



**Agriculturally derived polymers and composites
targeted toward a circular economy.**

**William Orts
USDA**



December 11, 2019

USDA Western Regional Research Center



Albany, California

~400 people

~50 in Biofuels/
& Bioproducts

Known for crop biotech.



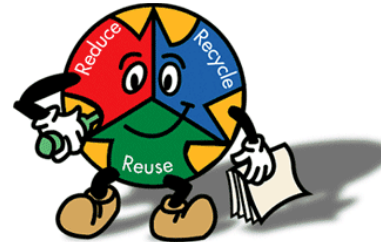
Partnerships: Industrial Collaborators



method.



SALINAS VALLEY
SOLID WASTE AUTHORITY
*Promoting the Environmental Health
of the Salinas Valley*



FULL CYCLE
Bioplastics for the Circular Economy



CORUMAT
BETTER MATERIALS



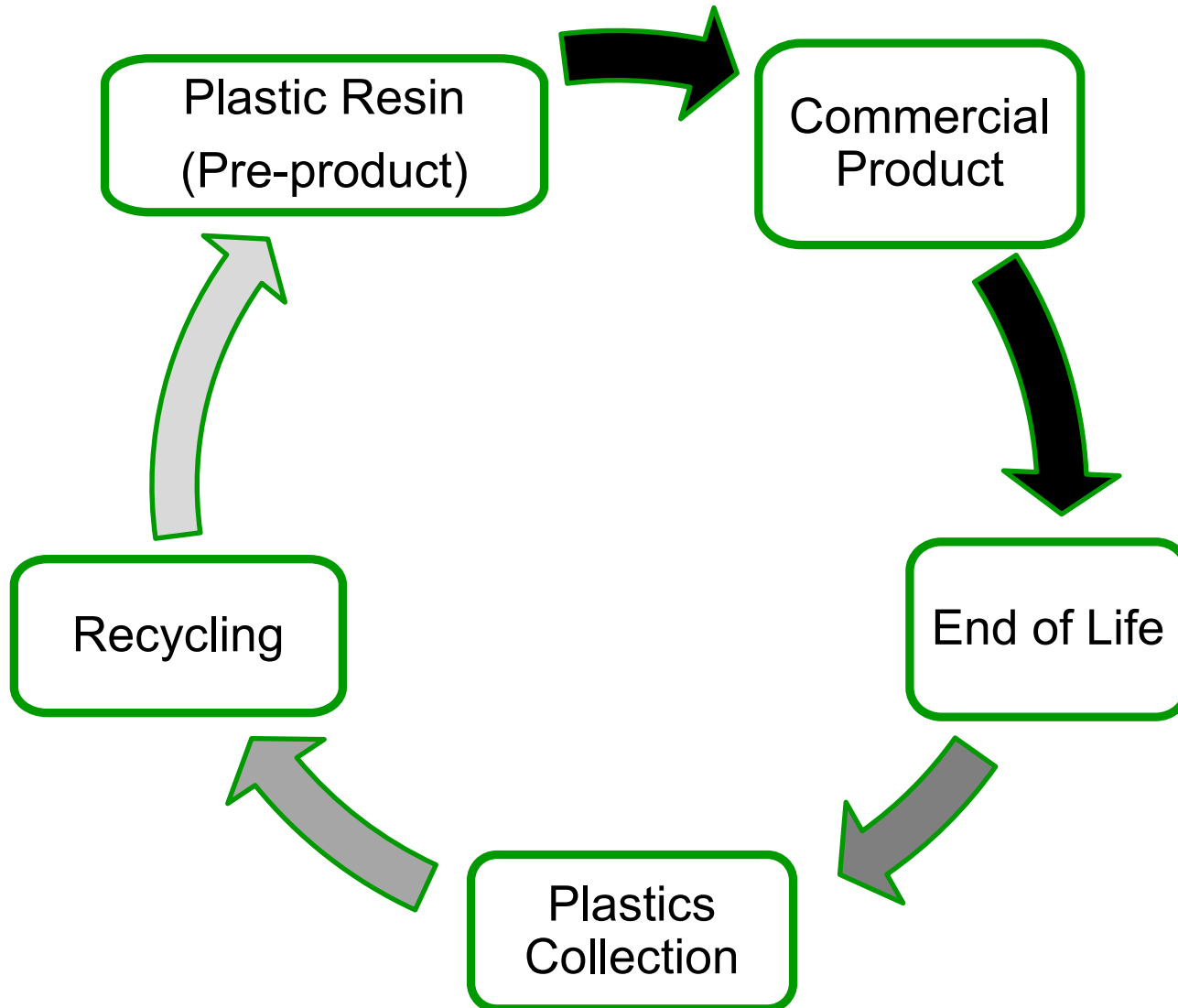
COOPERTIRES



MANGO MATERIALS



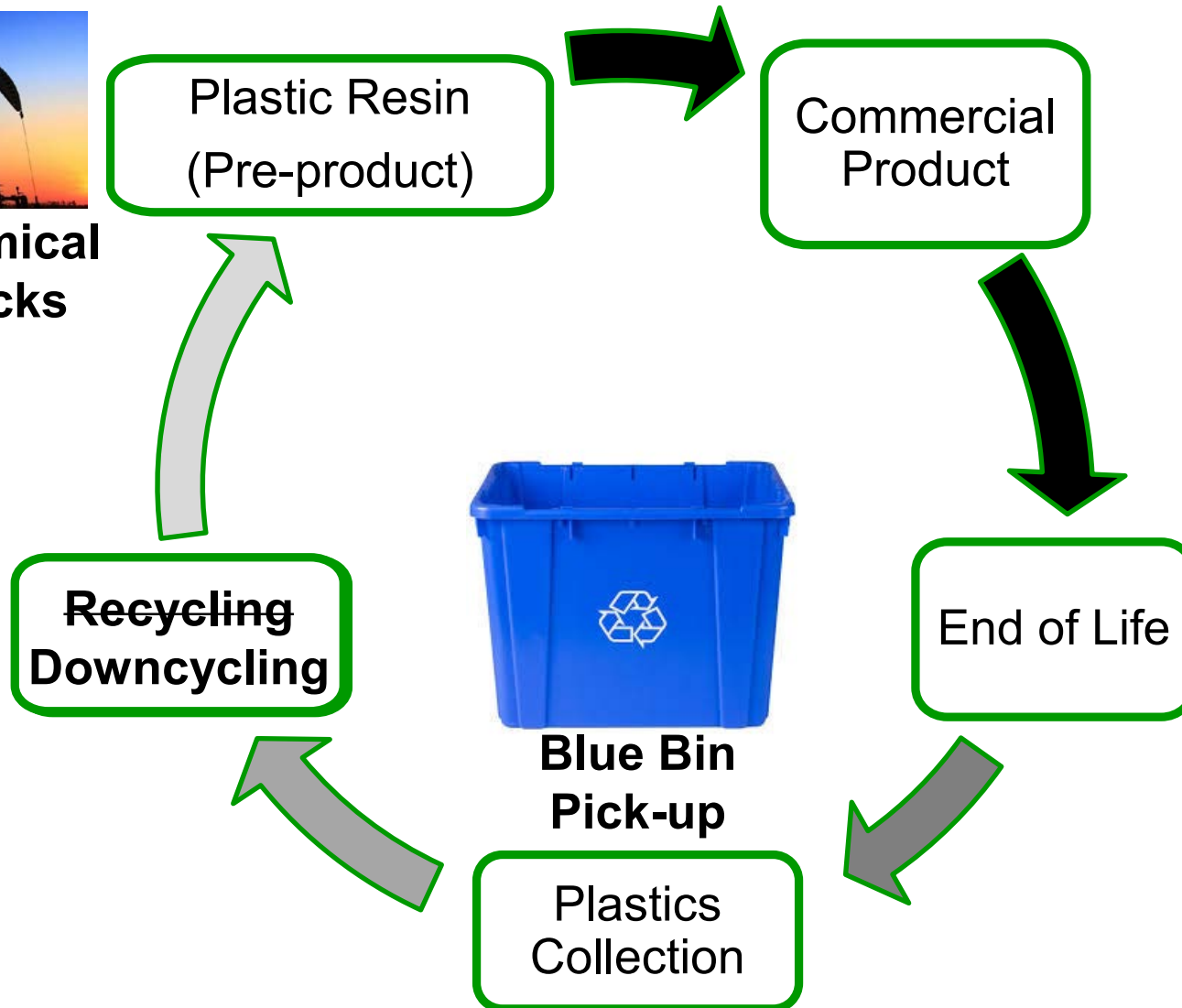
Circular Economy of Plastics



Traditional Synthetic Plastics



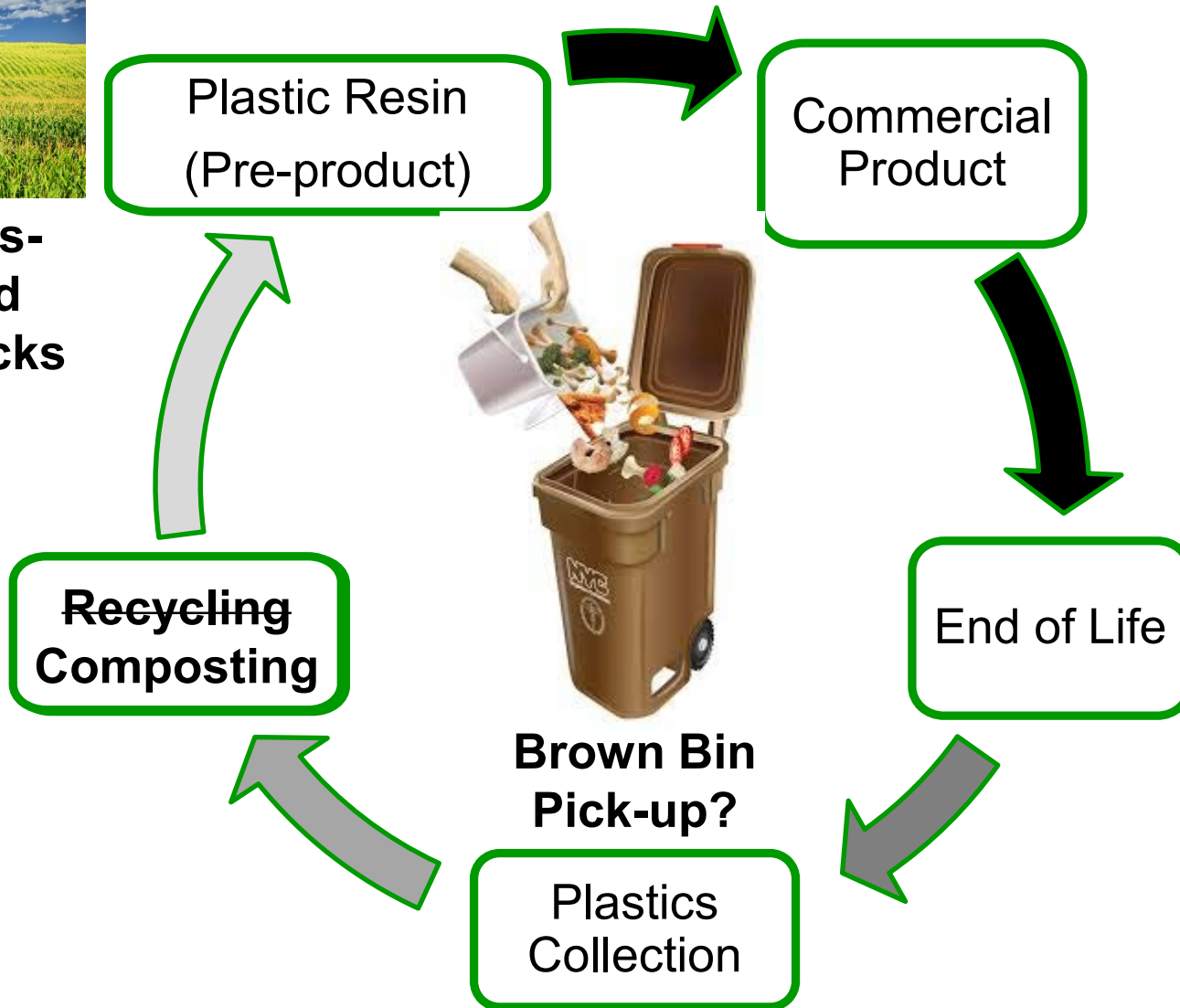
**Petrochemical
Feedstocks**



BioPlastics



Biomass-Derived Feedstocks



We need consistency in waste handling infrastructure

important changes to your bin collection

Starting from 22 October 2018



Find out more 

- ✓ Hedge Trimmings
- ✓ Twigs/Small Branches
- ✓ Flowers
- ✓ Weeds
- ✓ Leaves
- ✓ Prunings

- X Stone, Rubble, Soil, Turf
- X General Waste
- X Food Waste
- X Animal Waste
- X Japanese Knotweed
- X Ragwort

Collection calendars available online or call 01349 886603

For further information:

☎ 01349 886603 ✉ recycle@highland.gov.uk

 www.highland.gov.uk/recycle

Drivers toward sustainable plastics

Adding value to agricultural products.

- Optimizing use of waste streams & surplus byproducts.

Biodegradability. Compostability.

- Reduce litter. Prevent microplastics. Divert waste from landfills.

Regulatory.

- Prevent negative health/environmental impacts. Eg. Banning microbeads. Ocean Plastics! The USDA's BioPreferred Program.

Recycling and Landfill Diversion.

- Re-using carbons. Closing the circular economy.

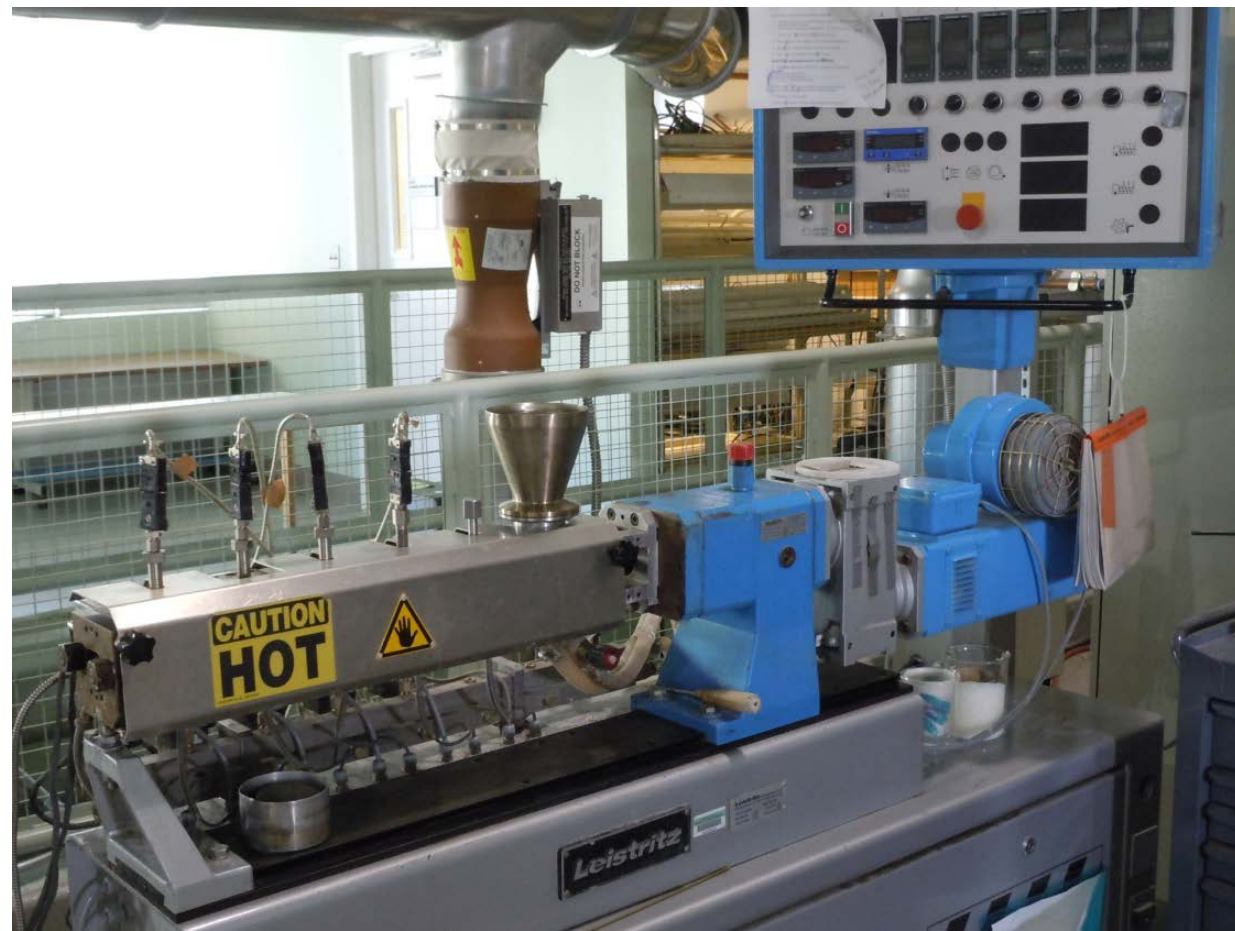
Greenhouse gas reduction.

Making the best product at a good price

Making plastic parts with ag-derived additives

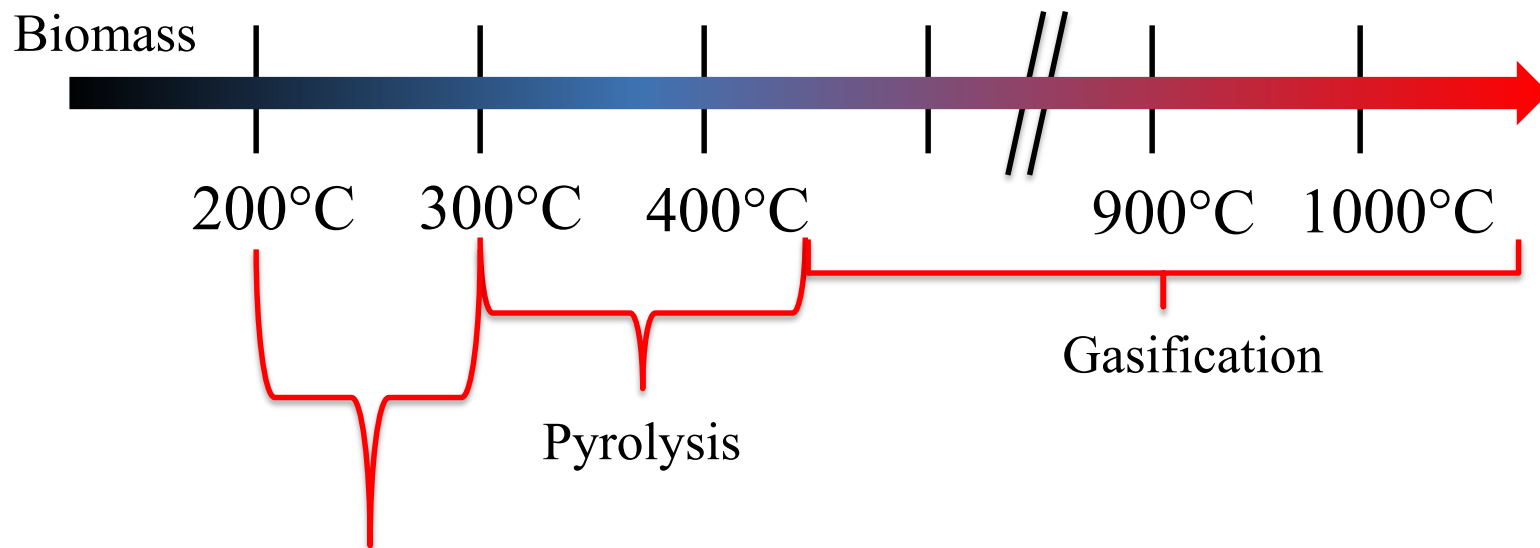


Bor-Sen Chiou



Torrefaction, Pyrolysis & Gasification

Processing Temperature

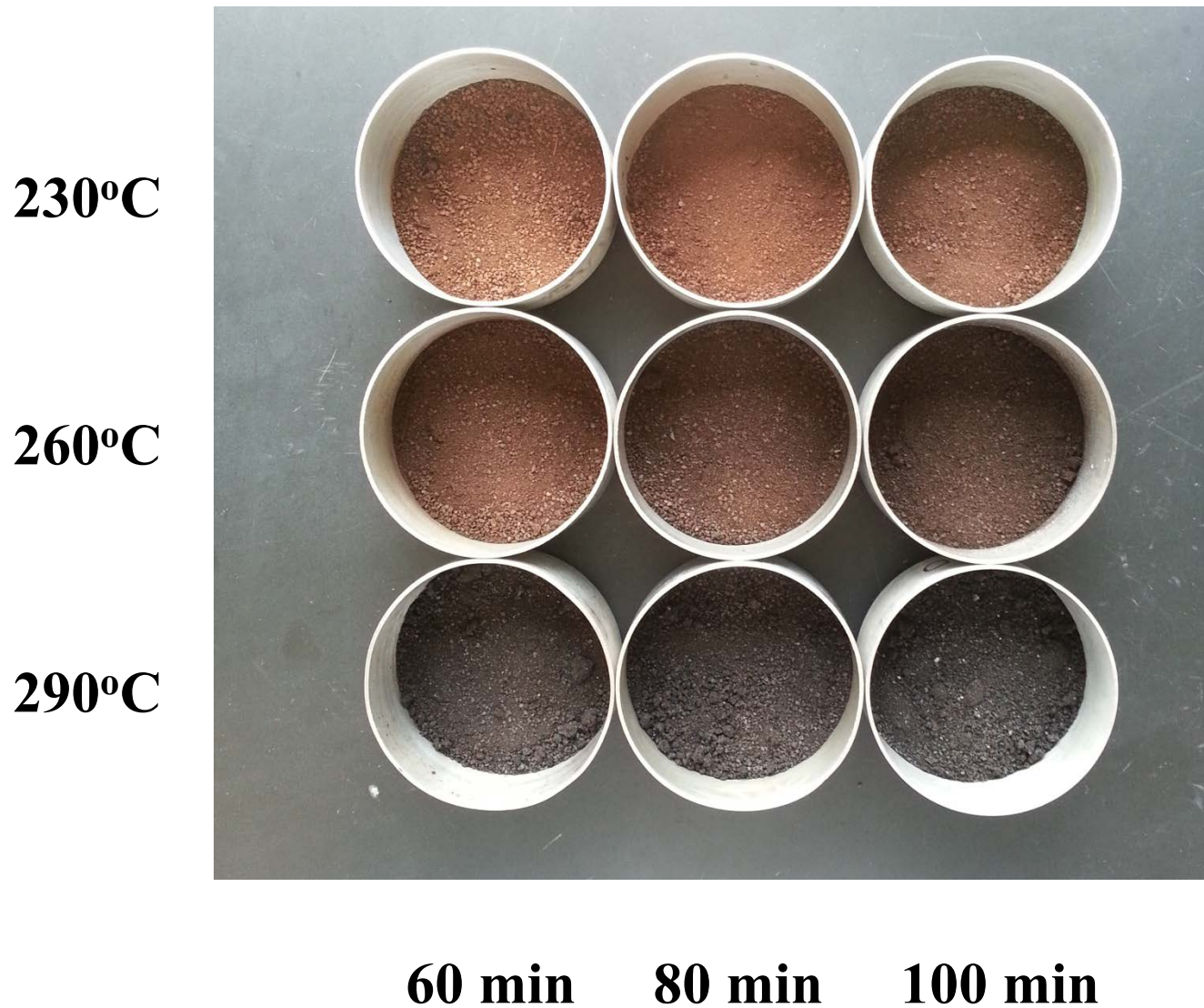


Torrefaction

Densifies the biomass

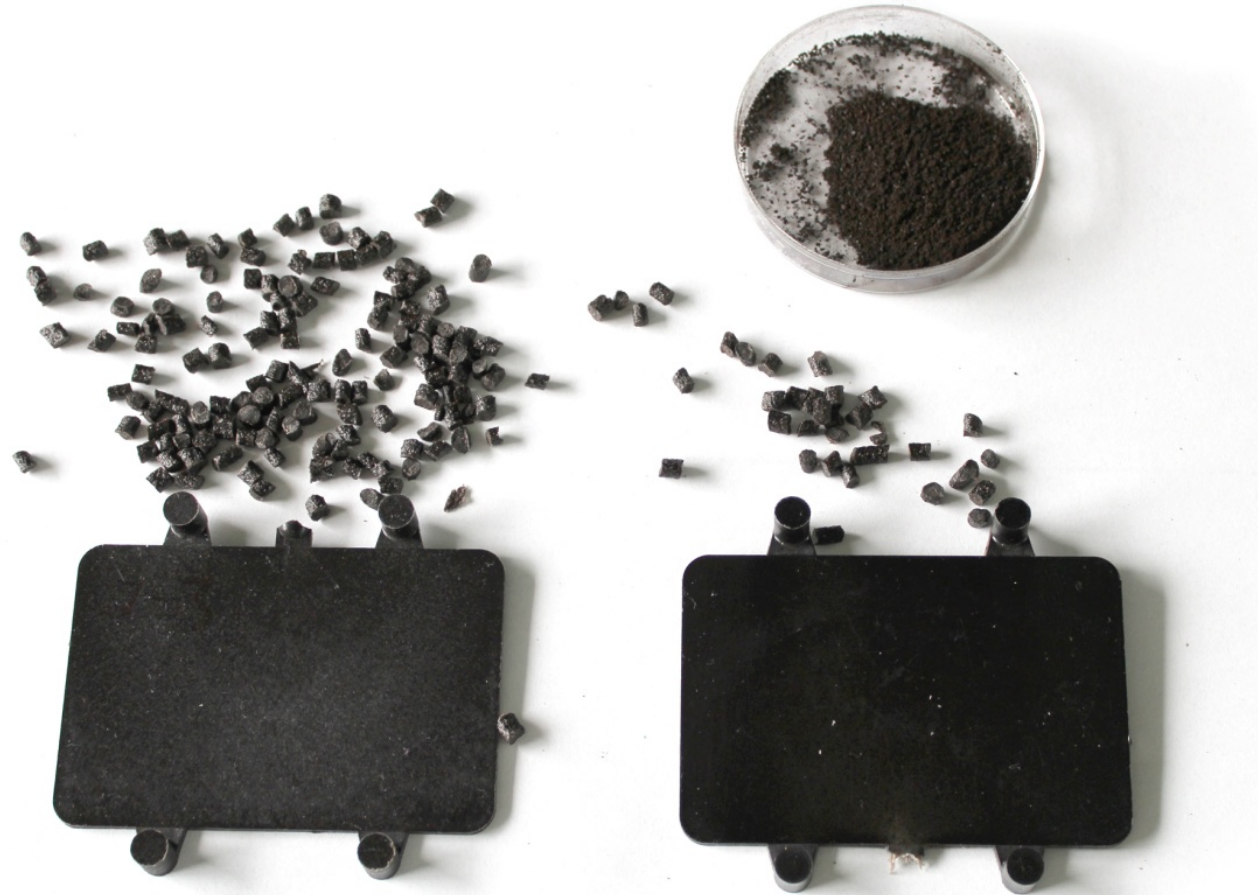
Removes moisture and volatiles

Torrefied Almond Shells



Torrefied Biomass-Polymer Composites

Torrefied Almond Shell



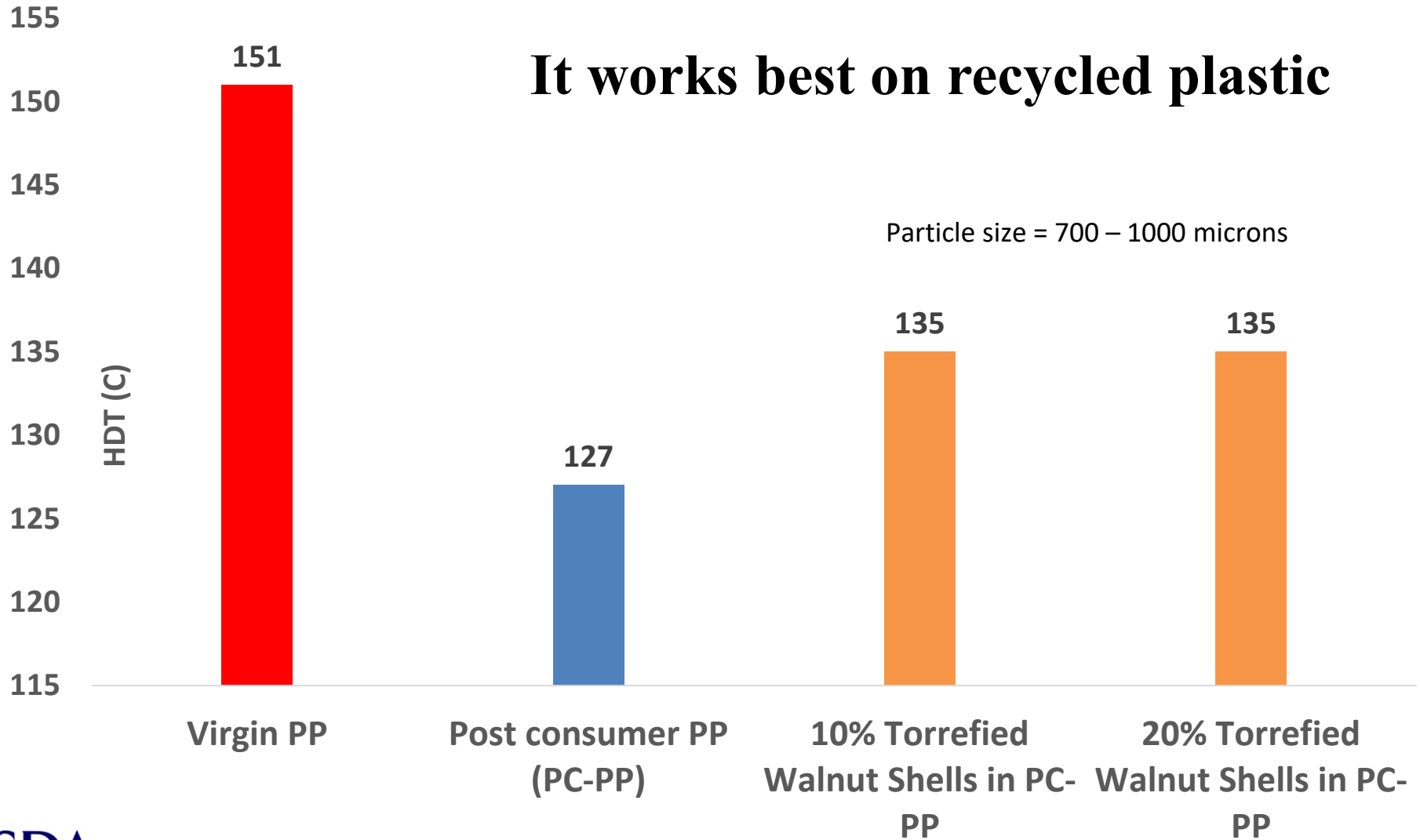
Torrefied Almond Shell in Polypropylene

Torrefied Almond Shell in PET

Can we reverse downcycling?

Torrefied shells in polypropylene

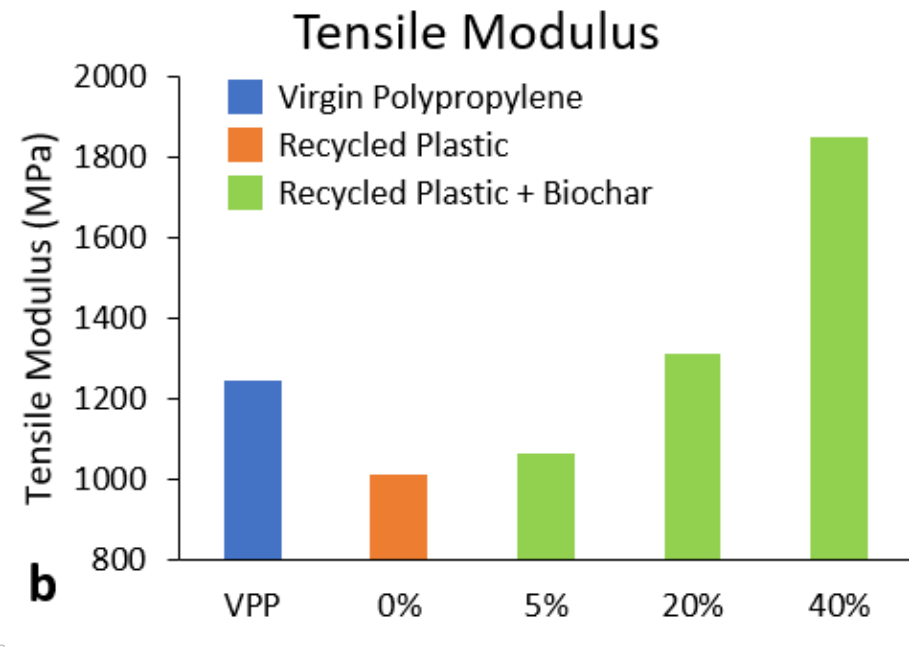
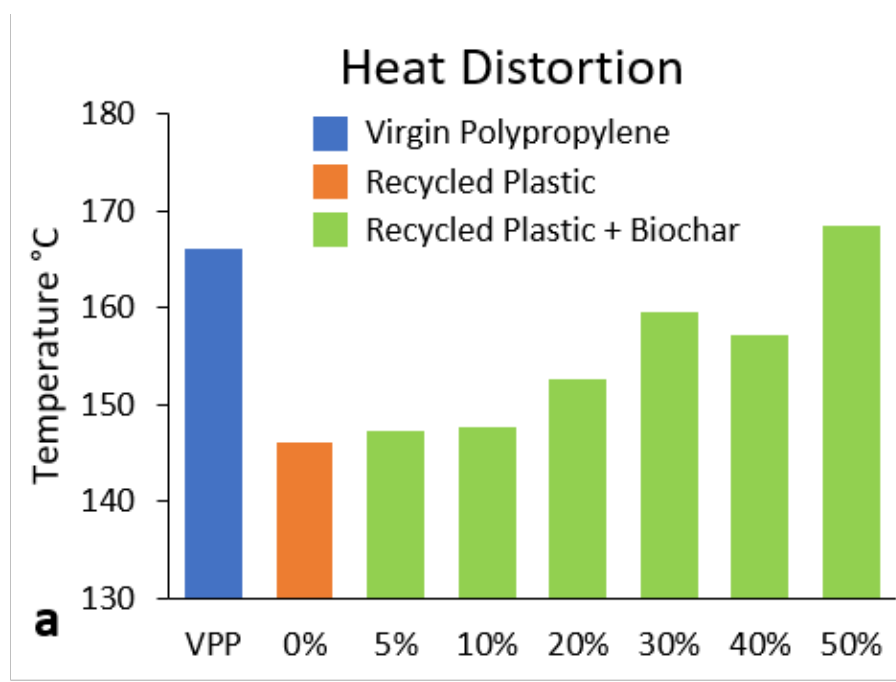
It works best on recycled plastic



Heat Distortion Temperature

Temperature at which material deforms under specific load

The heat stability of plastics is improved by adding shells



Torrefied Biomass in Plastics



Recycled Plastics from MRFs



Mike Centers

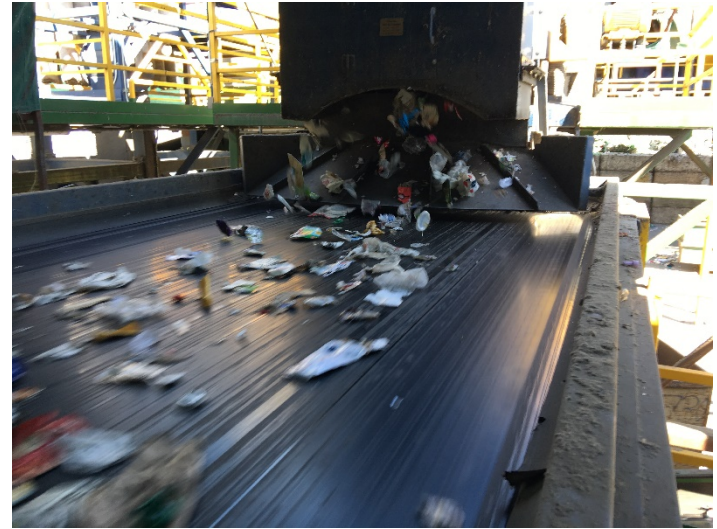


“Clean” Material Recovery Facilities
↔ **Downcycling**

Recycled Plastics from MRFs



Recycled Plastics from MRFs

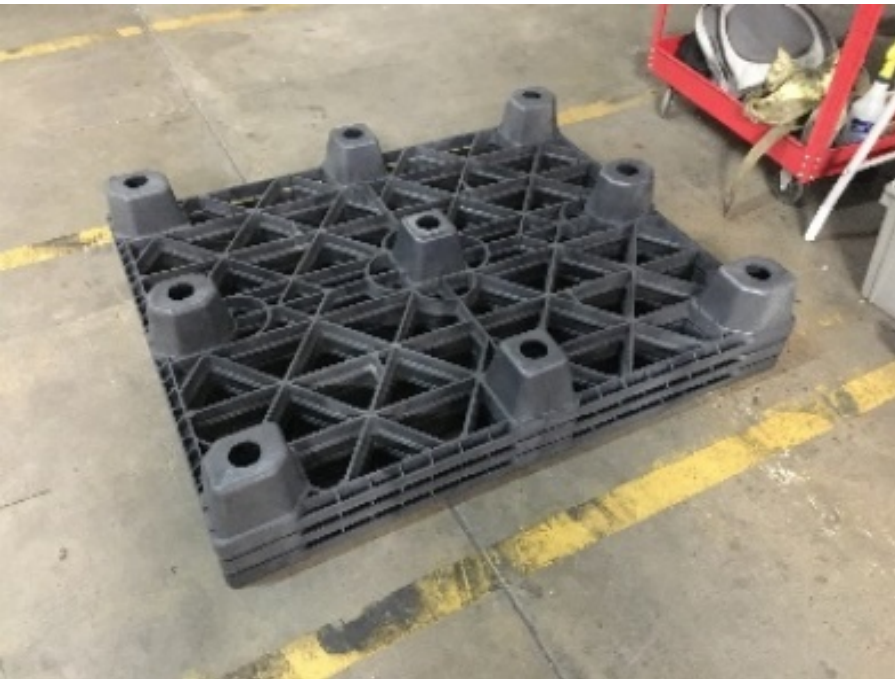


Post-Consumer Recycled PP/PE Blend

Our Feedstock



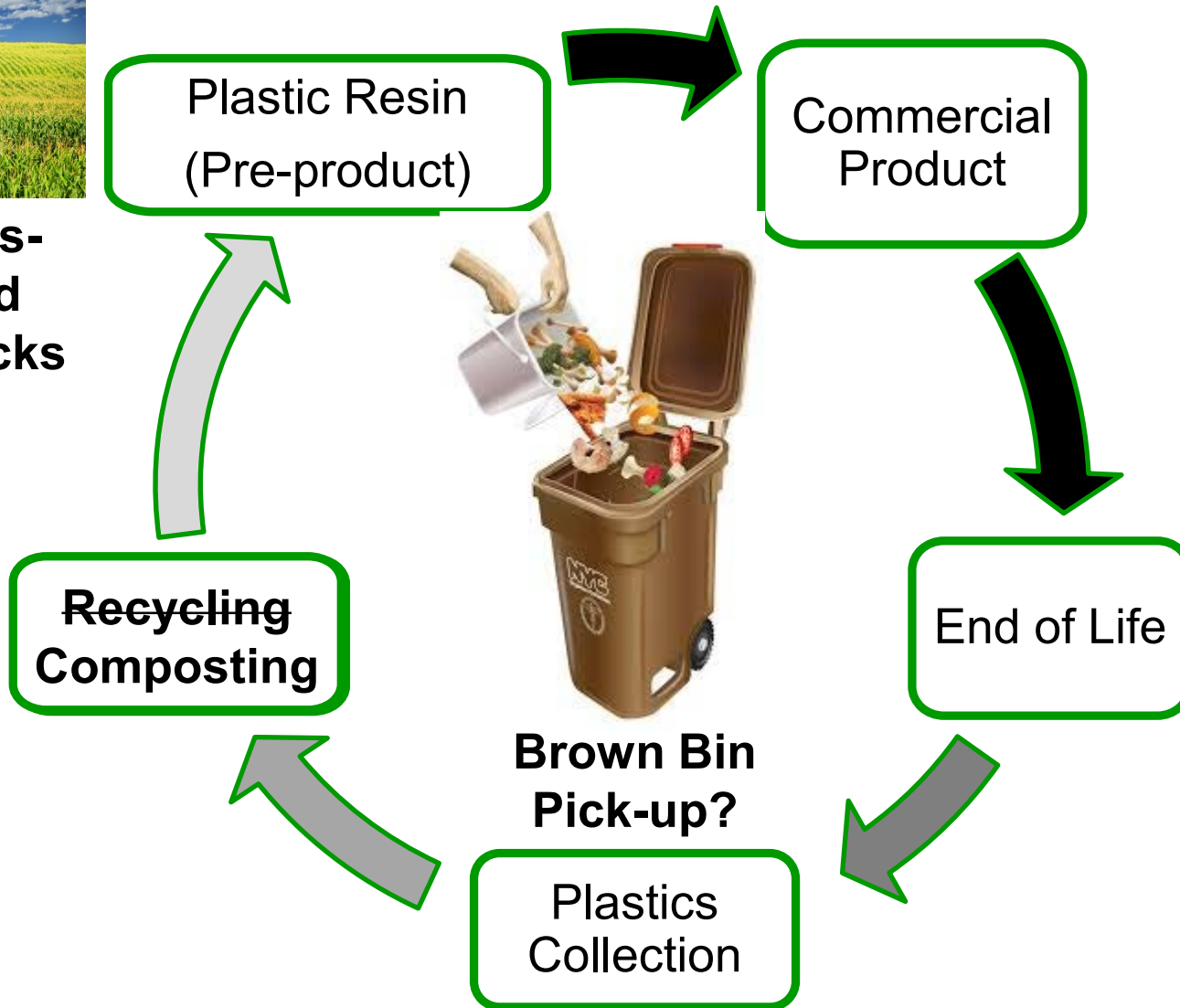
Torrefied Biomass in Plastics



BioPlastics

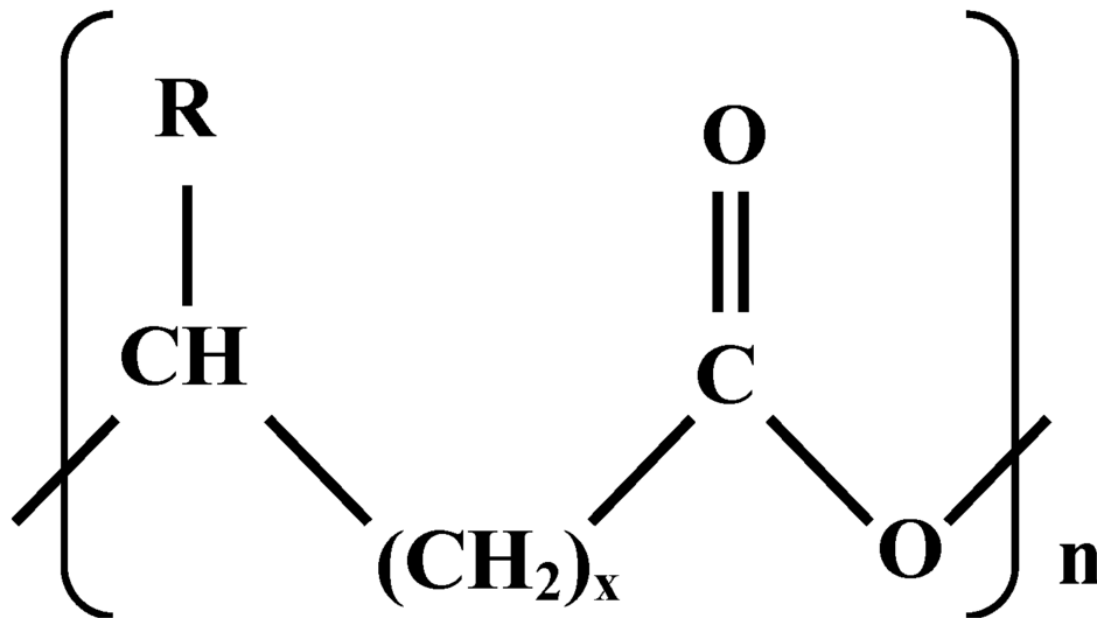
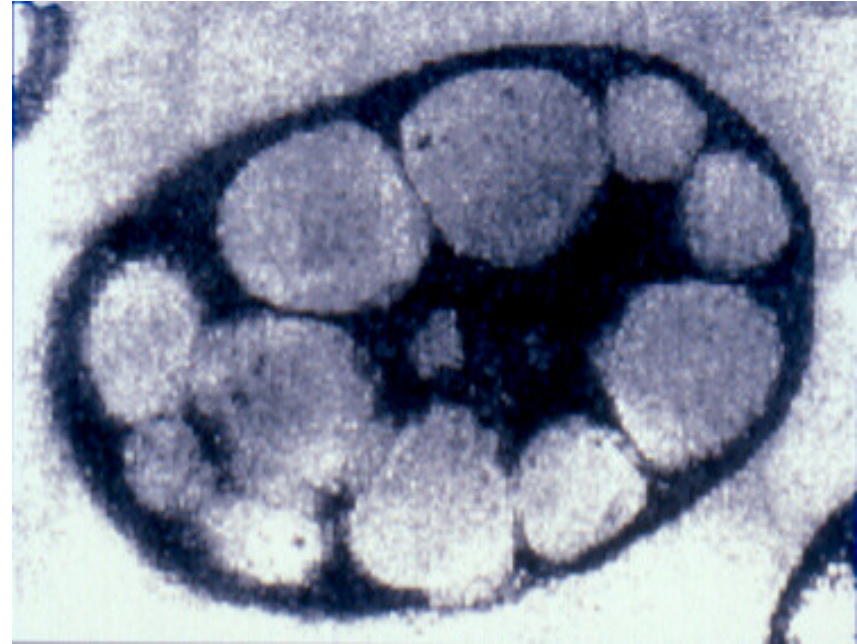


**Biomass-
Derived
Feedstocks**



PHA Bioplastics: PolyHydroxyAlkanoates

Bacterially-produced polyester providing a wide range of properties

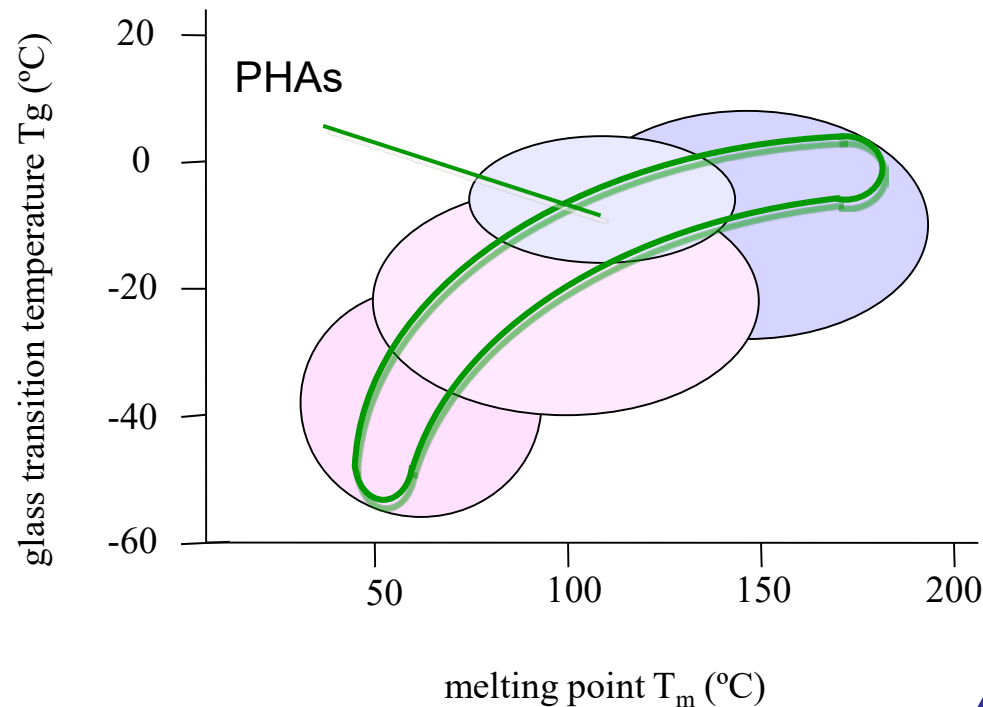


PHAs: Possible Bioplastic Properties

THERMAL
PROPERTIES

XEROX

- thermoplastics
- hot melt adhesives
- coatings
- pressure sensitive adhesives



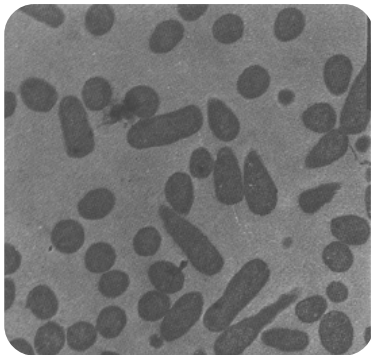
 **Metabolix**[®]



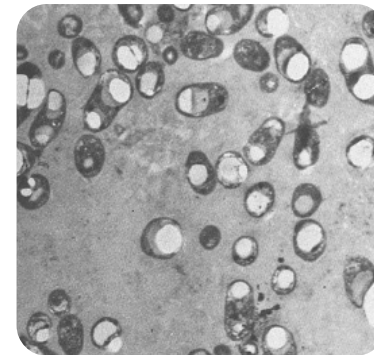
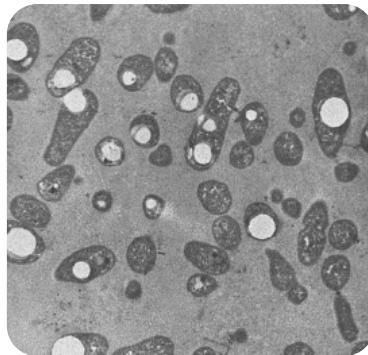
PHA from Biogas

- PHA = bacterial “fat”
- PHA is produced when **excess carbon** is present and/or when a **key nutrient is limiting**

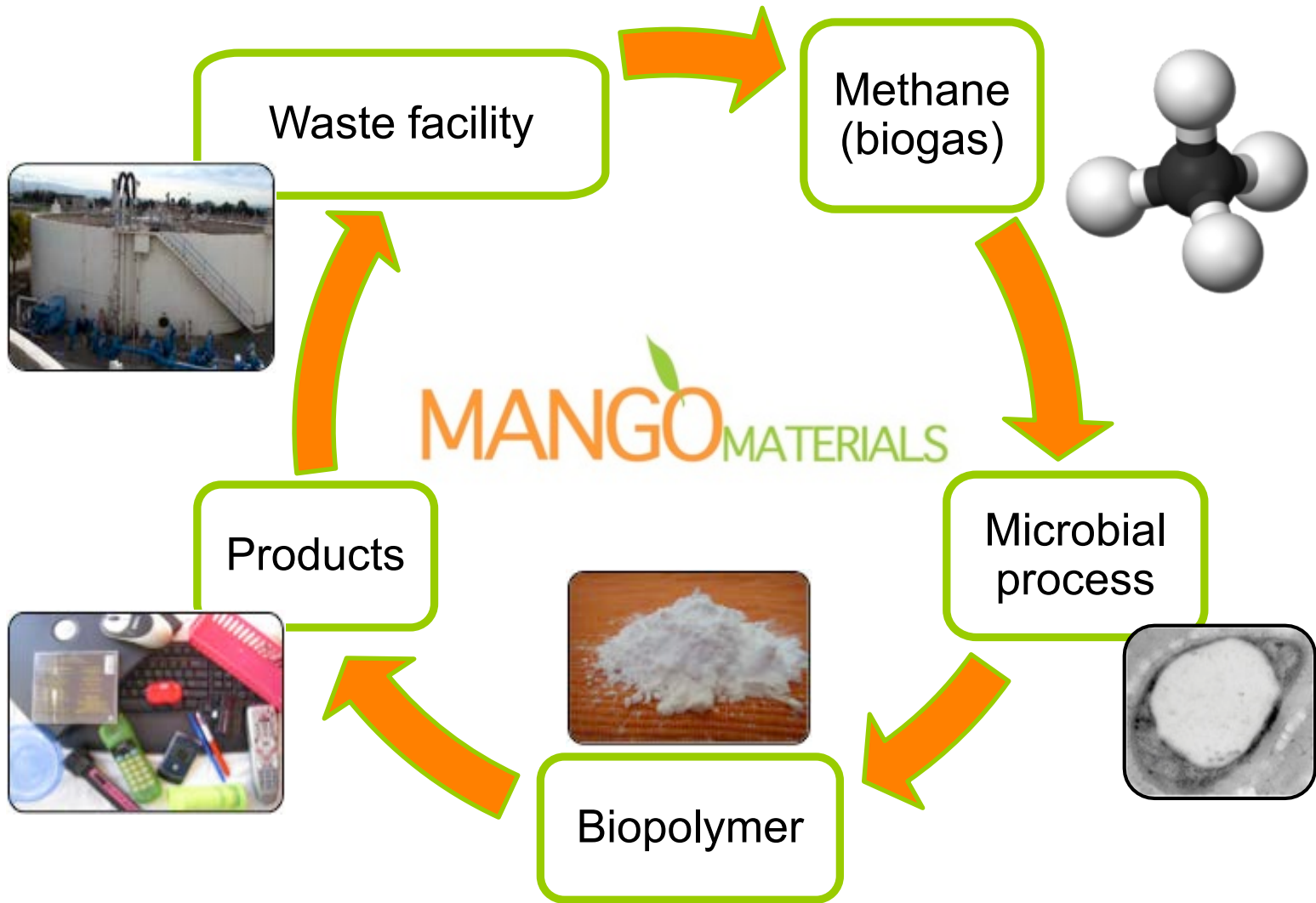
Balanced growth conditions



Carbon excess and/or nutrient deficiency; PHA granules begin to form



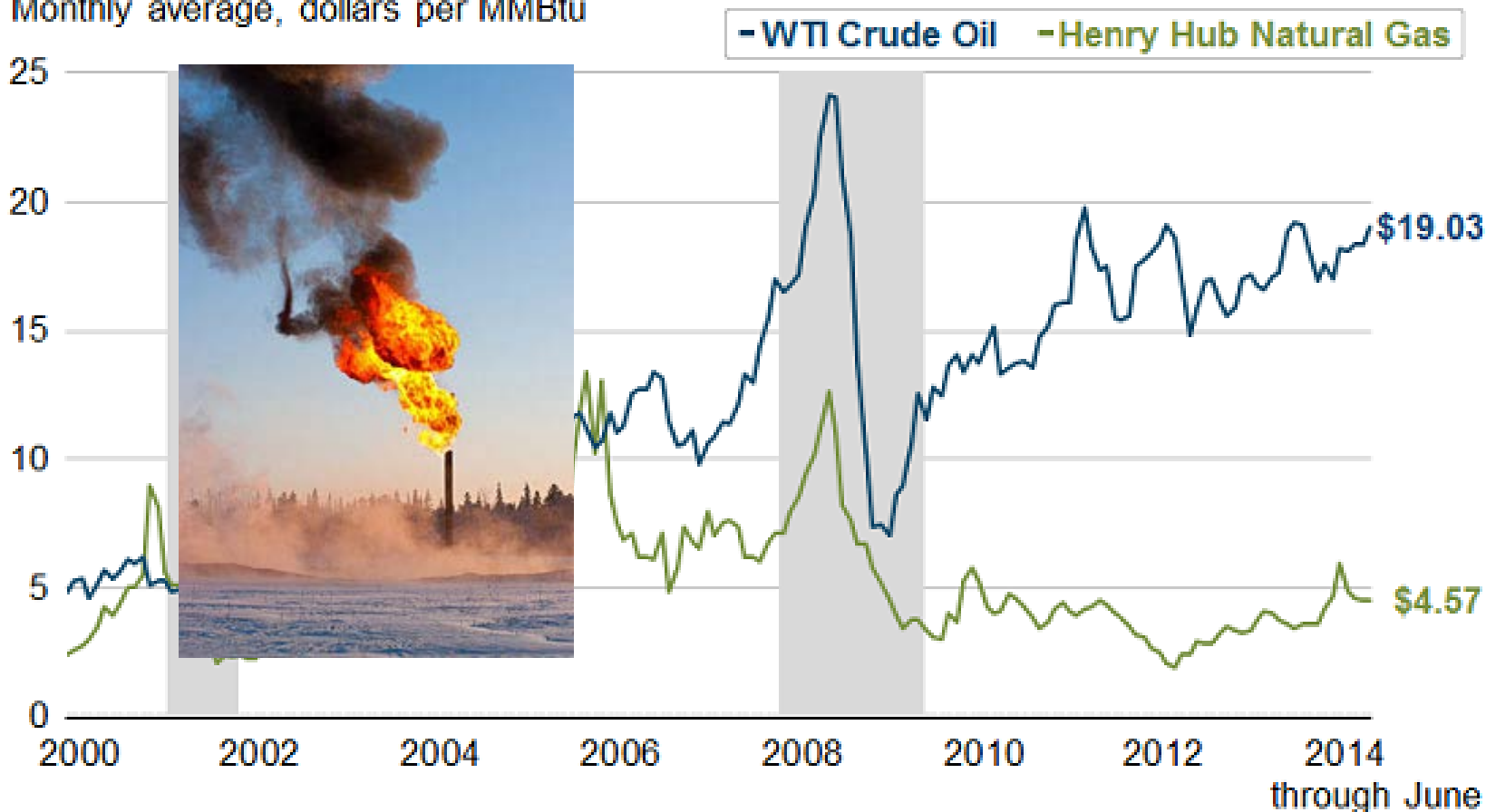
Daniel et al (1992)



Natural Gas vs Oil Prices

Crude Oil and Natural Gas Prices

Monthly average, dollars per MMBtu



Note: Oil prices have been converted to dollars per million BTU for ease of comparison.

Sources: *Wall Street Journal*, U.S. Energy Information Administration, Atlanta Fed calculations

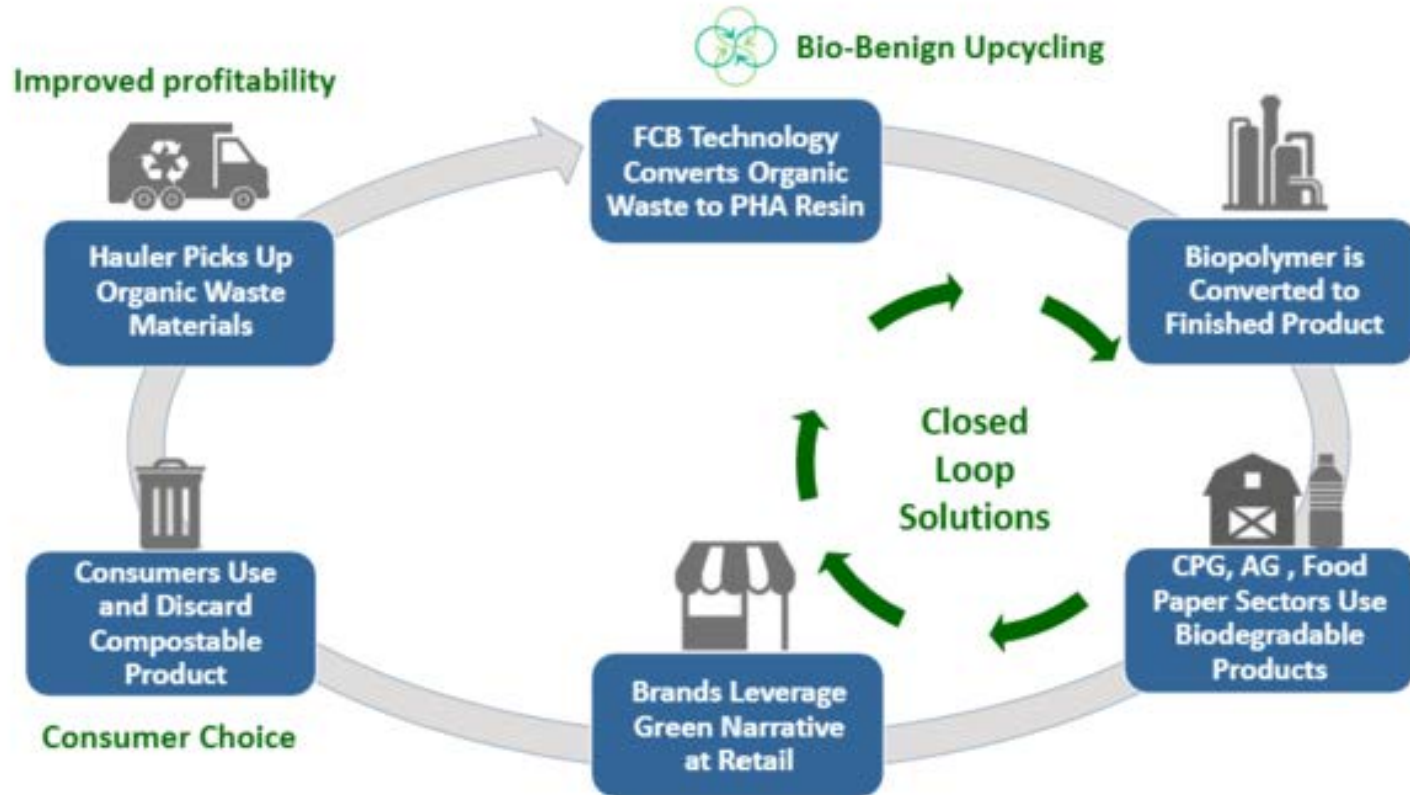
http://farmdocdaily.illinois.edu/2011/11/trends_in_crude_oil_and_natura.html



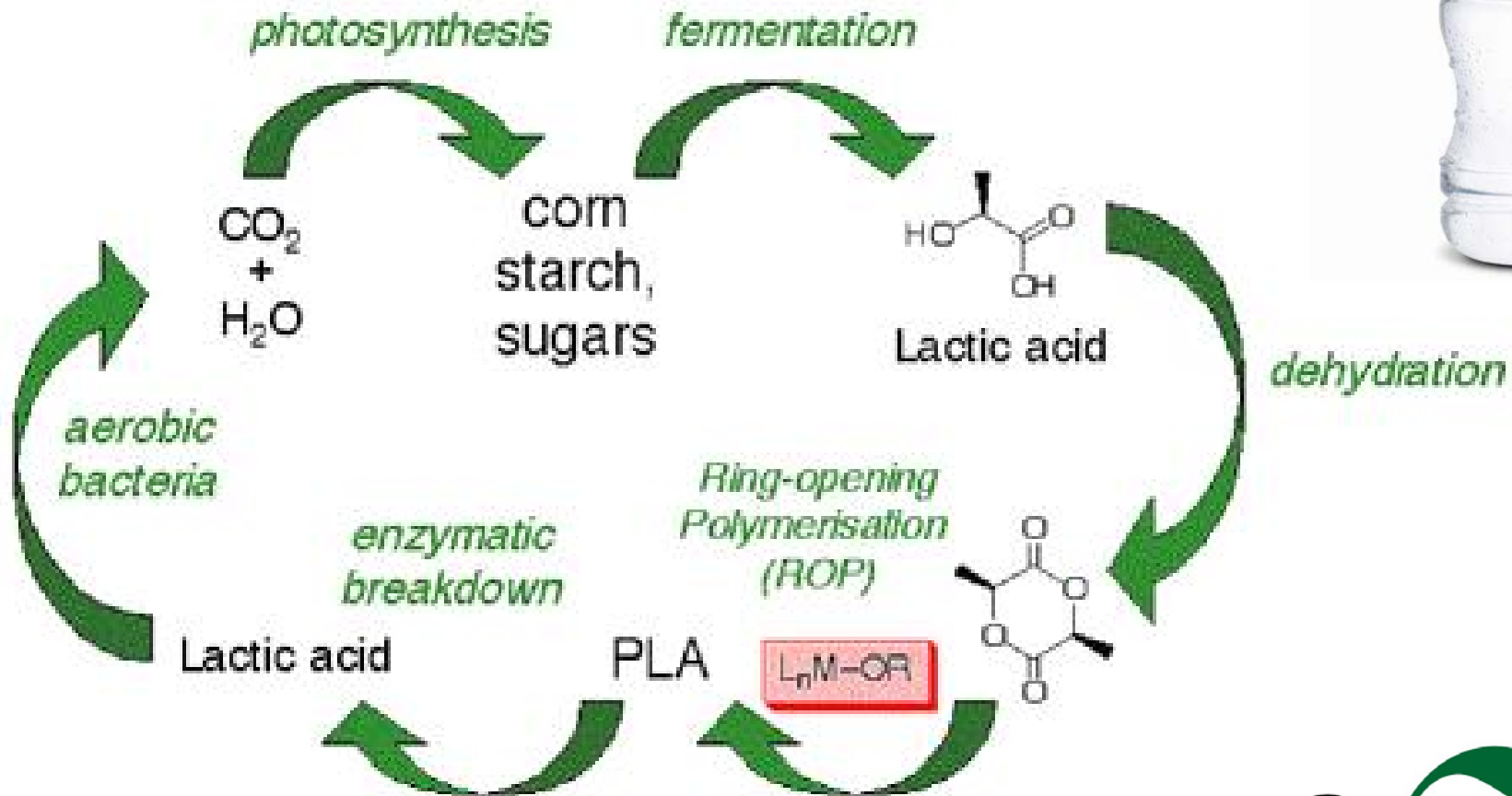
FULL CYCLE

Bioplastics for the Circular Economy

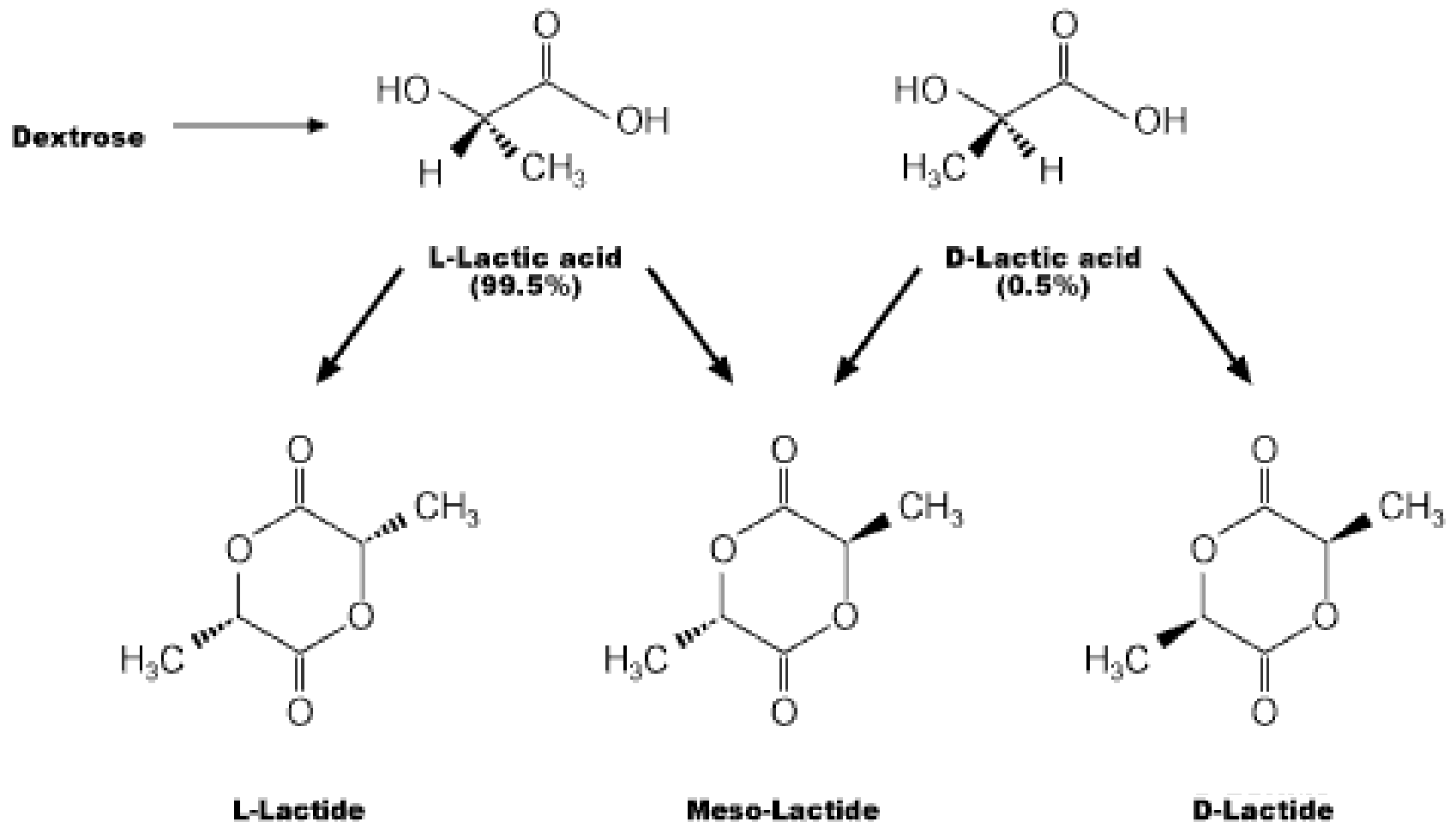
A Meaningful Circular Economy Solution

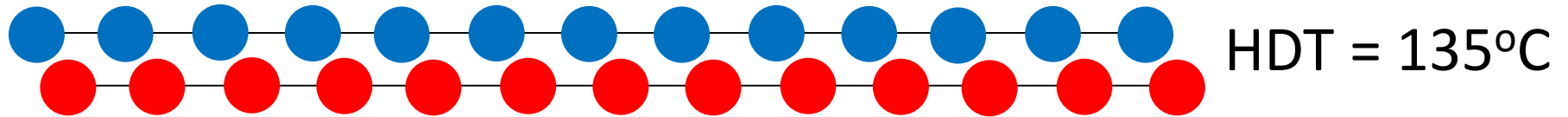
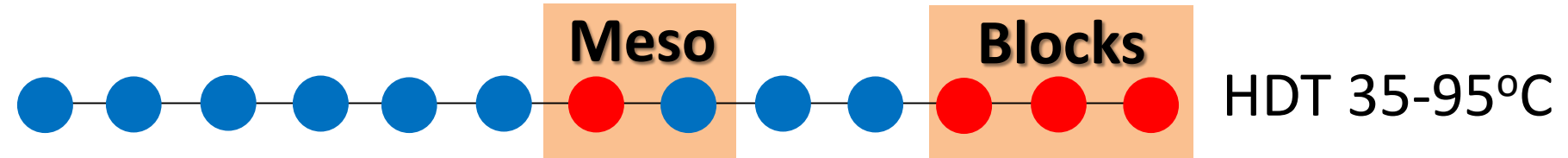
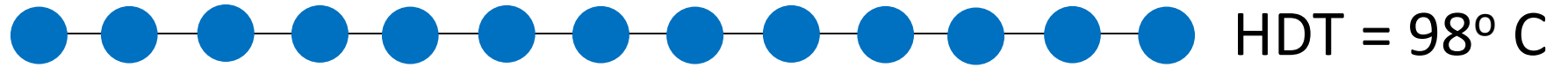
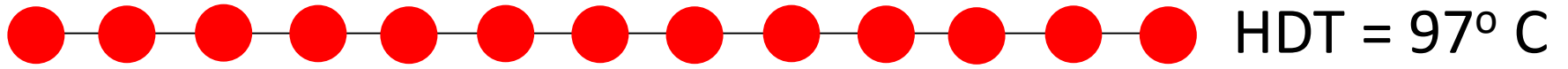


Poly(lactic acid):



Lactide Stereoisomers





D,L – stereo complexes

 D-lactyl monomer

 L-lactyl monomer

PLA Additives

(19) **United States**
(12) **Patent Application Publication** (1)
Sodergard et al. (2)

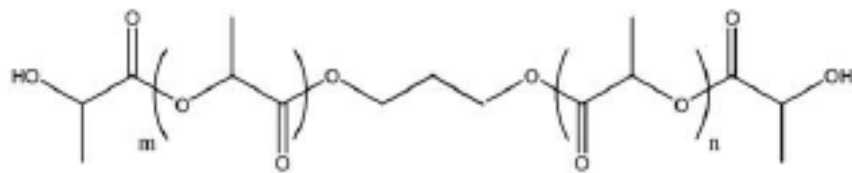
(54) **POLYLACTIC ACID STEREOCOMPLEX** (30)
Feb.
(76) **Inventors:** Nils Dan Anders Sodergard, Turku (FI); Erik Mikael Stolt, Turku (FI); Heikki Kalervo Siistonen, Turku (FI); Geoffrey A.R. Nobes, Decatur, IL (US) (51) I
(52) I
(57)

U.S. Patent 2008/ 0207840
Additives to thermal
stability...and flexibility



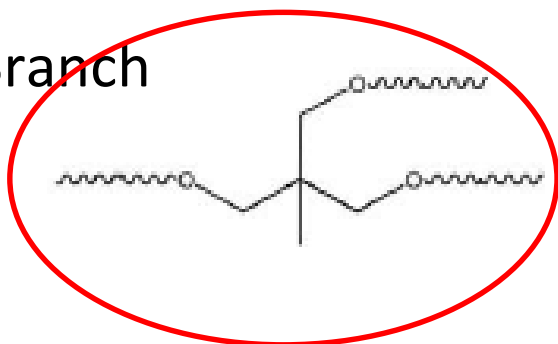
Stereoisomer Additives

Double Branch

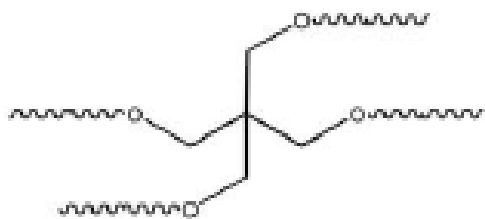


2-PDLA

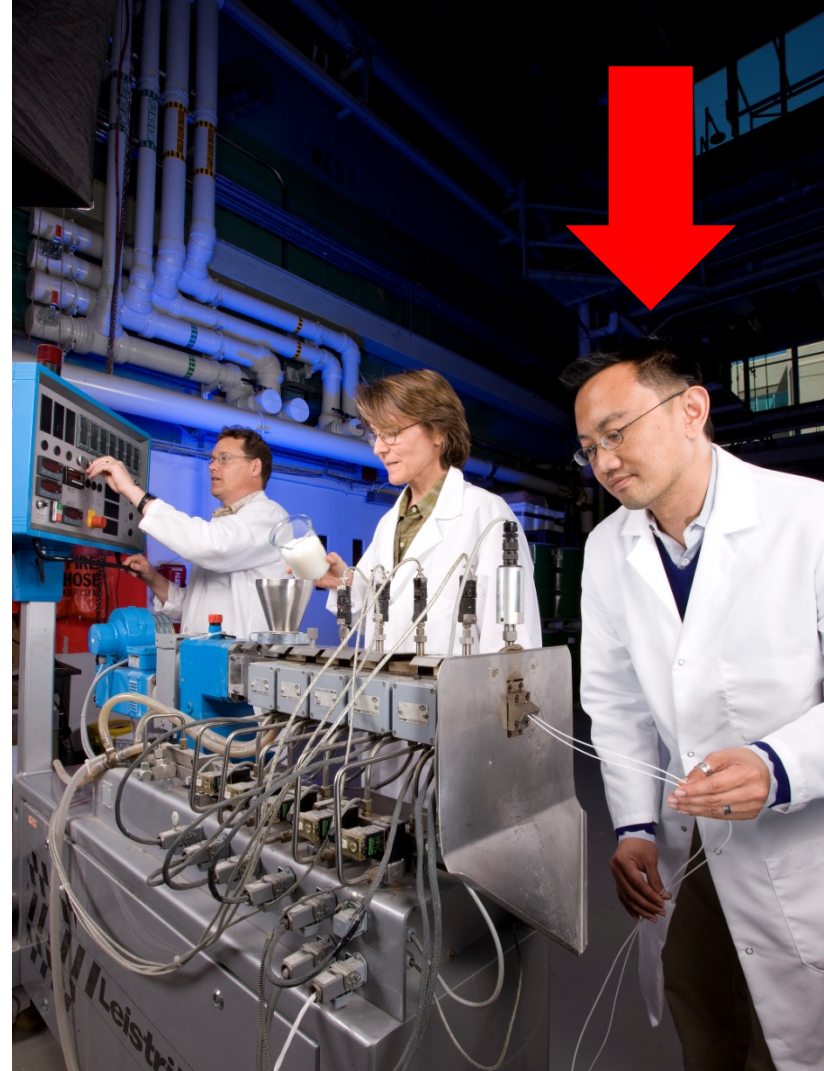
Triple Branch



Quad Branch



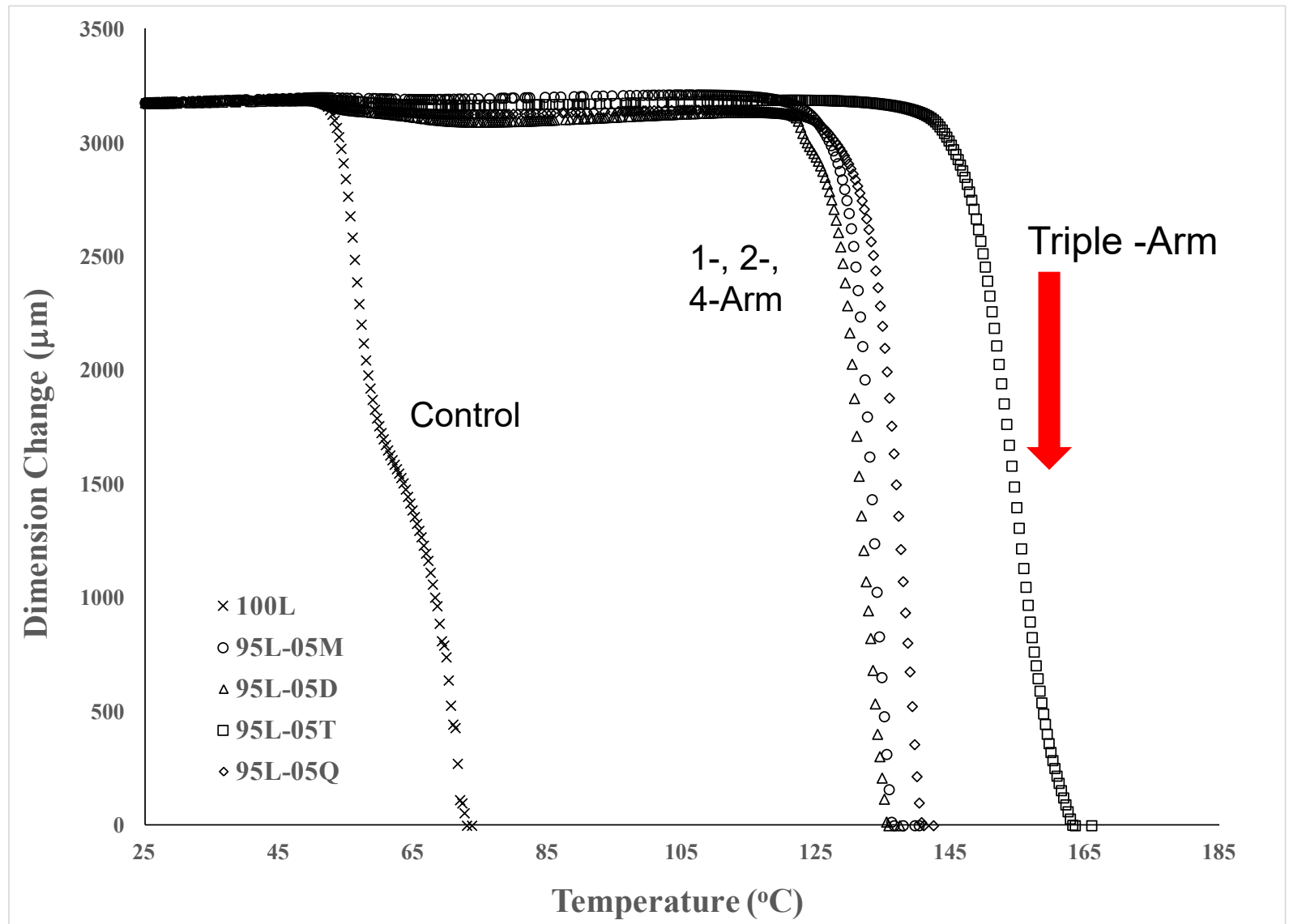
4-PDLA



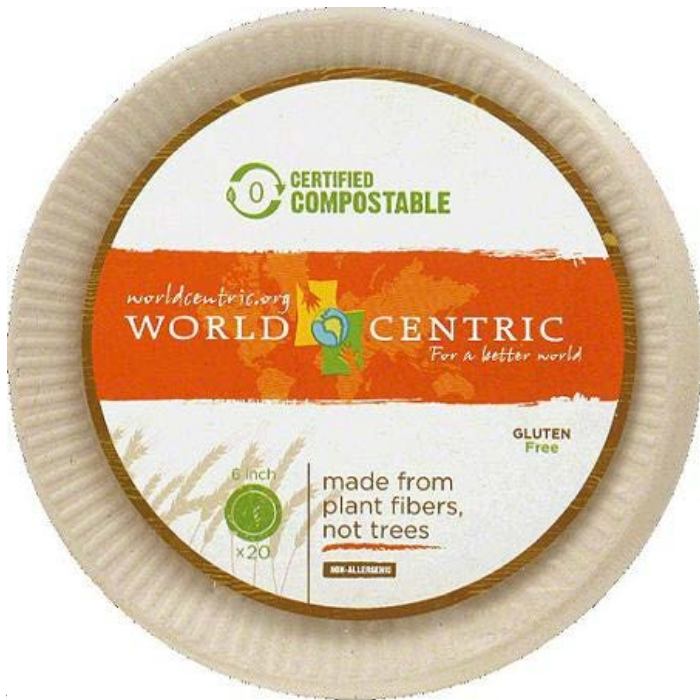
Lennard Torres
Ali Flynn



Poly(lactic acid): Heat Deflection



Partnerships: Single use items



Lightweight Degradable Plastics



CORUMAT

BETTER MATERIALS


**Lower
Cost**



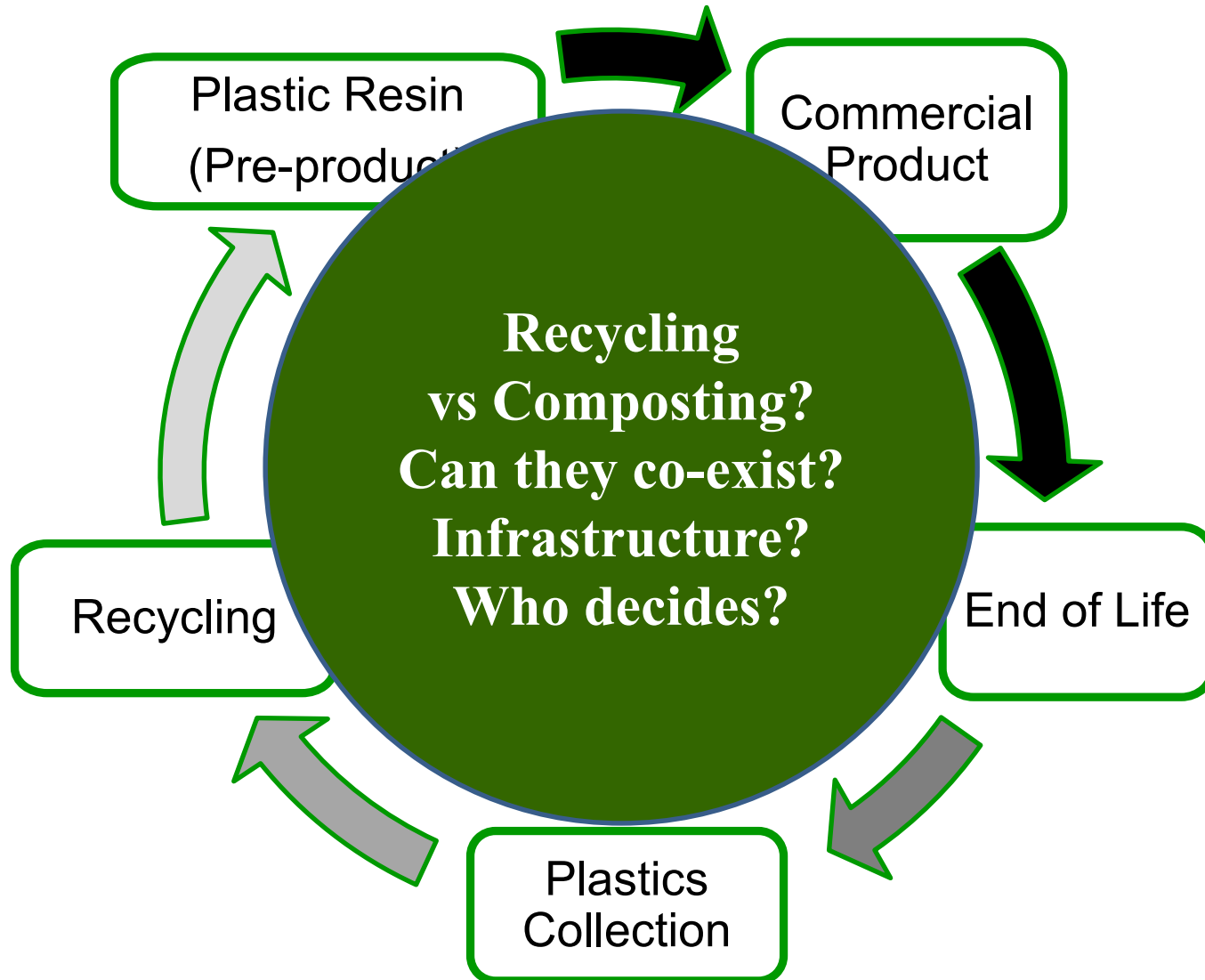
**Beat Solid Plastics
on Price by up to 40%**



Summary....

- 
- Development of sustainable plastics will vary depending on your drivers.
 - Recycled plastics are downcycled but provide a tremendous resource opportunity.
 - Viable bioplastic options are here.
 - This may not be simple....

Circular Economy of Plastics

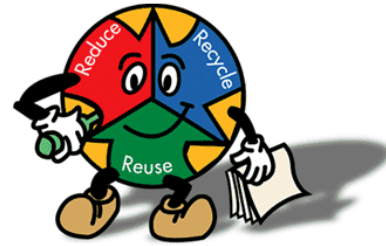




.....our visit to Illinois, especially this morning at the State fair, was to **bring a special message to America's farmers, one of concern and hope.** Amid general prosperity that has brought record employment, rising incomes, and the lowest inflation in more than 20 years, some sectors of our farm economy are hurting, and their anguish is a concern to all Americans.

"The nine most terrifying words in the English language are: I'm from the Government, and I'm here to help. " -- Ronald Reagan, 1986

Acknowledgements



Researchers: Plastics Team

USDA

De Wood
Bor-Sen Chiou
Zach McCaffrey
Mark Wechsler
Lennard Torres
Allison Flynn
Trung Cao
Artur Klamczynski
Greg Glenn
William Orts



Bill.Orts@USDA.GOV



William Orts ⇔ 510-559-5730
bill.orts@ars.usda.gov

The BioPreferred Program

<http://www.biopREFERRED.gov/>

The BioPreferred program gives vendors a significant advantage in filling federal contracts. This can be HUGE when filling military contracts, etc.

Biobased content measured by the ratio of C-14 to C-12 (ASTM D6866)



What is BioPreferred?

- **USDA brand name for Biobased Markets Program established in Farm Bill**
- **Identifies and seeks to establish new markets for biobased products**
- **Two major program elements**
 - **Federal procurement preference program requires Federal agencies and contractors to purchase qualifying products**
 - **Voluntary labeling program will allow product vendors to use a USDA logo to identify qualifying products**

Federal Procurement Preference

Federal purchasers must give a procurement preference to designated items composed of biobased products.



plantbottle™

up to **30%** plant-based
100% recyclable bottle

redesigned plastic,
recyclable as ever.



