home-compost conditions



Manipulating biodegradation rate of PLA via formulations



- Blends of PLA & polycaprolactone (PCL) exhibit higher rates of biodegradation in both types of PLA resins
- This synergistic effect allows tailoring of PLA formulations to achieve home-compostable compounds

Absolute biodegradation experiments conducted according to ISO 14855-1 at 28°C

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Thank you

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