Biobased, Biodegradable Polymers and Coatings for Food Packaging

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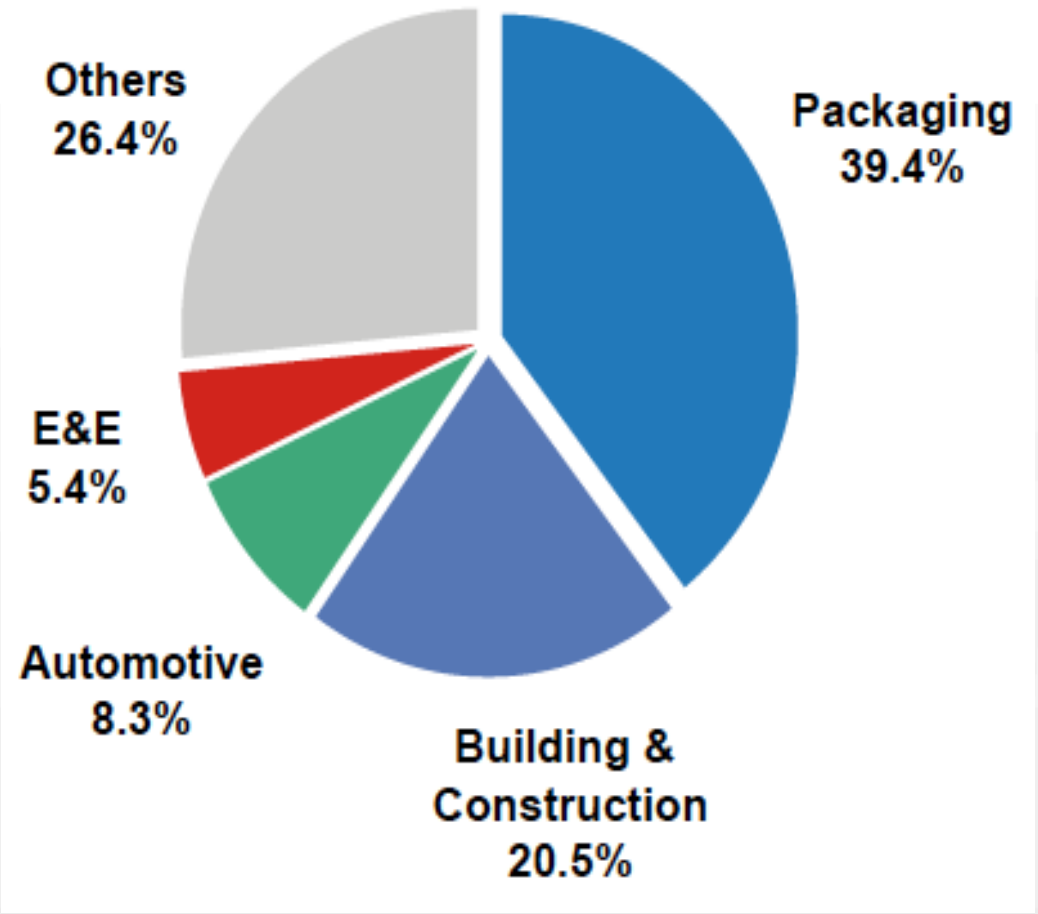
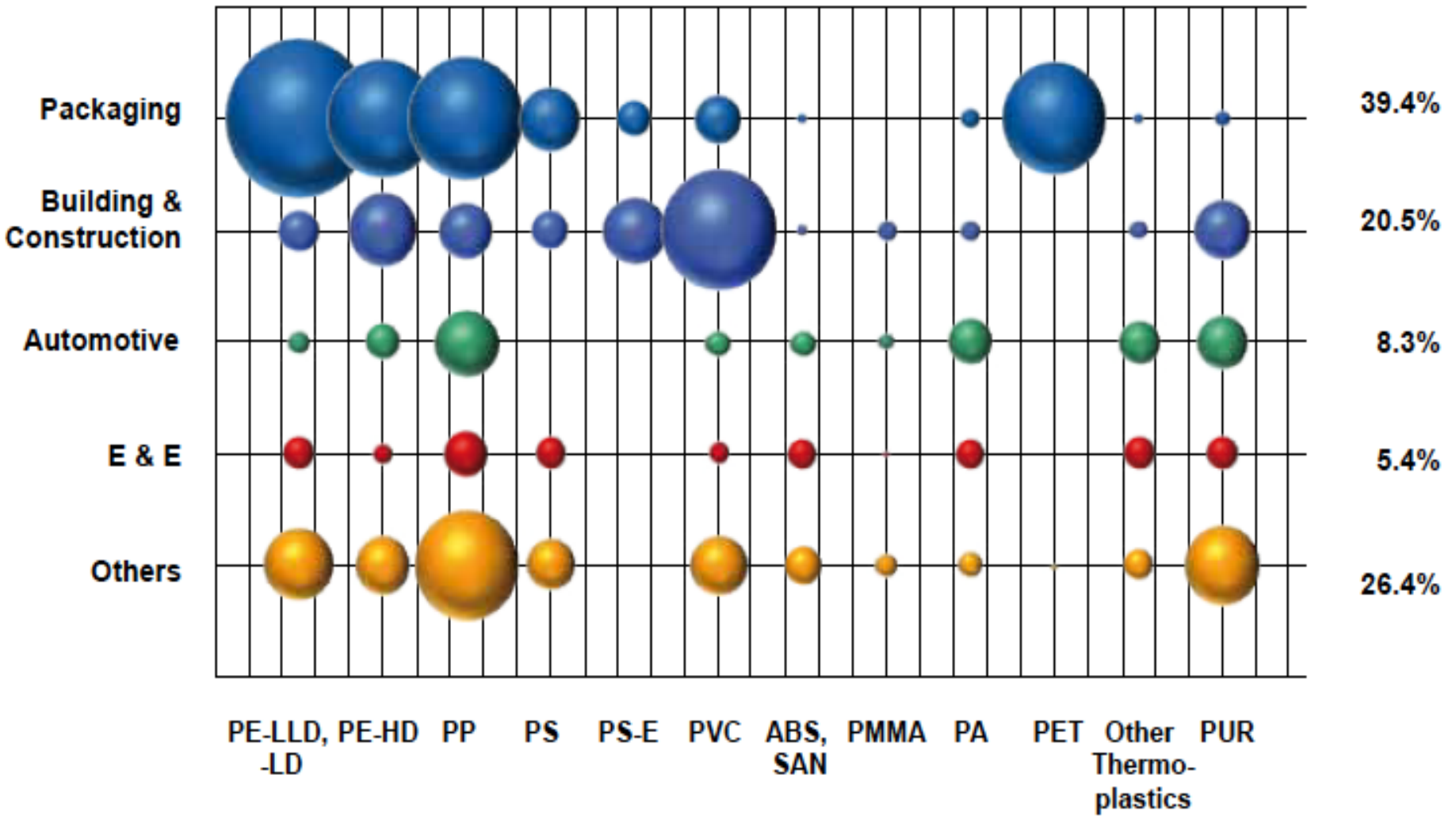
Plastics demand by market segment



Source: Plastics Europe

Plastic consumption by type



Source: Plastics Europe

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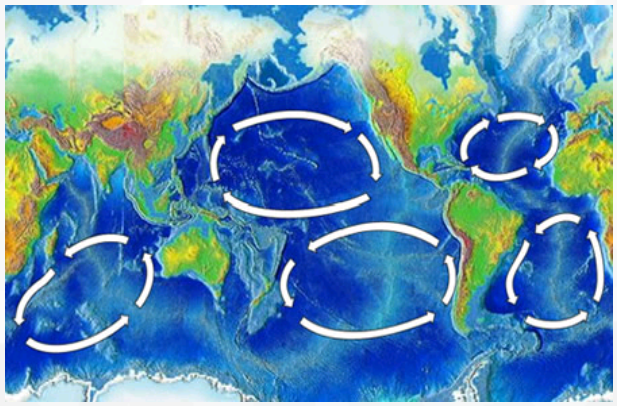
Plastics Packaging Waste – the dark side of a gift?



Land and water equally Polluted

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Motivation

Packing waste - global problem

- By 2017 – Global plastics film and sheet production will exceed 100 Billion Pounds[1]
- Currently more than 10 billion pounds of plastic packaging waste generated annually in the US alone[2].
- ~ 8 -10% of waste is recycled in US[2]
- Recycling is only a partial solution
  - Low density of plastics used in food packaging renders recovery and recycling not economical
  - Disposal infrastructure ?!

[1] Global Industry Analyst,
[2] MSW Generation, Recycling, and Disposal in the United States report, 2010

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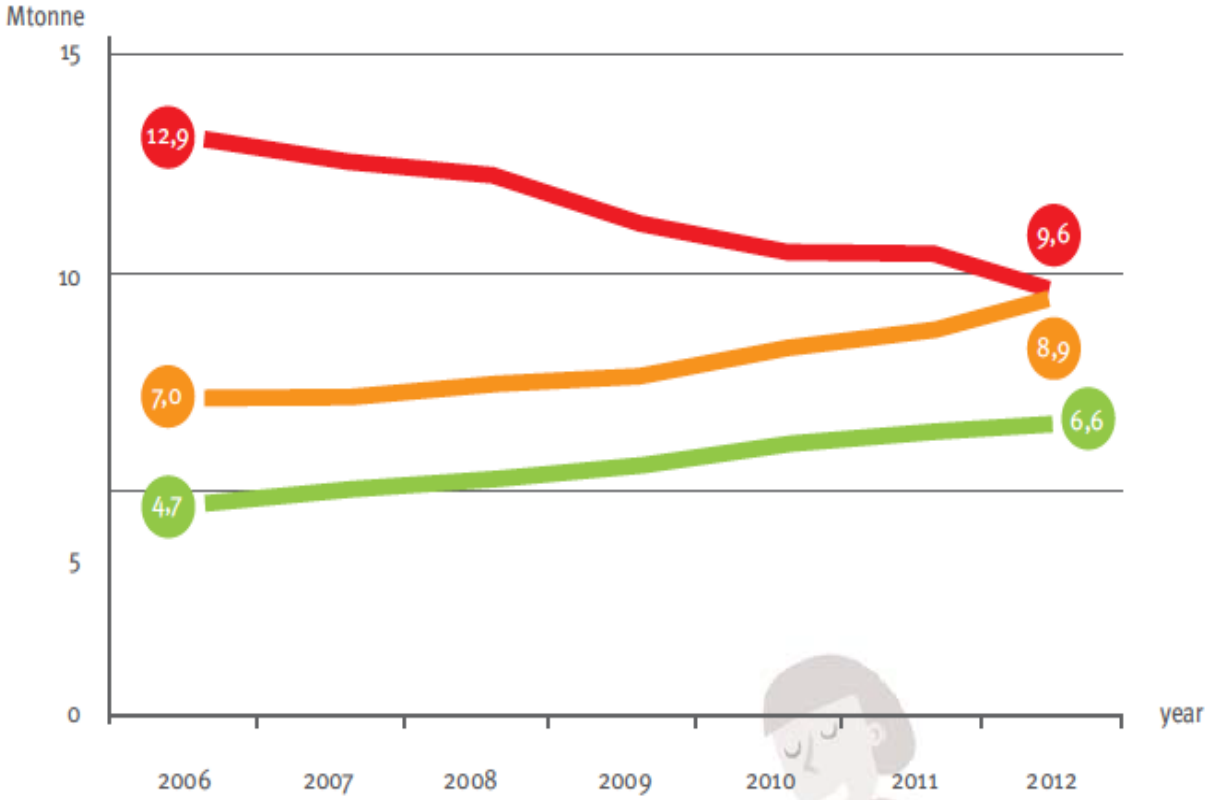
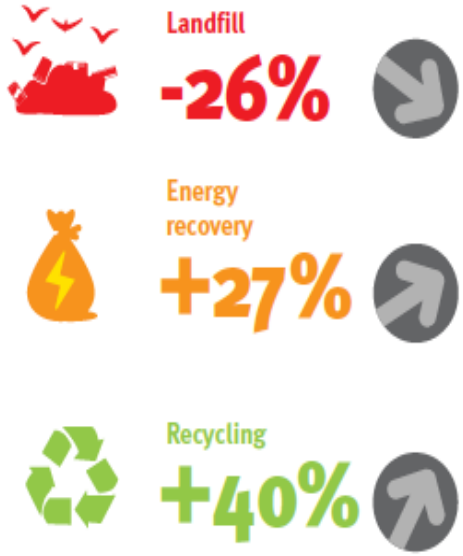
Post consumer plastics waste recovery efforts are improving

But only in some countries - EU, Japan!

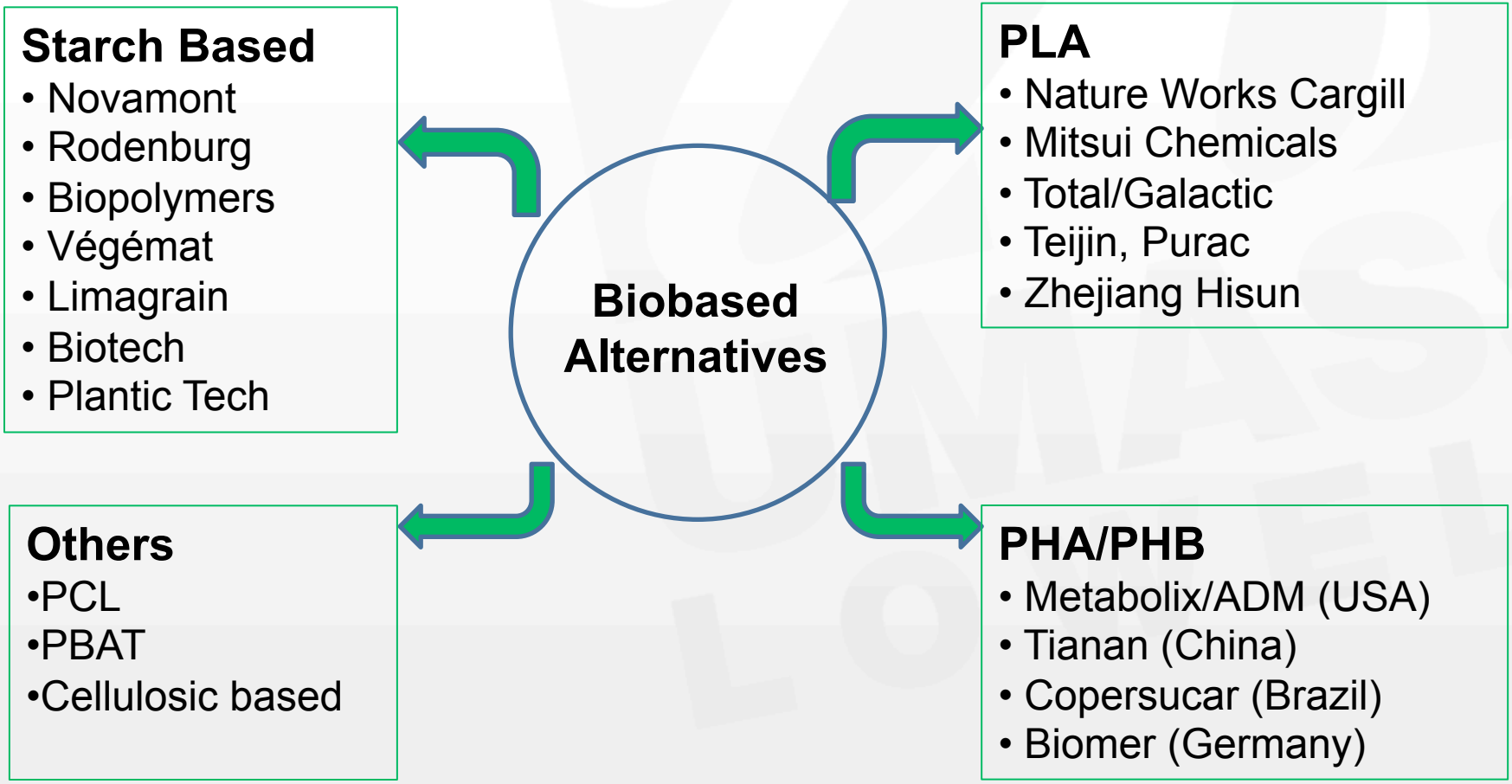


Total plastics waste recycling and recovery 2006 – 2012

Source: Consultic



How about Biodegradable Plastics for food packaging?



Challenges with the Current Alternatives

- Resin availability
- Inferior properties as compared to polyolefins
- Processing issues - shear sensitivity and low thermal stability
- High Oxygen Transmission Rate (OTR)
- High Water Vapor Transmission Rate (WVTR)
- Higher cost
- Commercial composting is often required

Material Properties

Oxygen and Water Vapor Transmission Rates

Materials	WVTR ($g/m^2*day*atm$)	OTR ($cc/m^2*day*atm$)
PLA (Nature works , 4032D)	375	>1000
PHB	178	350
PBAT (Ecoflex)	135	1200
PE-LD	425	1.-1.5
PP	150	0.5
EVOH	0.05-0.2	1-5
PET	5-10	2-4
PVDC	0.15	0.1

- Even for packaging dry foods like Coffee beans, bioplastics don't meet the requirements
  - WVTR < 8 g/m2*day*atm
  - OTR < 55 cc/m2*day*atm

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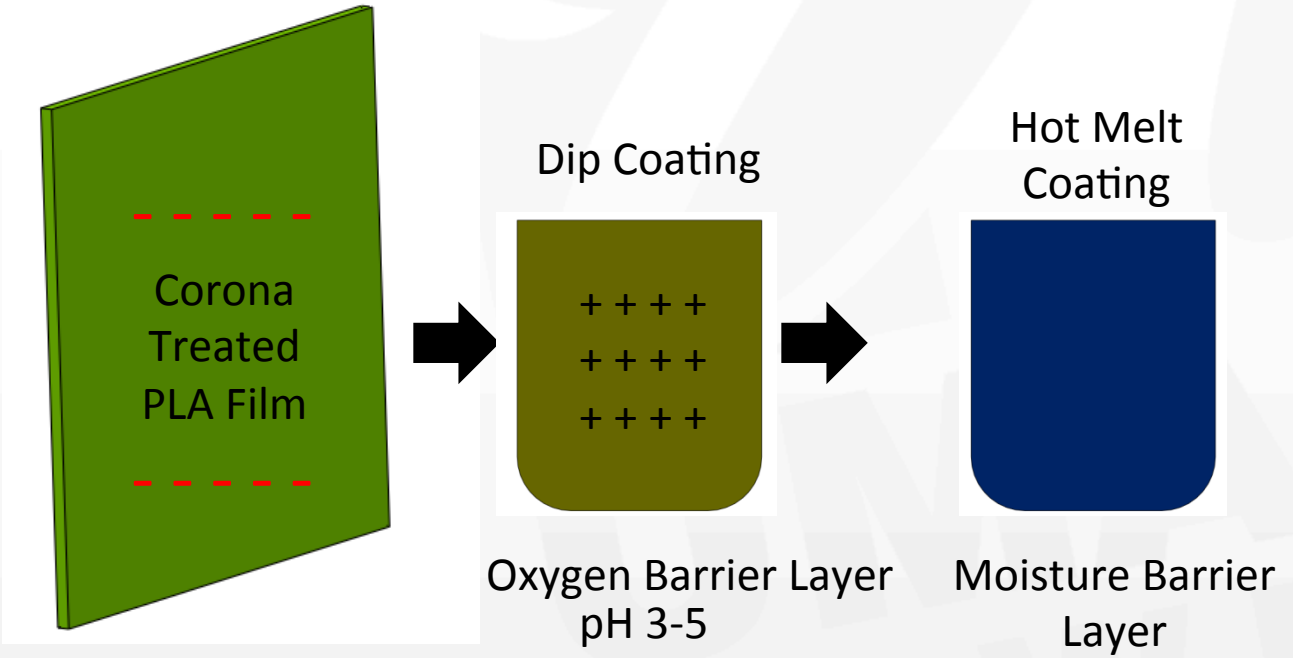
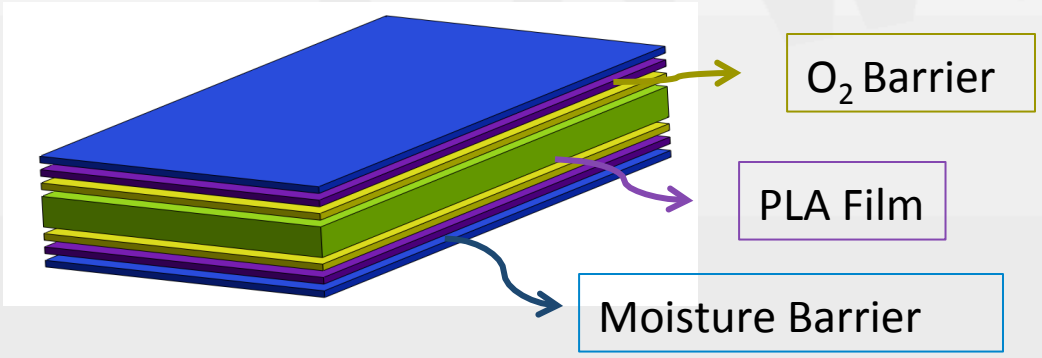
Can Bioplastics be tailored for food packaging?

Goals

- Extend the functionality of the existing biodegradable resins
- Improve Oxygen Transmission Resistance and Water Vapor Transmission Resistance
- Use biodegradable and naturally occurring materials
- Achieve economic viability

Layer by Layer Coating





Characterization of OTR and WVTR

Oxygen Permeation Analyzer 8001

ASTM D-3985

Water Vapor Transmission

ASTM E- 96 / ASTM F-1249*

* Tested by MOCON

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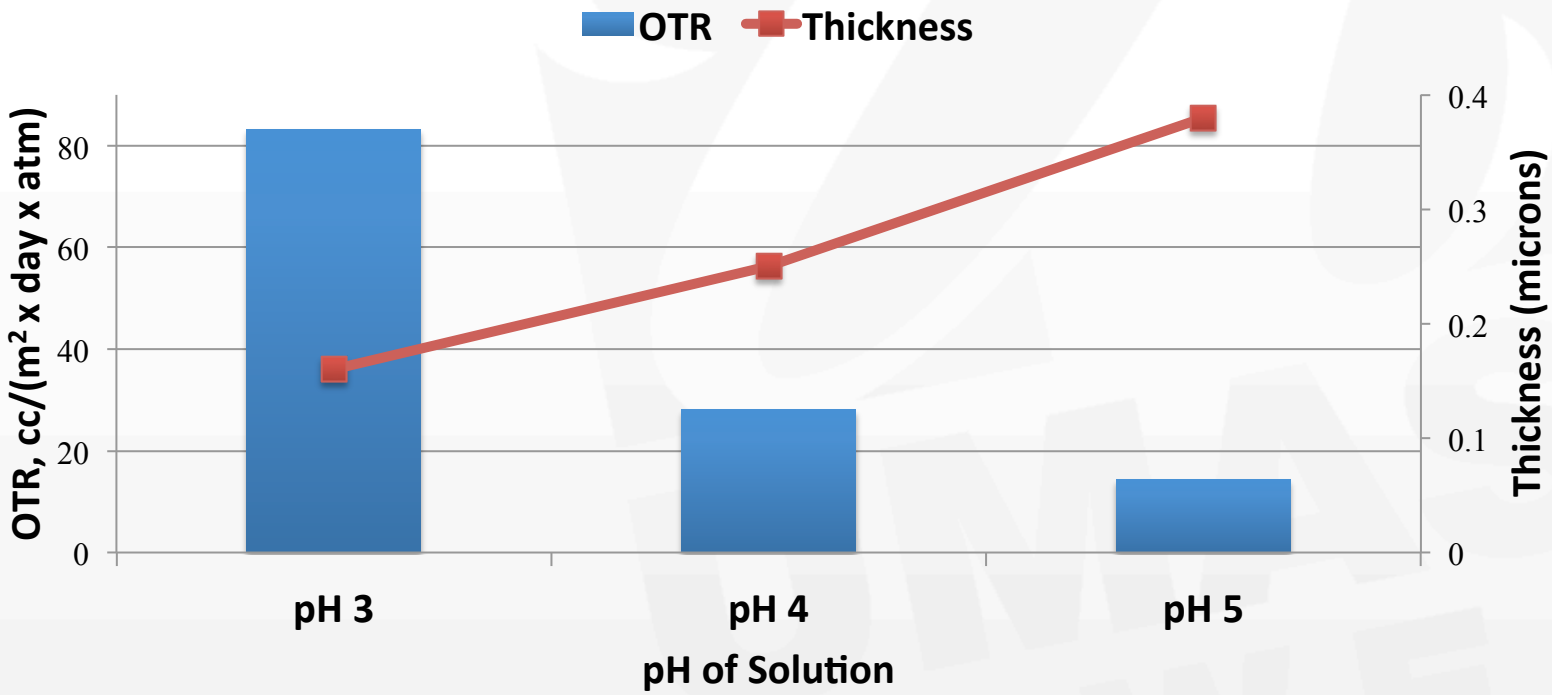
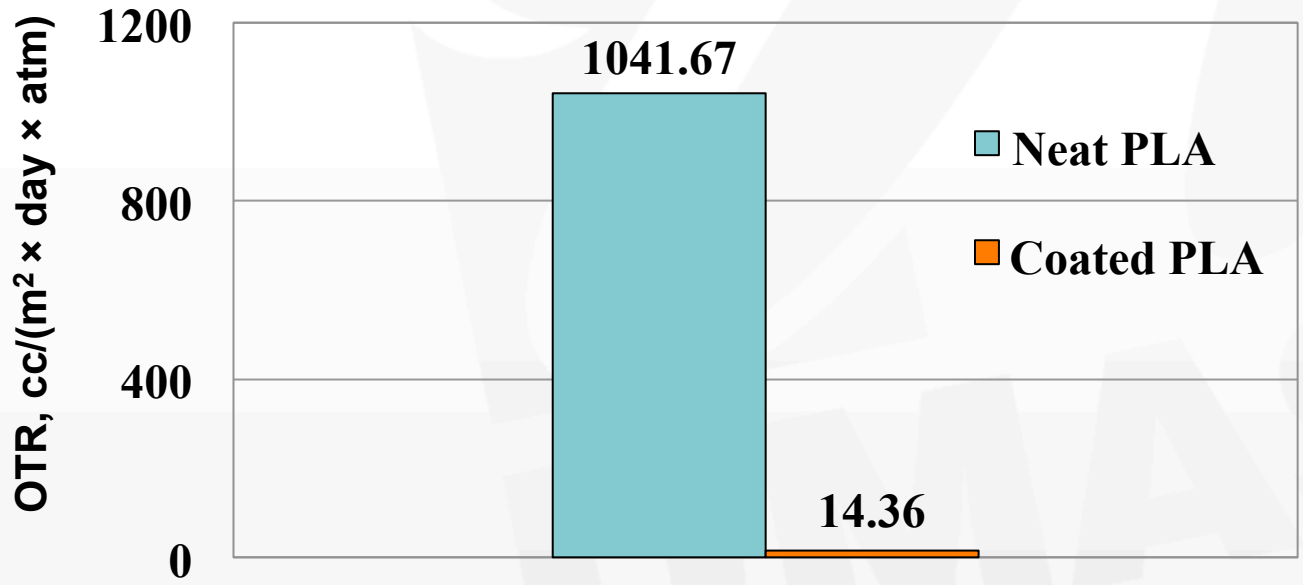
Effect of pH on OTR and thickness



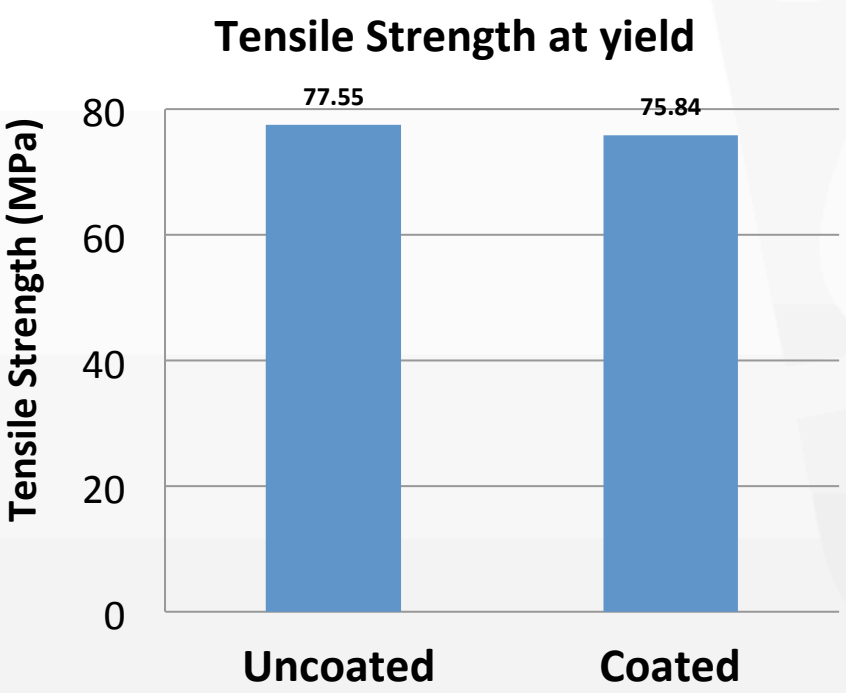
- As pH increased, Thicker layers are formed, decreasing OTR

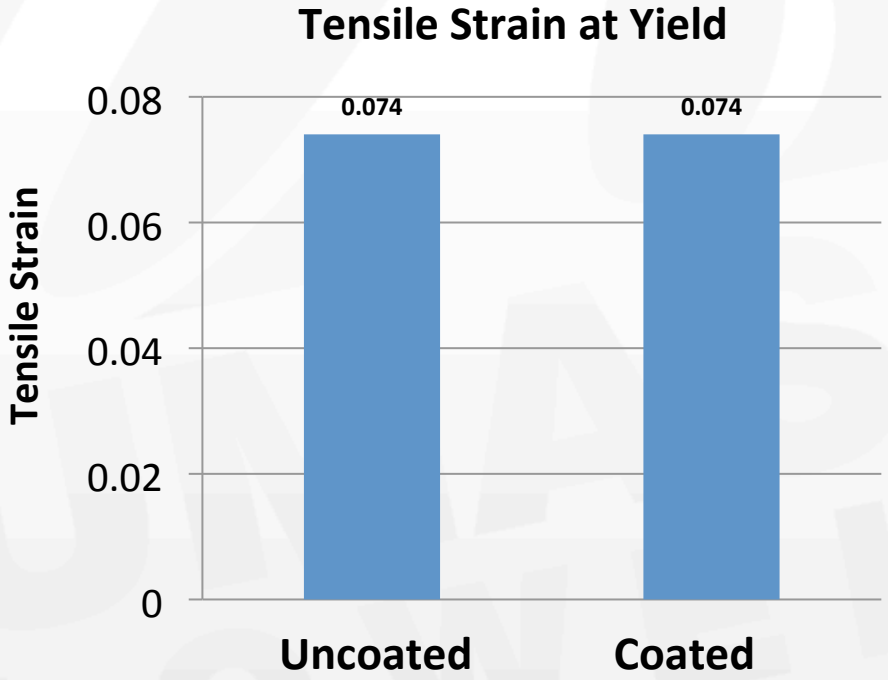
Effect of Coating on OTR



- Untreated PLA has a very poor barrier to Oxygen and thus the OTR is relatively High at >1000 cc/(m^2.day.atm)
- Biodegradable coating effectively reduces Oxygen transmission from 1040 cc/(m2.day.atm) to <15 cc/(m^2.day.atm)

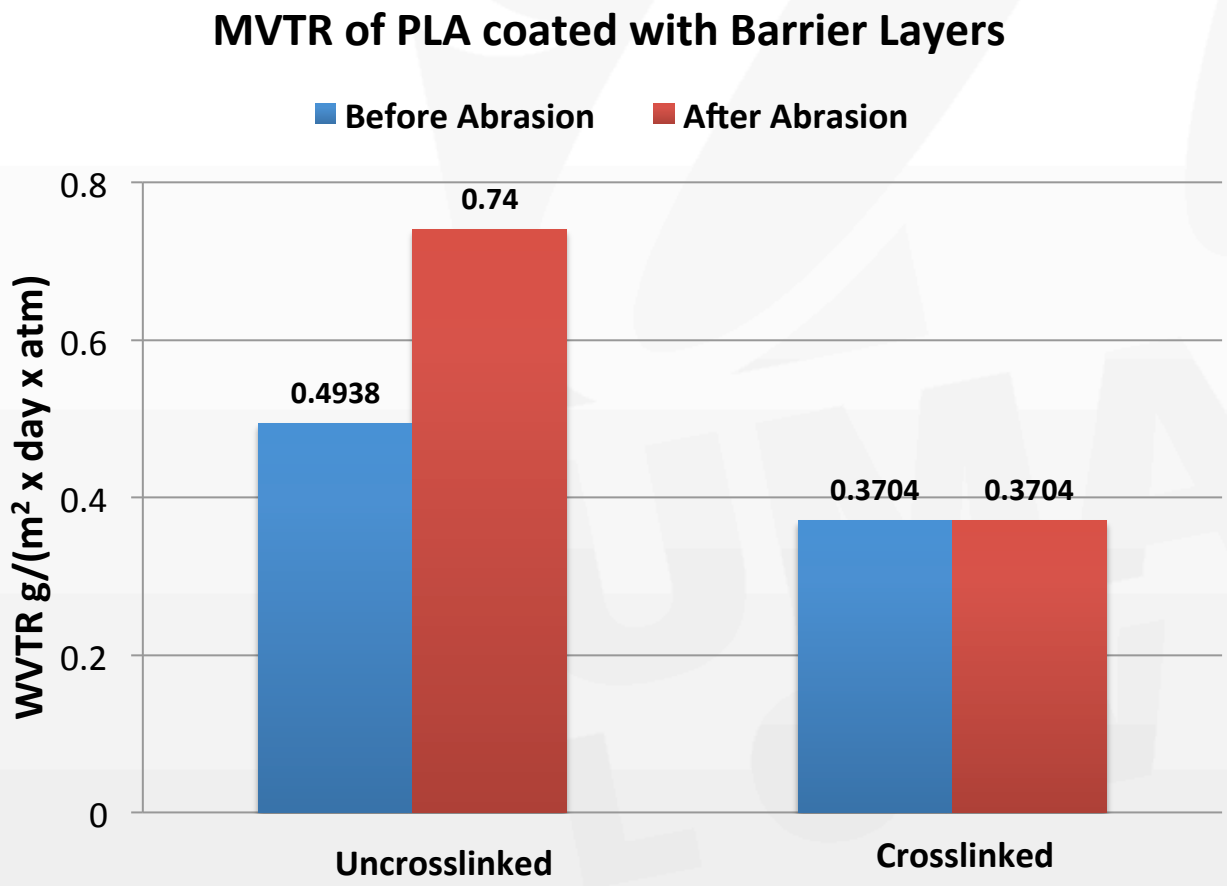
Mechanical Properties remain intact





No significant change in mechanical properties after coating

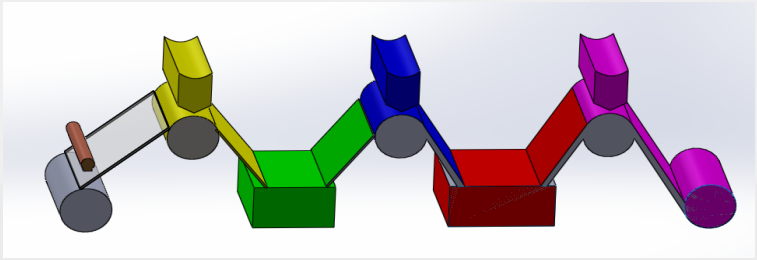
Effect of Crosslinking on WVTR



Crosslinking retains barrier properties of PLA coated films

Conclusions

- A strategy for biobased, biodegradable polymer film with improved barrier properties has been developed and tested
- OTR <10 cc/(m^2 x day x atm) & WVTR <1.02 g/(m2 x day x atm) achievable
- Crosslinking improves barrier properties and abrasion resistance of the coatings
- Approach is scalable – engineering solution exists



Outlook for food packaging films

- Compostable bioplastics have a place in food packaging
  - where low barrier properties can be tolerated
  - thin films where recovery is not economical
  - single use products
- Recycling (down-cycling) should be part of the solution
- Integration with disposal infrastructure – requirement for making the entire exercise sensible

Acknowledgements

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Thank you!