Using Primers in Combination With Adhesive Tie-Layer Resins, or Their Blends, to Make Structures with Unique Performance

Richard Allen

Mica Corporation

Shelton, CT USA

Objectives

- ***In co-extruded structures:*** primers can significantly enhance performance.

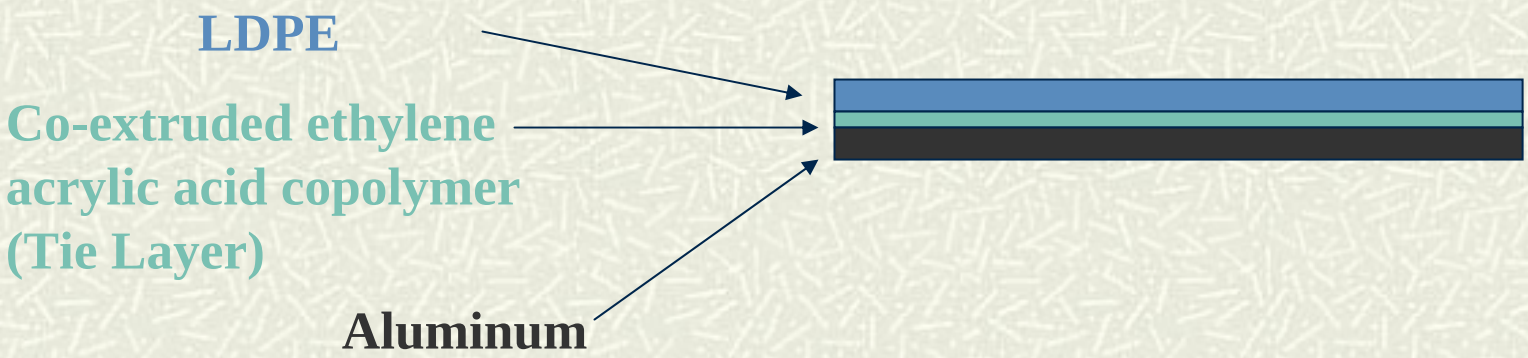
- ***In mono-layer extrusions with primers:*** low levels of tie-layers blended into conventional extrusion resins can produce structures with outstanding properties.

Previous Work

- Tie Layer:
  - Pascal, J., "Adhesive Properties of Ethylene – Acrylic Ester – Maleïc Anhydride Terpolymers in Extrusion Coating / Lamination," TAPPI PLACE Europe, Rome 2003.
- Coextruded Tie Layer + Primer:
  - Trouilhet, Y., and Foster, B., "A New Approach to Clear, Retortable Packaging Films," TAPPI PLACE Europe, Rome 2003.

What is an Adhesive Tie-Layer?

- Functionalized polymer designed to adhere to two different surfaces
- Usually co-extruded with a commodity resin.



Tie-Layer Compositions

- Backbone is usually a typical extrusion resin:
  - Polyethylene
  - Ethylene copolymers
  - Polypropylene
- Functional groups are often:
  - acrylic acid
  - methacrylic acid
  - glycidyl ether (epoxy)
  - maleic anhydride

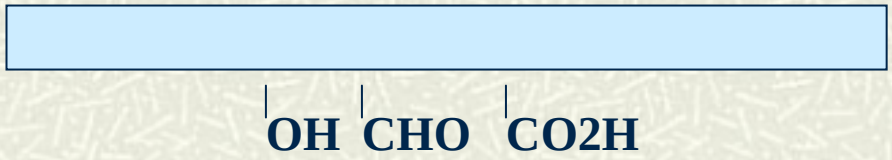
What is a Primer?

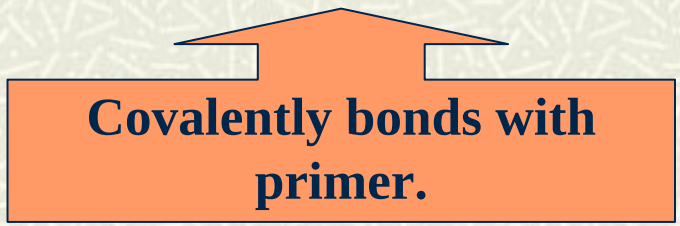
- Surface modifying coating applied to substrate.
- Bonds well to both substrate and extrudate.

With PE, Oxidized Surface Required for Good Bond Strength

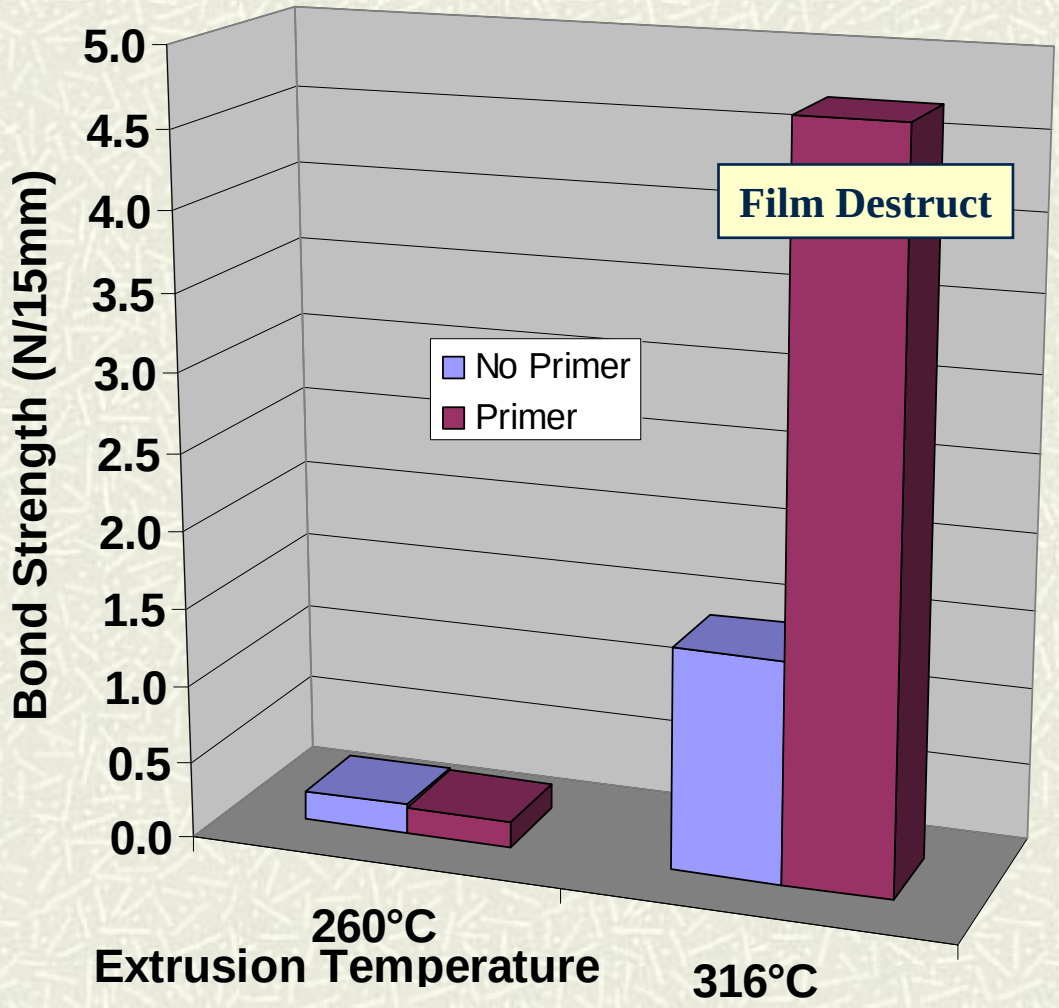
Polyethylene extruded at 260°C.
No oxidation, poor adhesion.

Polyethylene extruded at 315°C.
Surface oxidation, good adhesion.

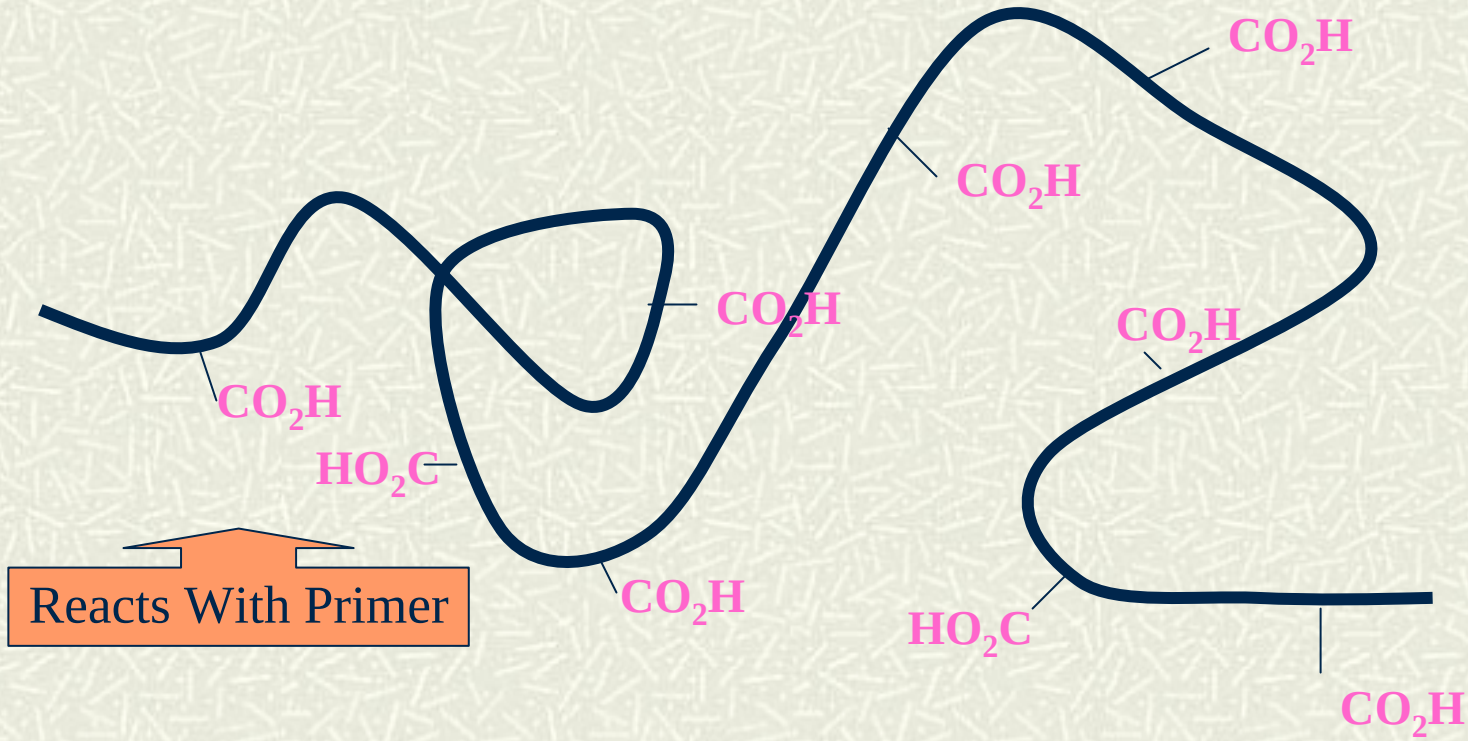




Effect of Primer and Extrusion Temperature on Bond Strength of LDPE/PET Structure.



Tie-Layers Have Built-in Functional Groups.



…So no oxidation is needed with tie-layers to form strong bonds with primers.

Tie-Layers Used in This Study

Code	*Supplier*	*Grade*	*Composition*	*Tm (°C)*	*MI or MFR (g/10 min)*
TL-L1	Arkema (Atofina)	Lotader 3410	Ethylene [illegible] – maleic [illegible]	95	5 MI
TL-L2	Arkema	Lotader 3210	Ethylene-[illegible] maleic an[illegible]	107	5 MI
TL-B1	DuPont	Bynel 50E803	Polypropylene-g-maleic anhydride [illegible]	135	450* MFR
TL-B2	DuPont	Bynel 50E739	Polypropylene-g-maleic anhydride [illegible]	142	6 MFR

For EVA Blending

For LDPE Blending

For PP Blending

For PP Coextrusion

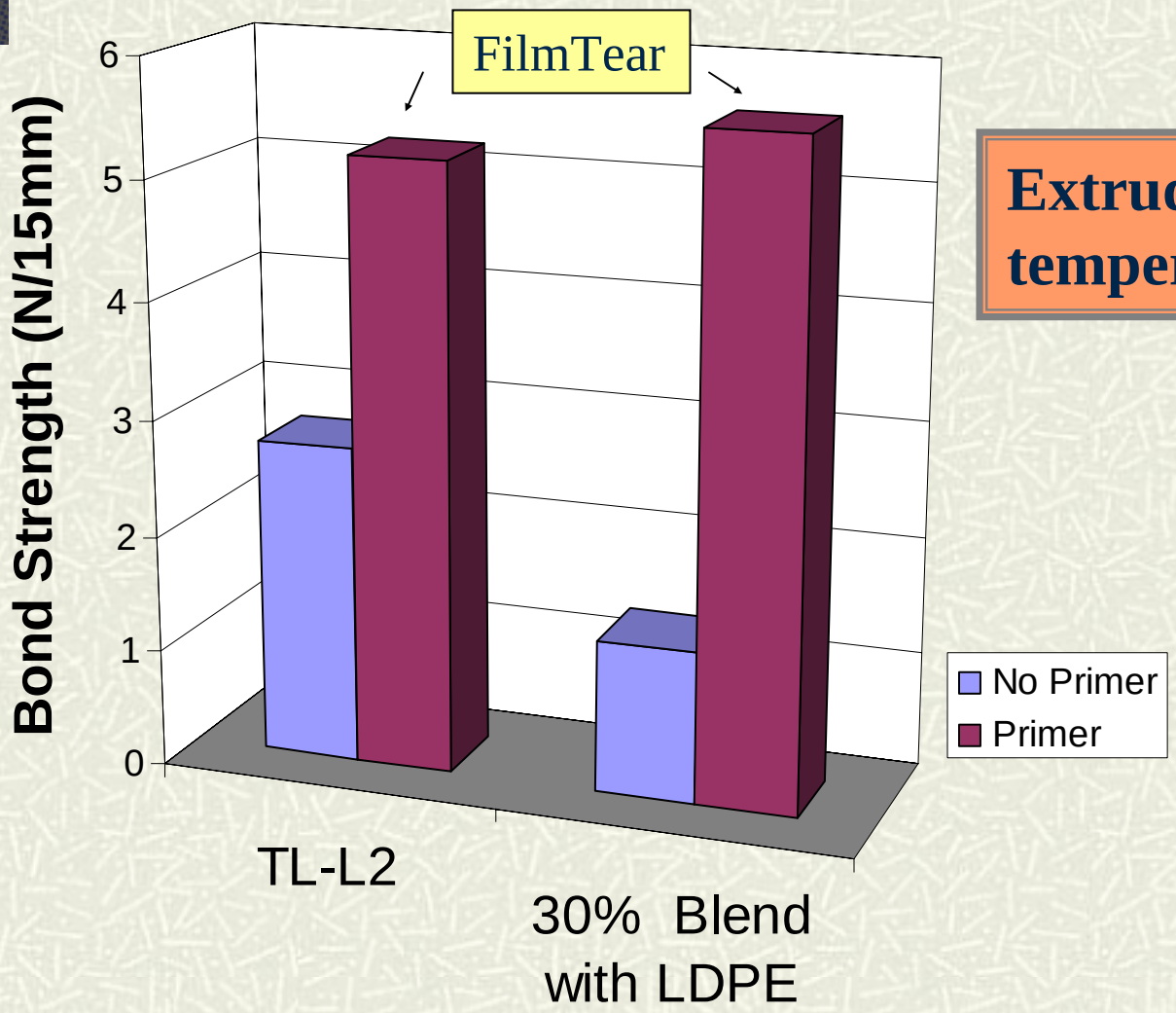
* Calculated

Tie-Layer L1 and L2 in Polyethylene

Extruded Polyethylene

- Requires extrusion at high temperature (>315°C) for oxidation.
- May extrude better at lower temperatures.
- May affect taste and odor.

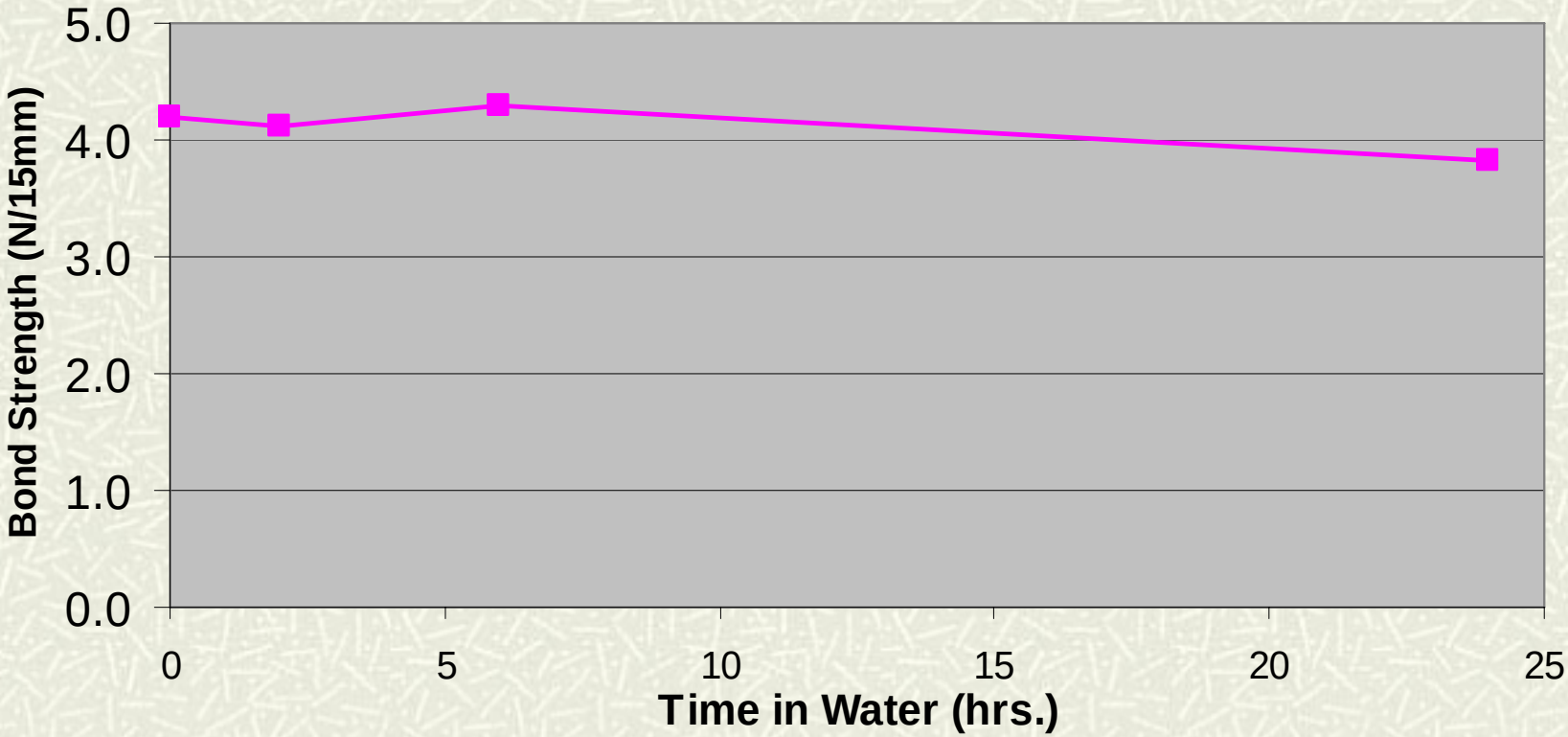
Effect of Primer on Adhesion to Aluminum of TL-L2 and its LDPE Blend.



Extruded at low temperature, 260°C

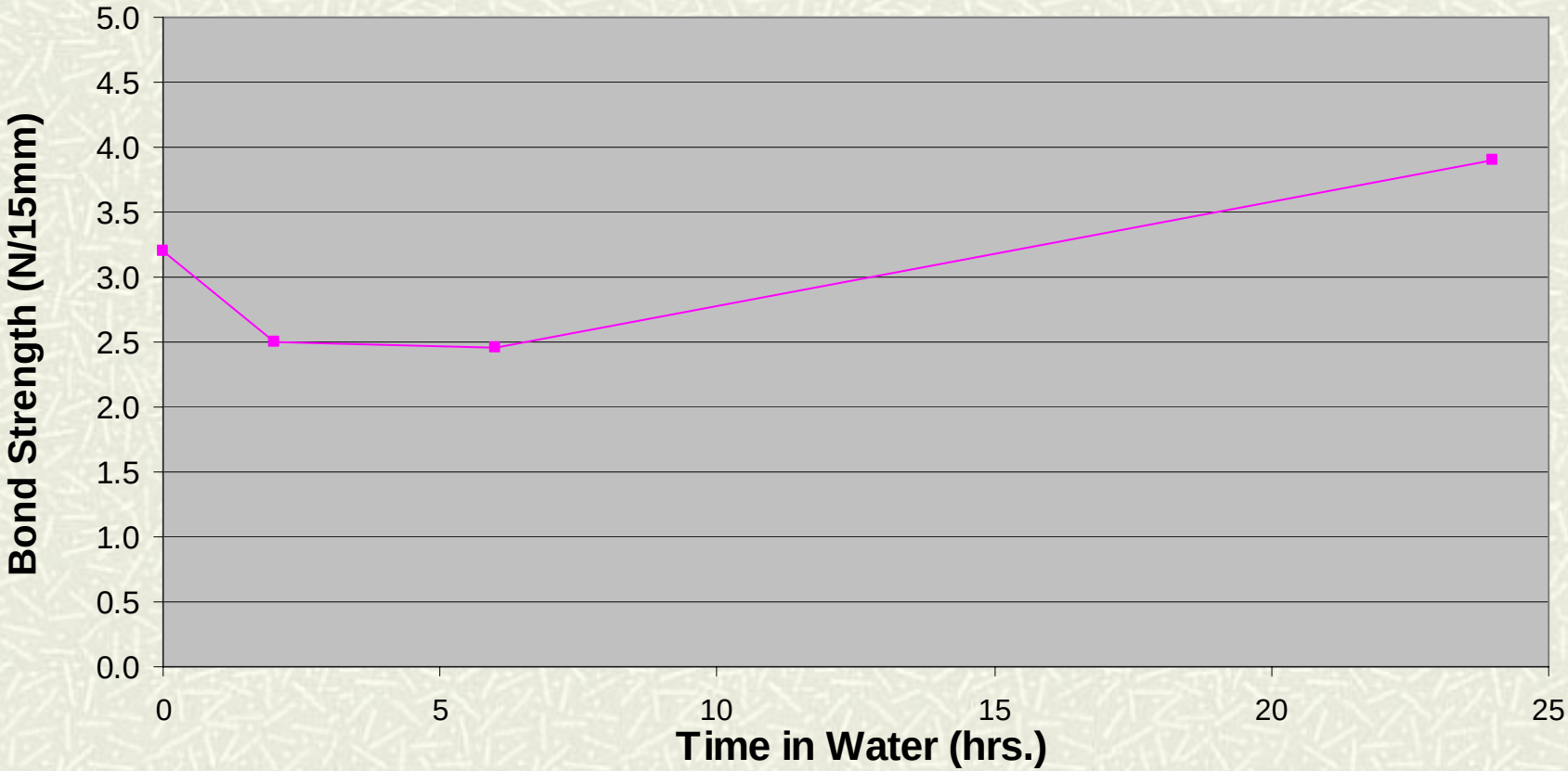
Water Resistance

100% TL-L1/primer/aluminum

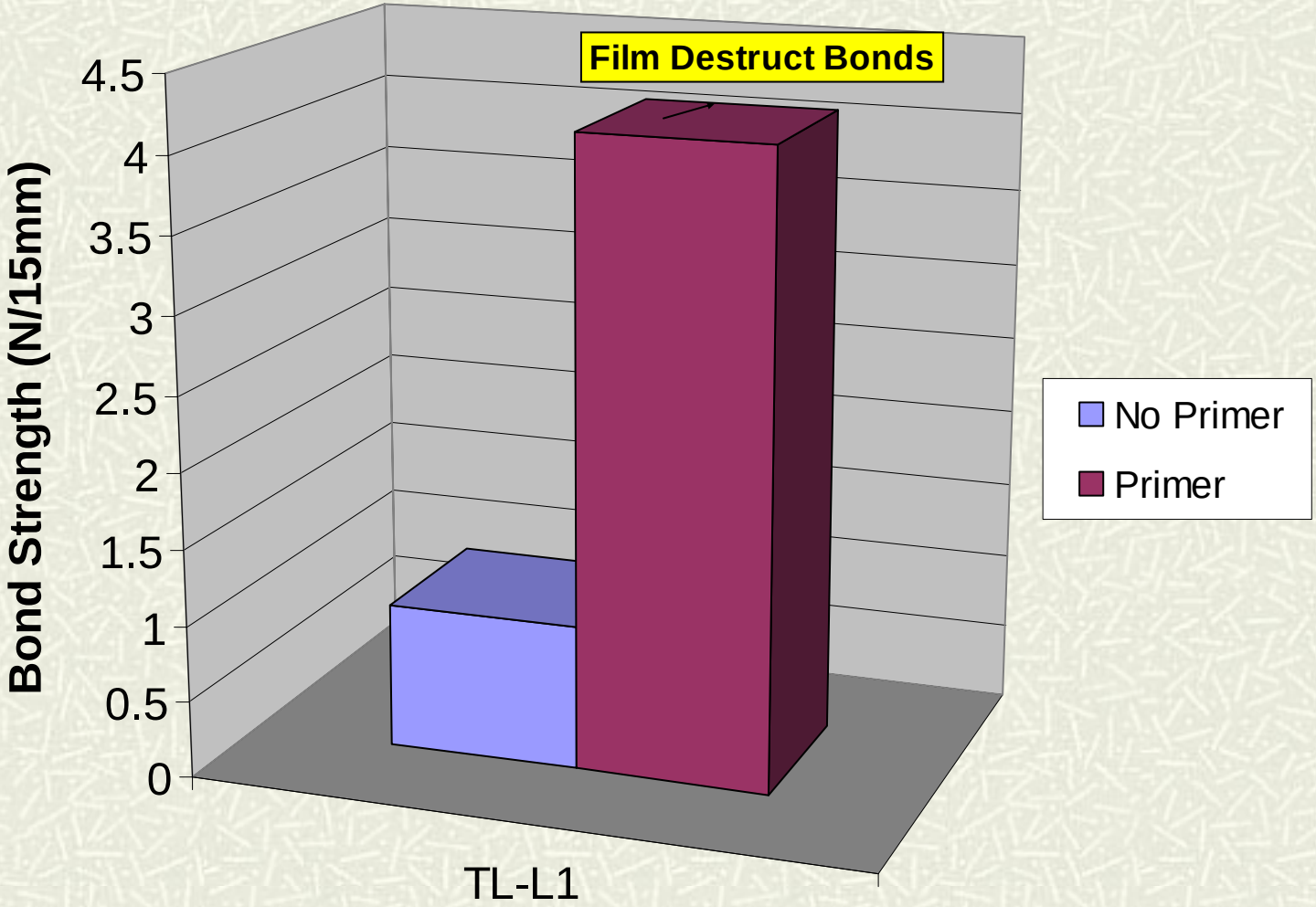


Water Resistance

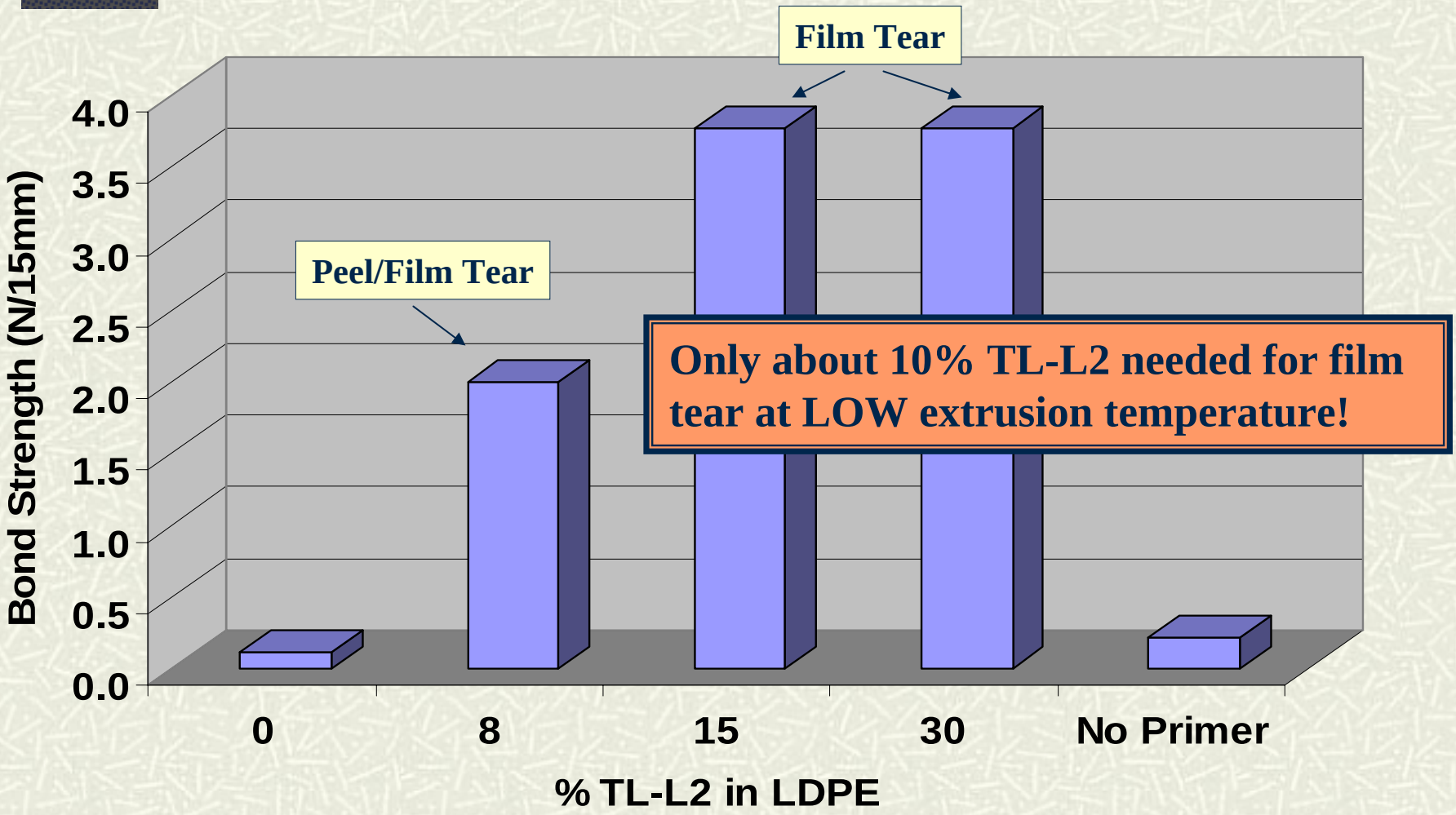
Blend of 30% TL-L1 in LDPE/primer/aluminum



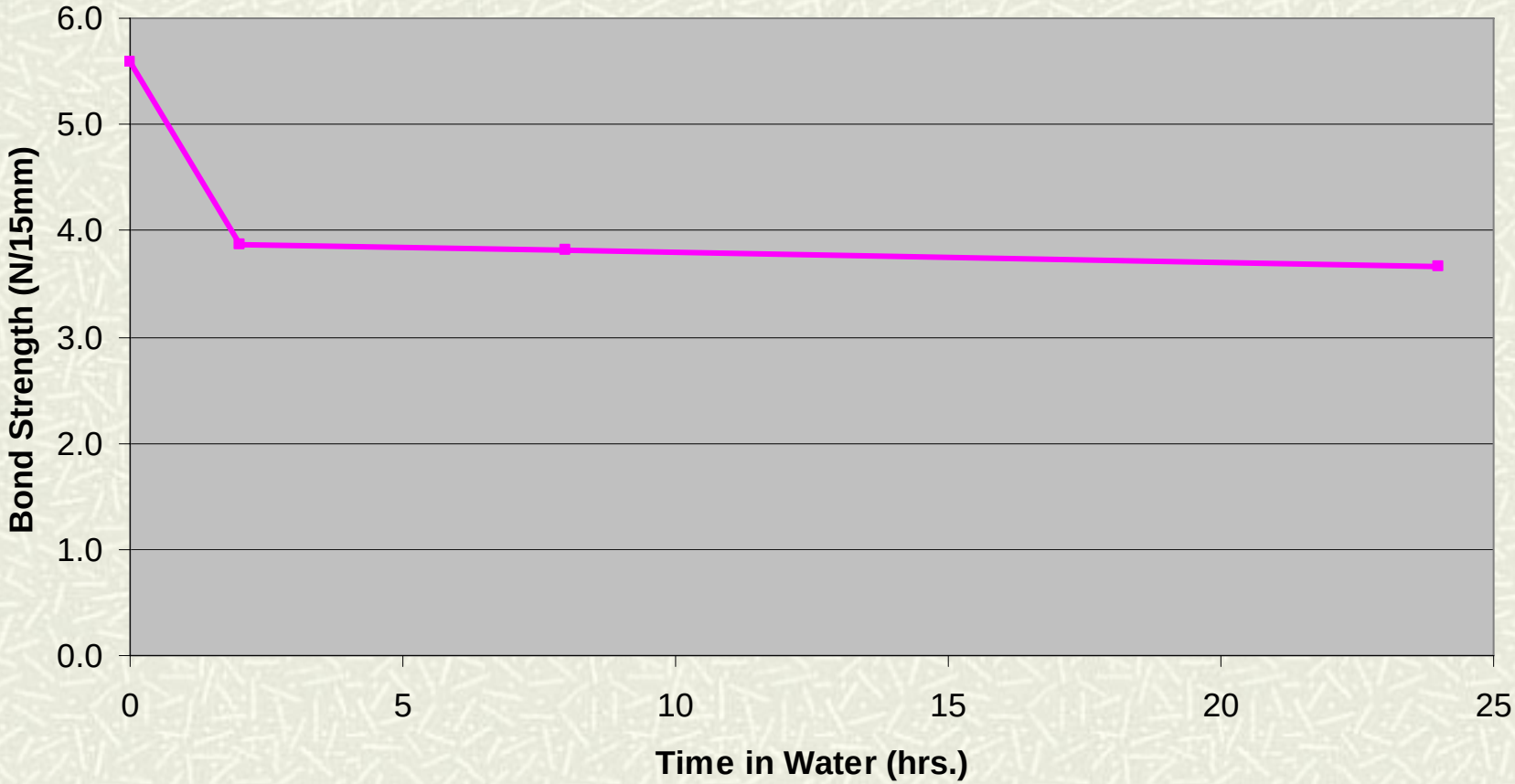
Effect of Primer on Adhesion to PET of TL-L1 (Extruded at 260°C)



Effect of %TL-L2 in LDPE on Adhesion to PET (Extruded at 260°C)



Water Resistance:
Blend of 30% TL-L1 in LDPE to PET



Possible Utility

- Low temperature extrusion of PE
  - Lower taste and odor?
  - Melt viscosity matching in coextrusion
- Enhanced Performance.
- Cost savings?

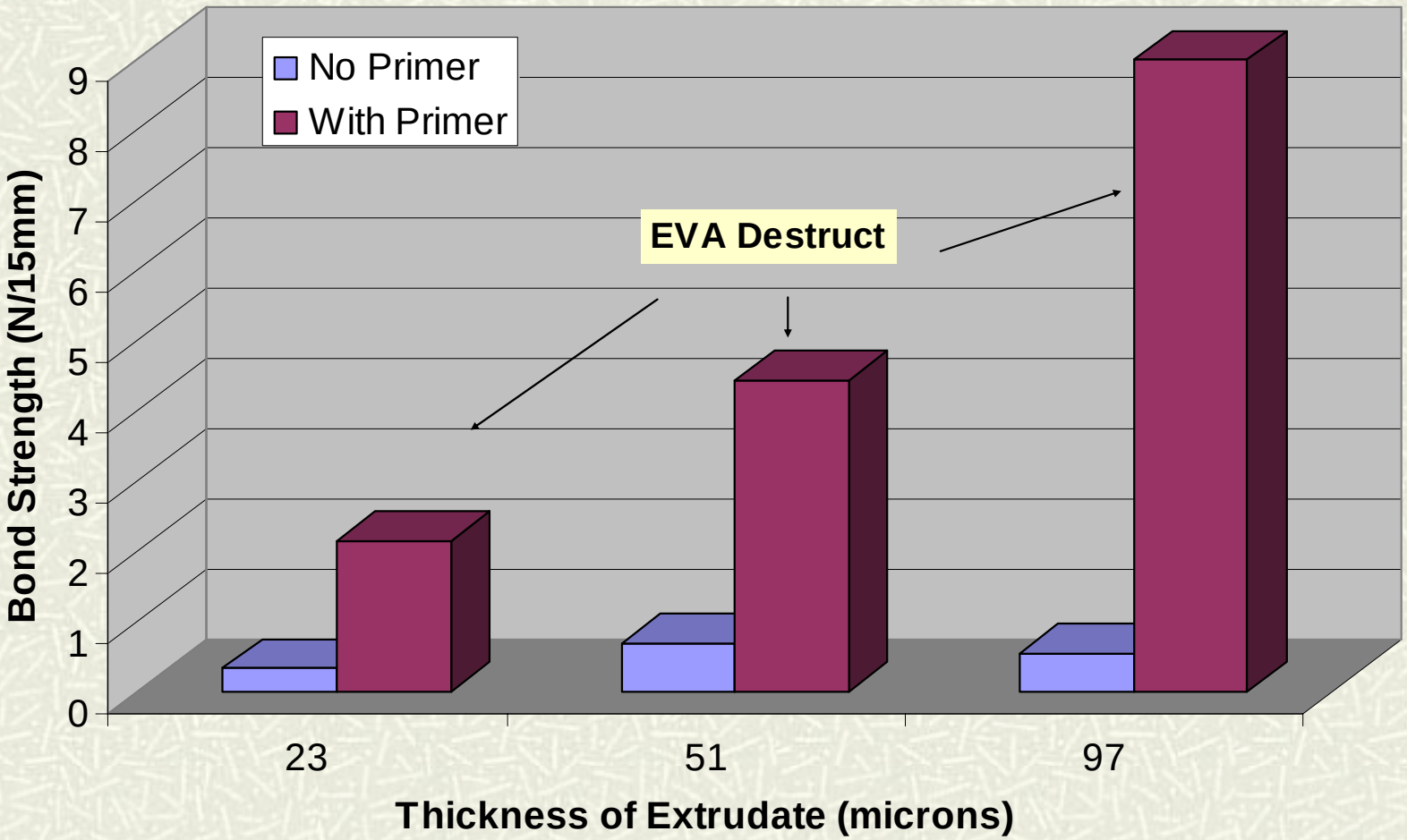
Tie-Layer L1 in Ethylene Vinyl Acetate

Extruded EVA

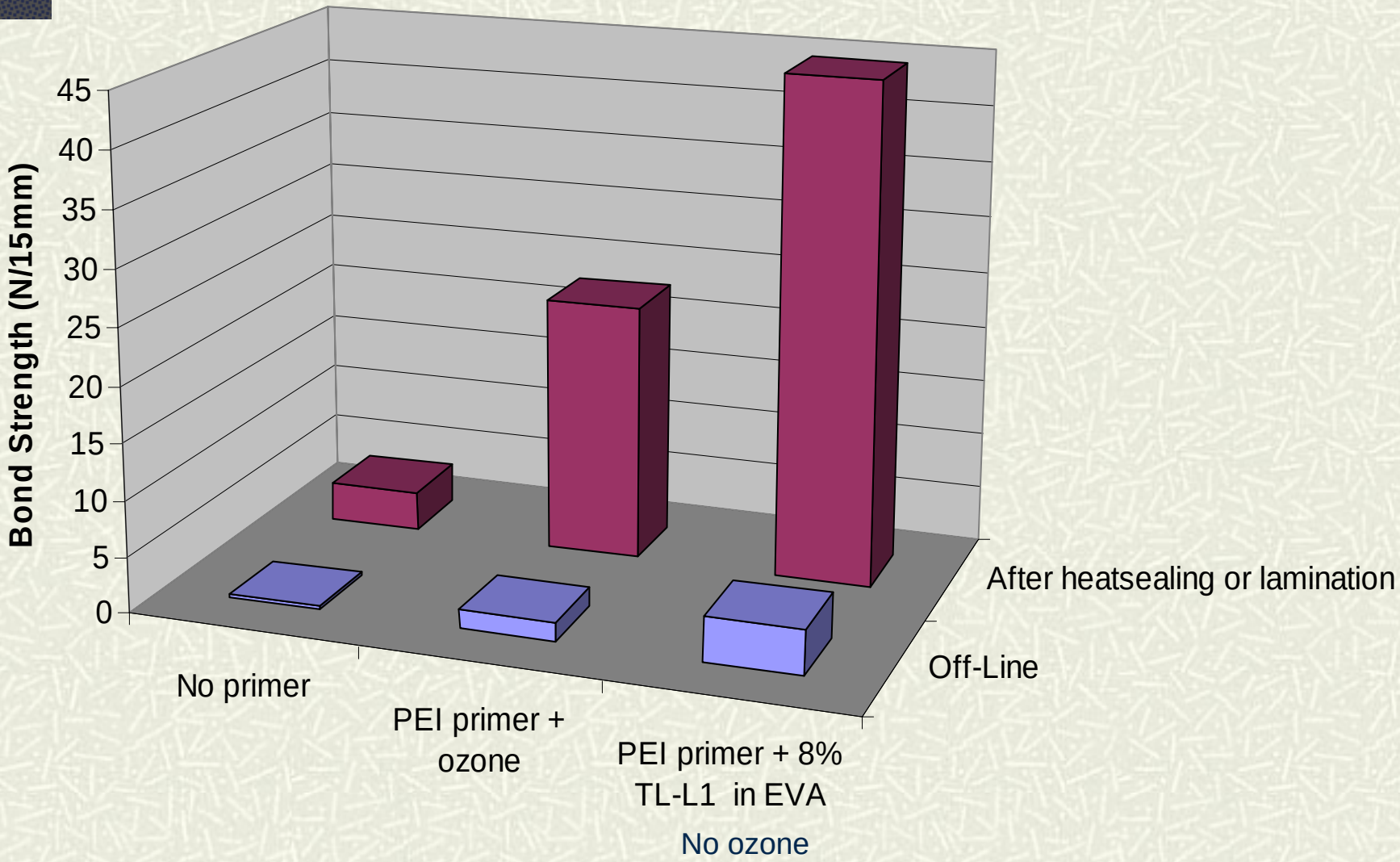
- Can generate acetic acid.
- For good bonds with primers, must extruded in presence of ozone.

Coating Thickness vs. Adhesion. Blend of 8% TL-L1 in EVA to PET

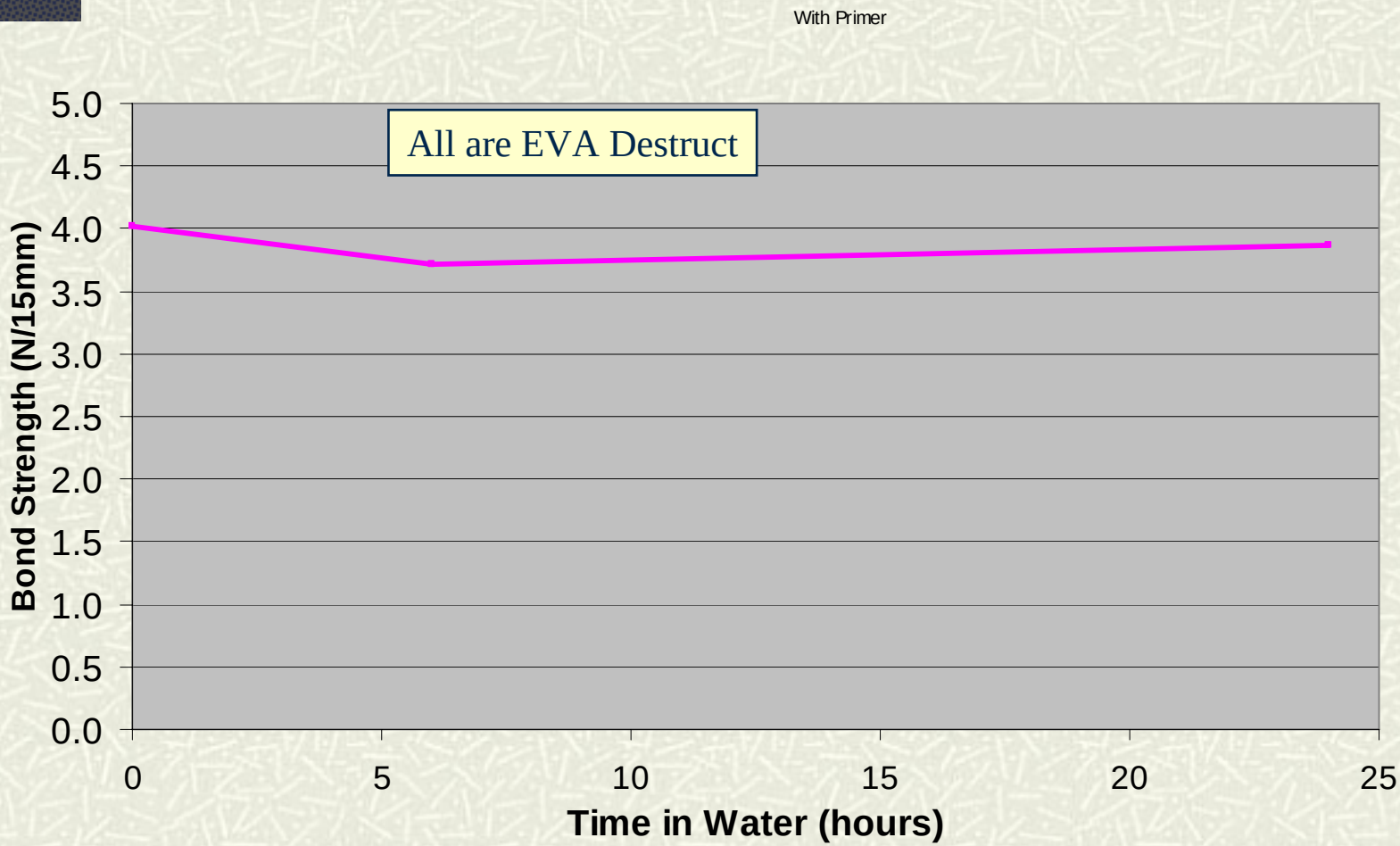
Extruded at 230°C with no ozone.



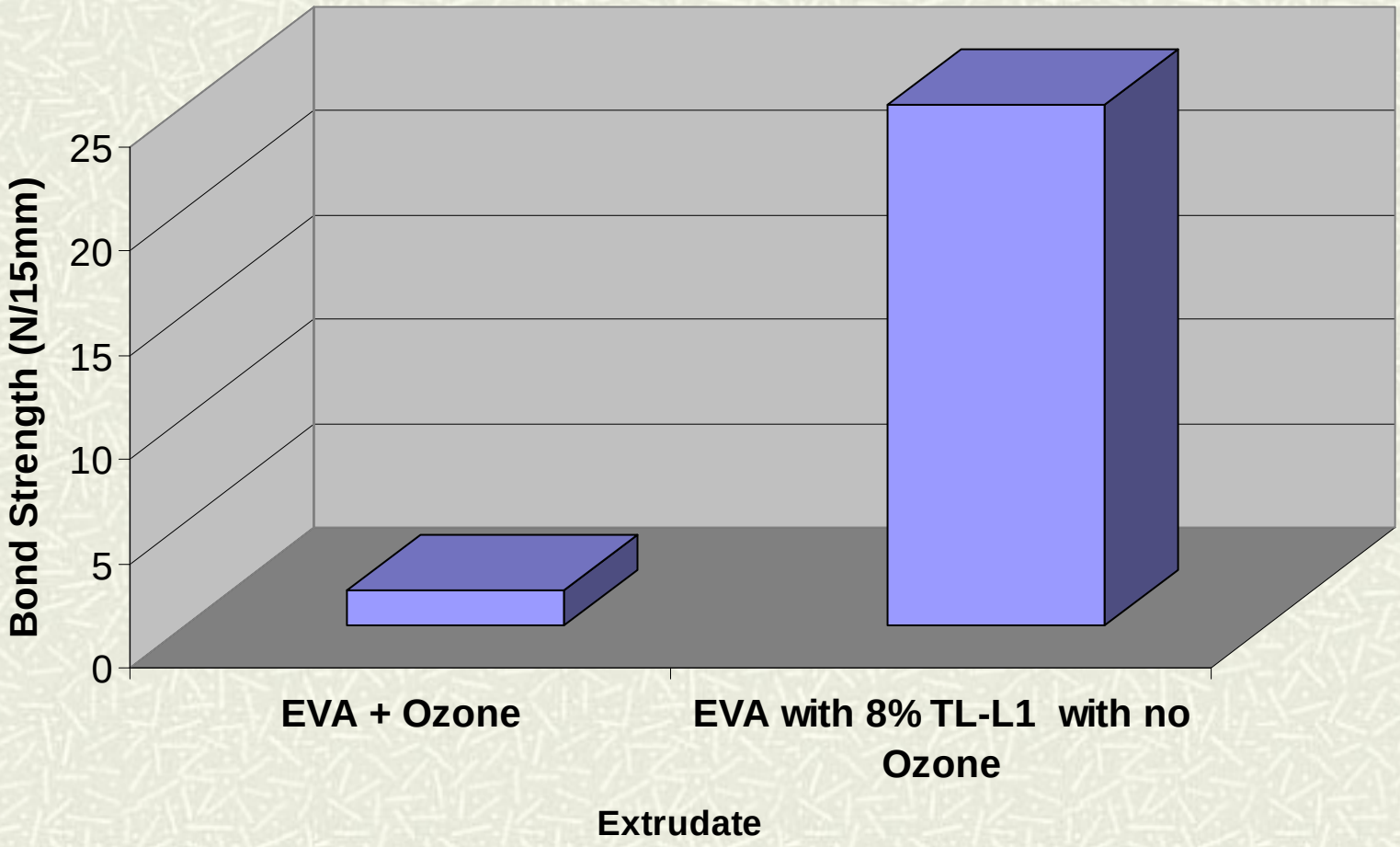
Typical Bond Strength of Various EVA / primer / PET Structures.



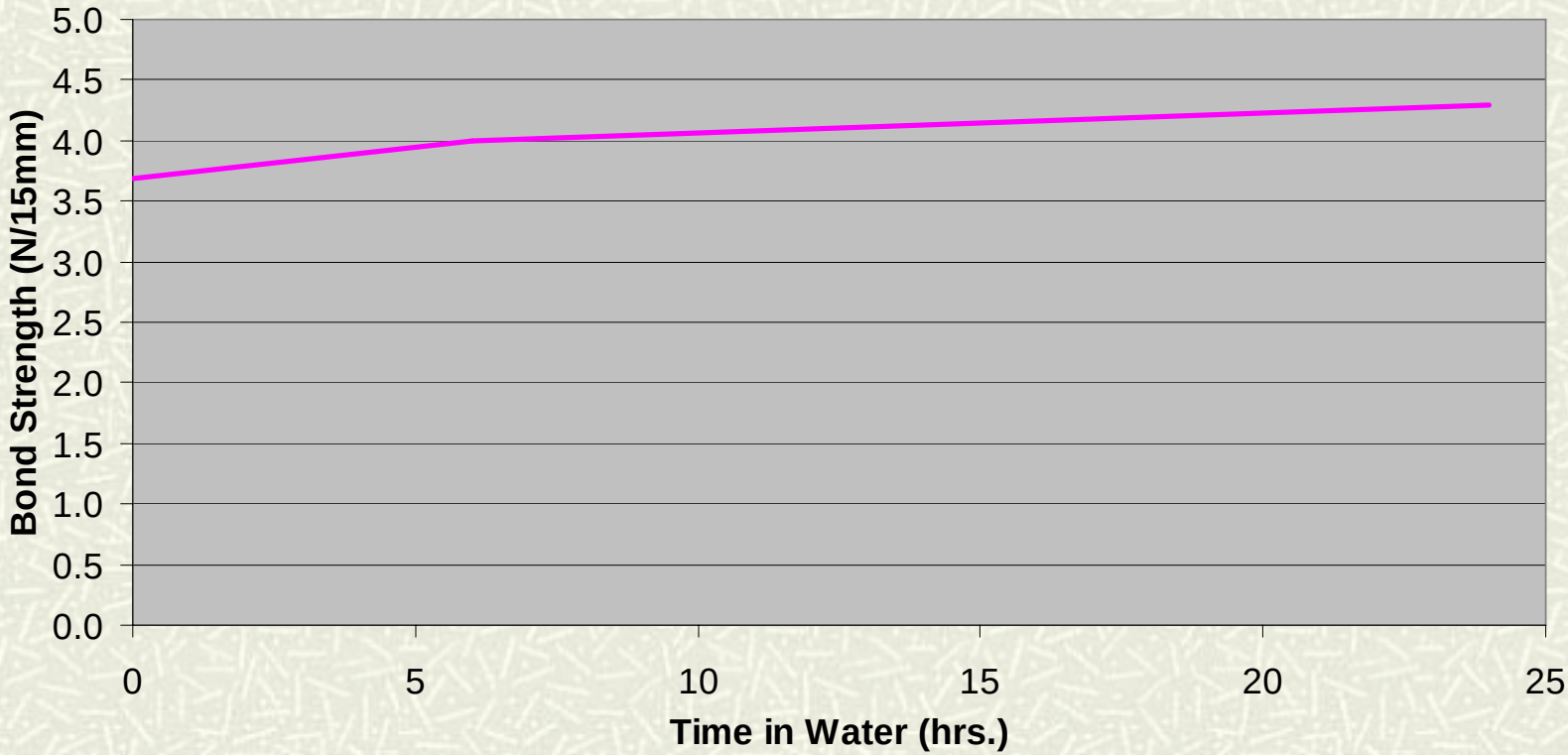
Water Resistance of a blend of 8% TL-L1 in EVA (45m) to PET



Bond Strength of EVA/primer/PET Structure After Exposure to 5 days at 70°C and 95%RH.



Water Resistance of a Blend of 8% TL-L1 in EVA (45m) to Aluminum



Possible Utility

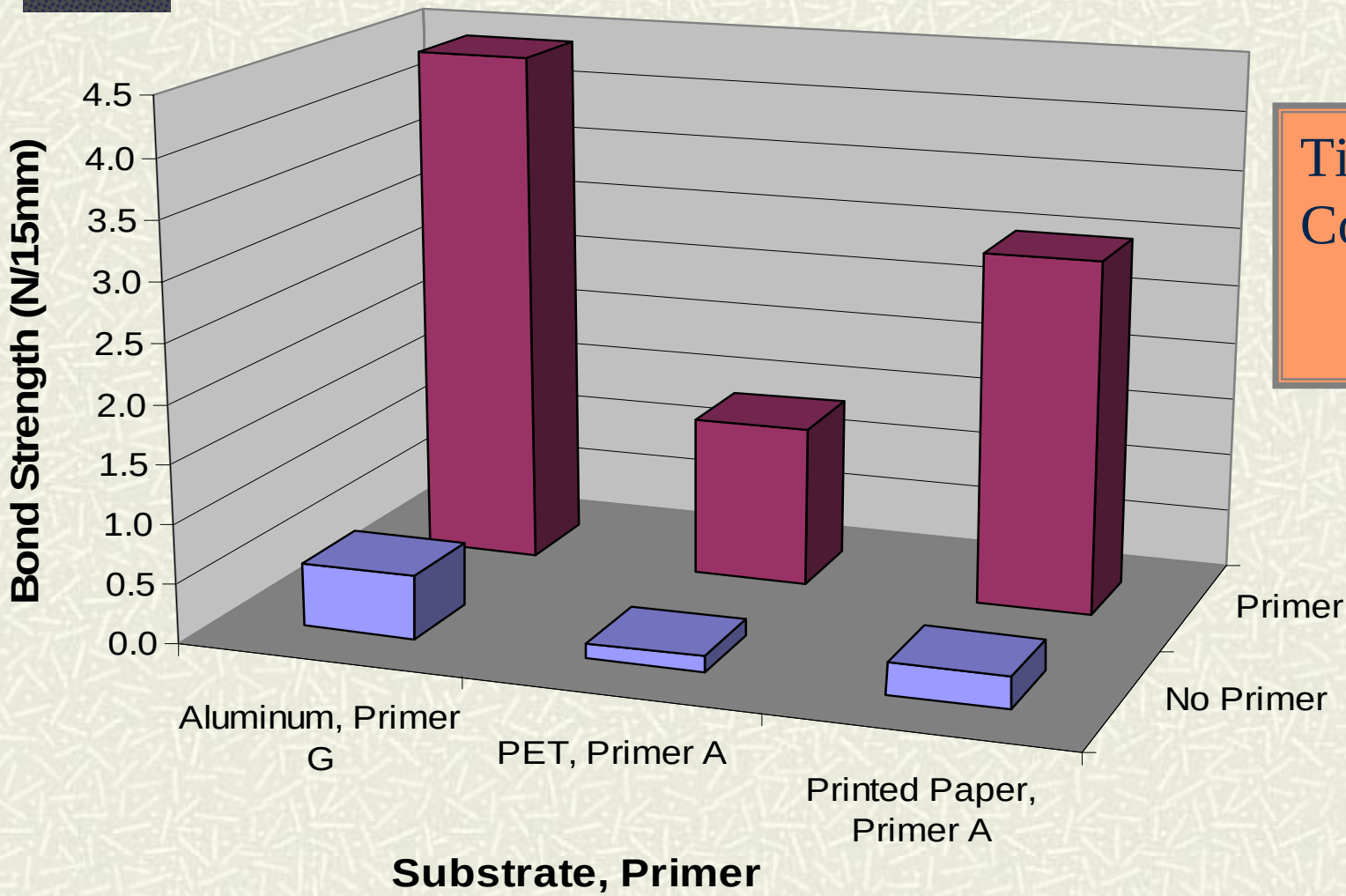
- More robust lamination stock.
- EVA extrusions without ozone.
- Enhanced bonding to substrate in lidding.

Tie-Layer B1 and B2 in Polypropylene

Extruded Polypropylene

- Does not oxidize at high temperatures.
- VERY difficult to bond, particularly to plastic film or aluminum foil.
- Limited use in extrusion coating despite excellent properties:
  - Low cost
  - High use temperature
  - High gloss, clarity
  - Grease and chemical resistance

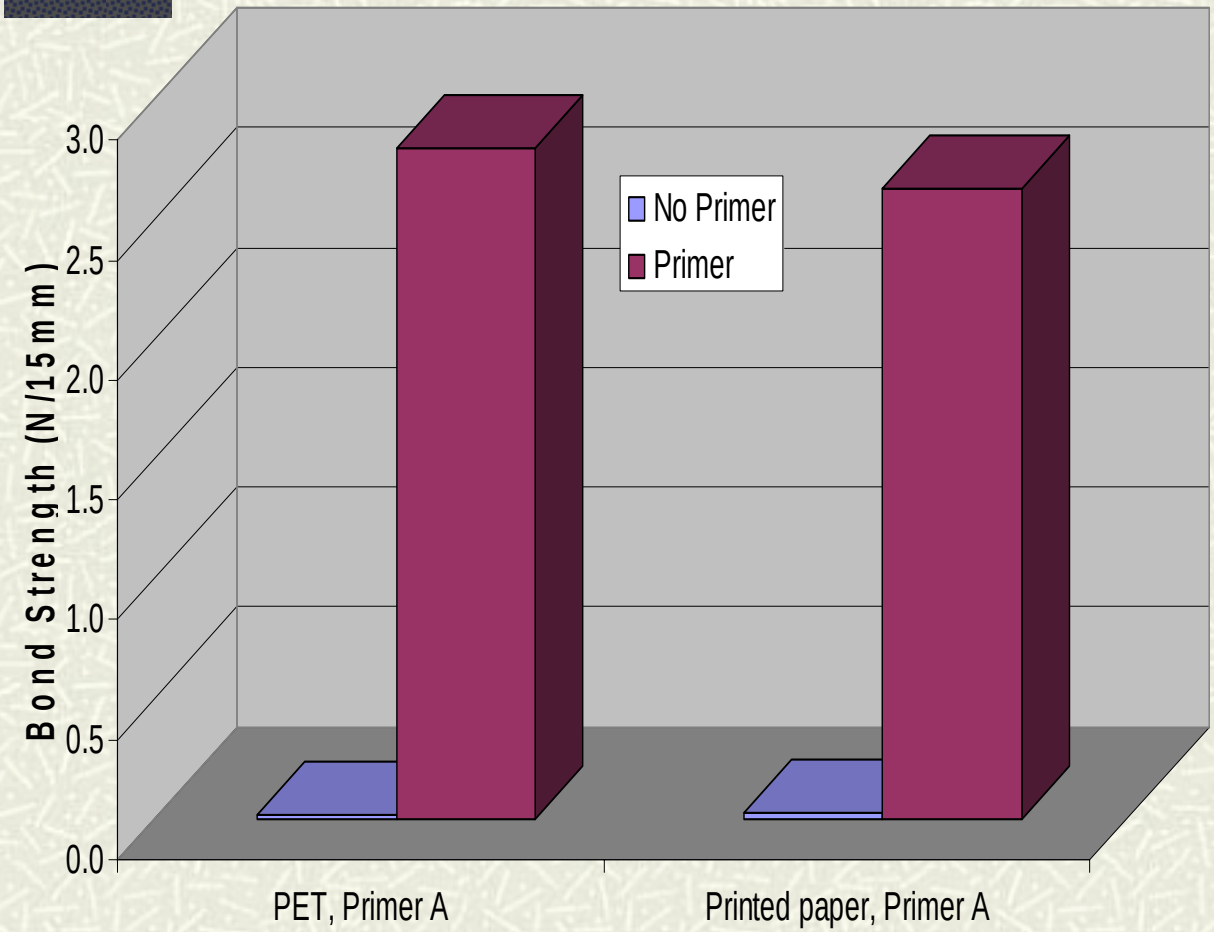
Effect of Primer on Adhesion of 100% TL-B2 to Various Substrates



Tie Layer for Coextrusion:

- Low MAH
- Low MFR

Effect of Primer on Adhesion of 15% TL-B1 in Polypropylene to Various Substrates.



Tie Layer for blending:

- High MAH
- High MFR

Possible Utility

- Clear, glossy, abrasion resistant, grease resistant coating.
  - Ream wrap
  - Pet food bags
- Possible clear steam sterilizable structures made by monolayer extrusion.

Conclusions

- Unique, superior or lower cost structures can be made by using primers and:
  - Tie-layers in coextrusion.
  - Tie-layers / commodity resin blends in mono-layer extrusion.