Performance Properties of EB Laminating Adhesives For Flexible Packaging Applications

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Laminating Technologies for Flexible Packaging

- Extrusion lamination
- Solvent base adhesives
- One-component water base
- Two-component water base
- Two-component solventless adhesives
- UV Curable adhesives
- EB Curable adhesives

Disadvantages of Two-Component Solventless Adhesives

- Adhesive can take several days to reach full cure
  - Can not QC bond strength immediately upon lamination
  - Creates delays in slitting and shipping product
- Requires accurate mixing of two components
- Difficult to start and stop lamination (adhesive continues to cure)
- Requires heated application equipment
- Adhesive misting upon application
- Toxicity concerns with residual aromatic amines

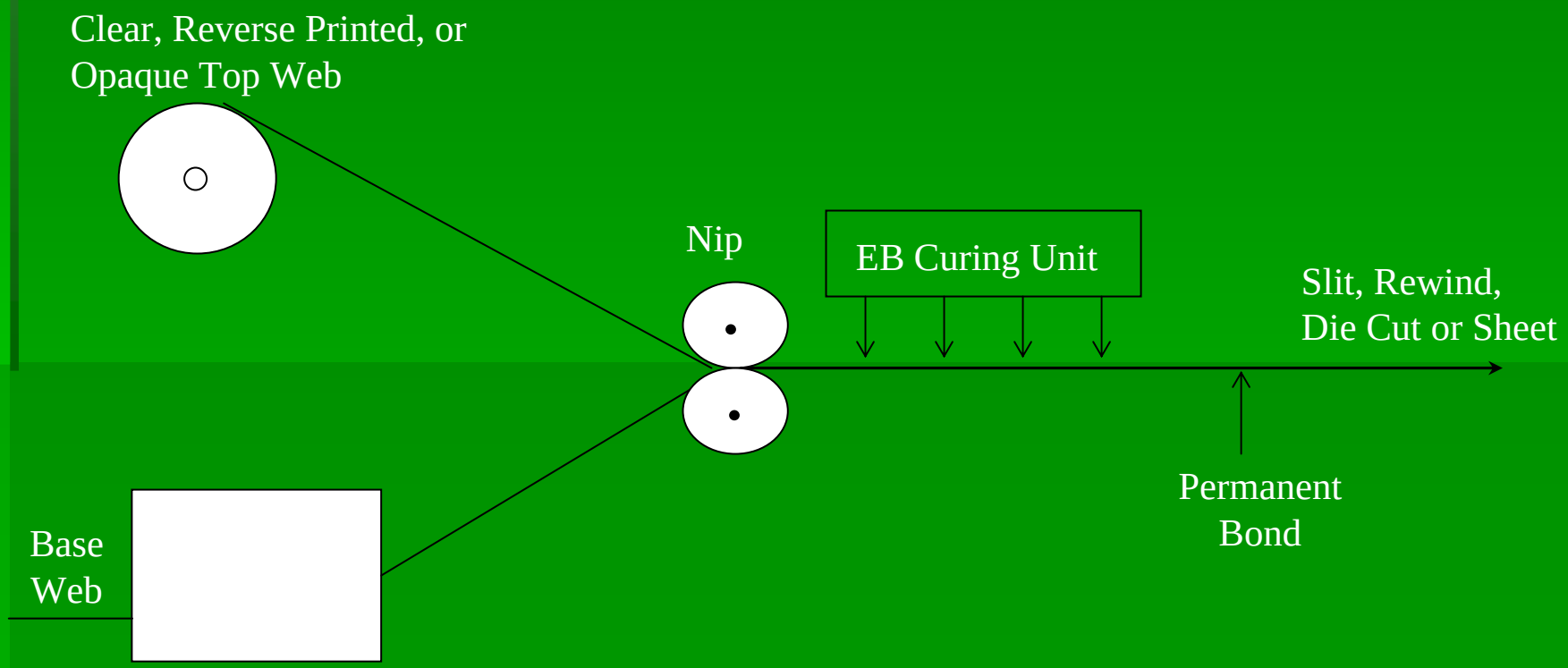
Advantages of EB Laminating Adhesives for Flexible Packaging

- One part systems that require no mixing or adjustments
- Low viscosity allows room temperature application with little misting
- Easy start, stop, and clean-up of laminating equipment
- Bond strength is achieved immediately upon cure

EB Laminating Adhesive Technology

- Generally based on free radical curing of acrylates
- No photoinitiator required for free radical curing
- EB can penetrate opaque substrates
- Penetration depth controlled by EB voltage
- Laminate structure eliminates the need for nitrogen inerting (ventilation of ozone required)
- Permanent tack-free bond offers good chemical and heat resistance
- High conversion and low odor may allow use in food packaging applications

EB Curable Laminating Adhesive



Objectives of Study

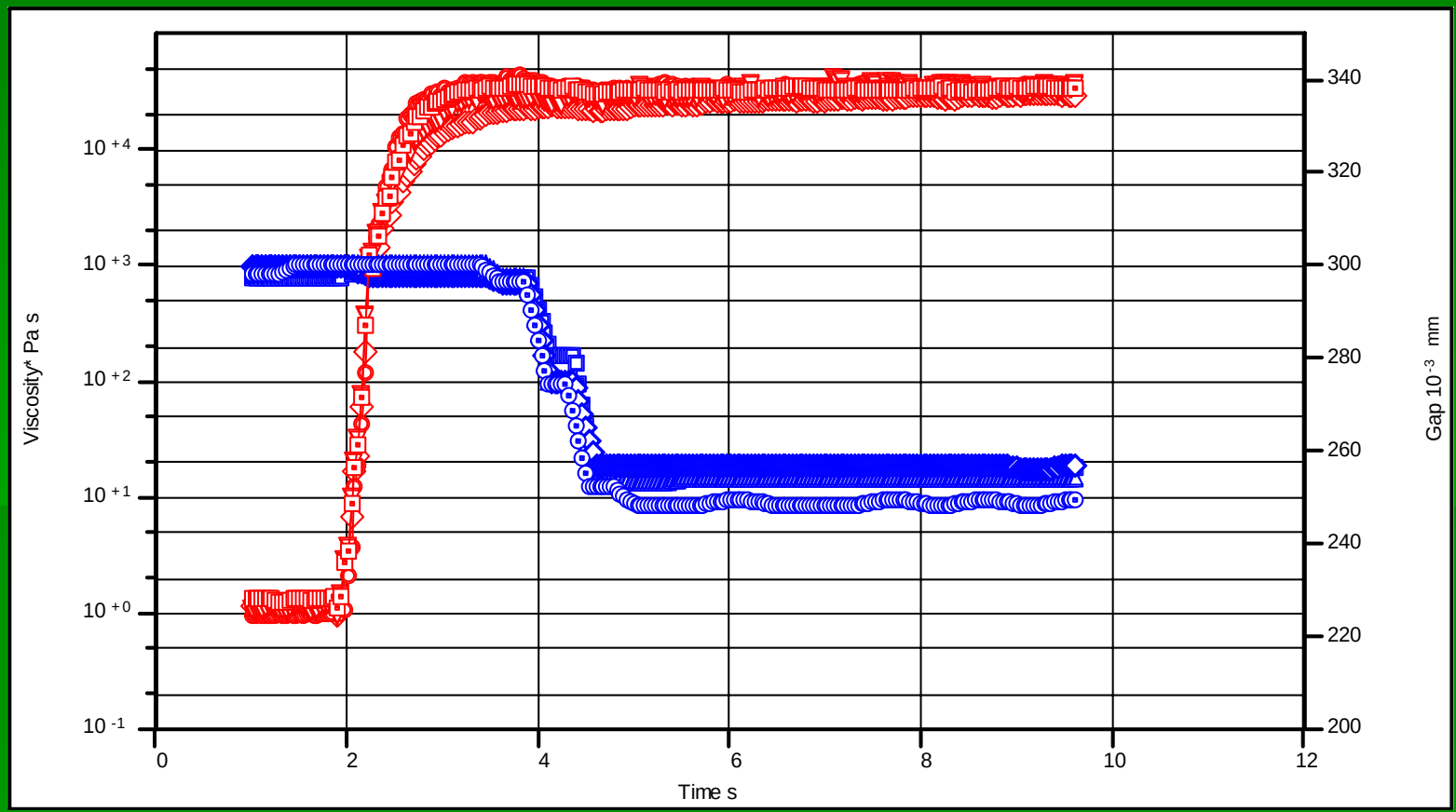
- Optimize cured adhesive properties through the use of dynamic mechanical analysis (DMA)
- Test bonding properties with multiple flexible packaging substrates
- Test water and food product resistance of the resulting laminates

EB Curable Adhesive Properties

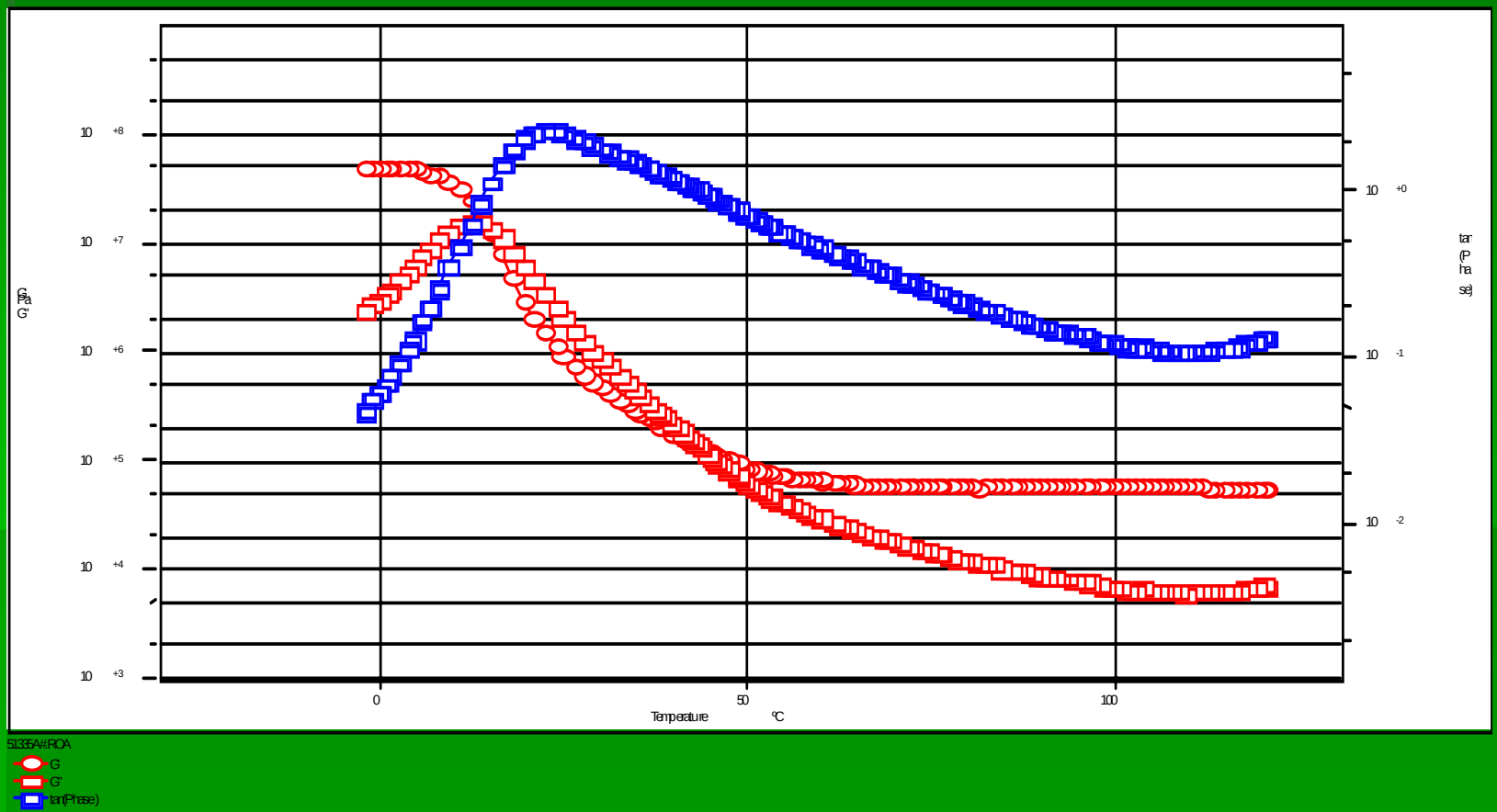
Adhesive	Viscosity (cps @ 25 °C)	Relative Hydrophobicity	Cured Tg (°C)
51325	**355**	**1 least hydrophobic**	**21.5**
51335	**473**	**2**	**22.4**
51345	**593**	**3**	**27.6**
51355	**852**	**4 most hydrophobic**	**29.2**

DMA Rheometer with UV Source
(Reological Instruments Stresstech HR)

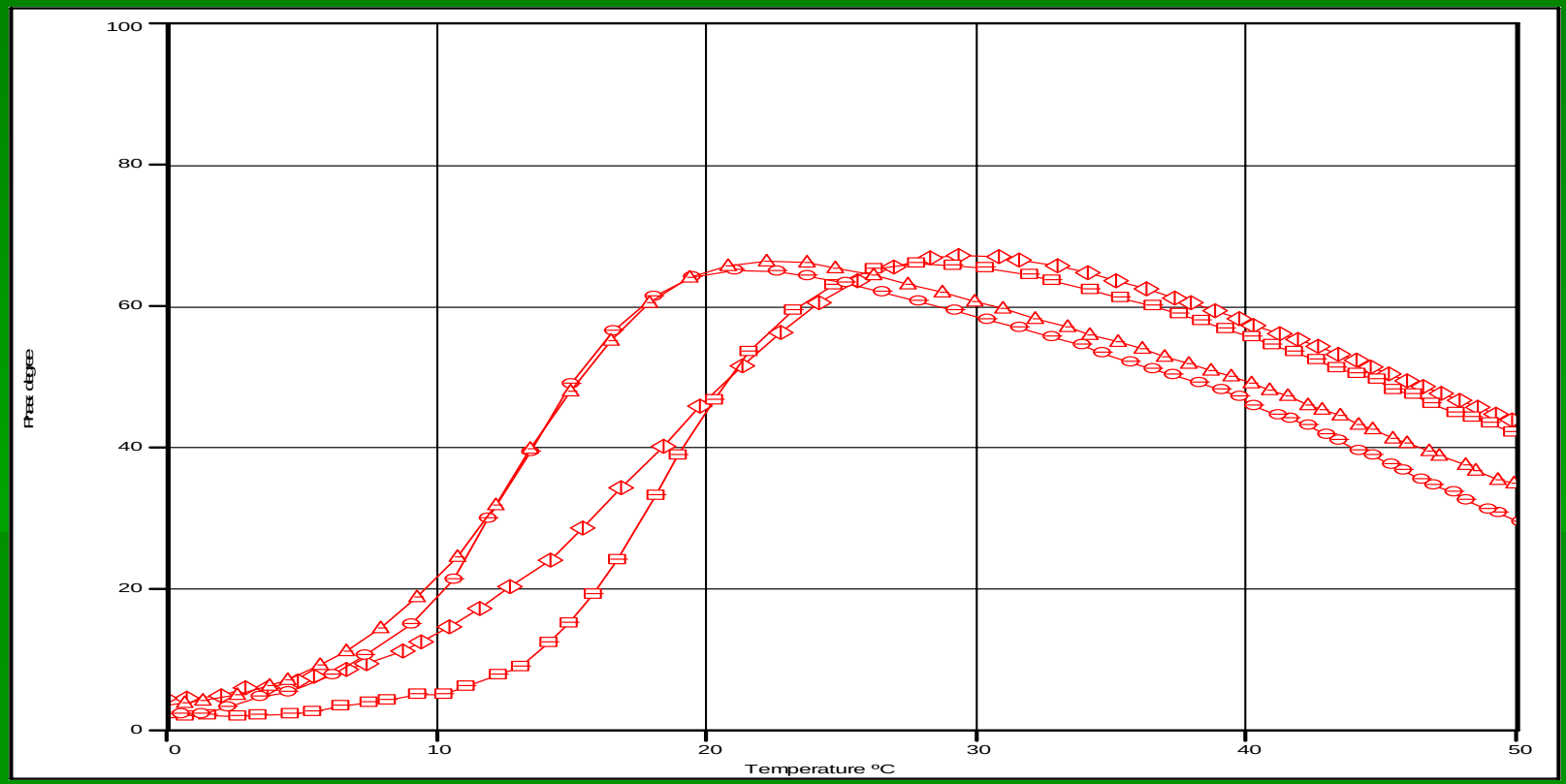
Adhesive Viscosity and Shrinkage During UV Exposure



DMA Properties of 51335 After UV Curing



Tan Delta Plots of Cured Adhesives



Adhesive DMA Analysis

- UV curing process monitored with the rheometer
- Cured adhesive properties characterized by DMA
- Tg of the four cured adhesives are in a desirable range from 21.5 to 29.2 ºC

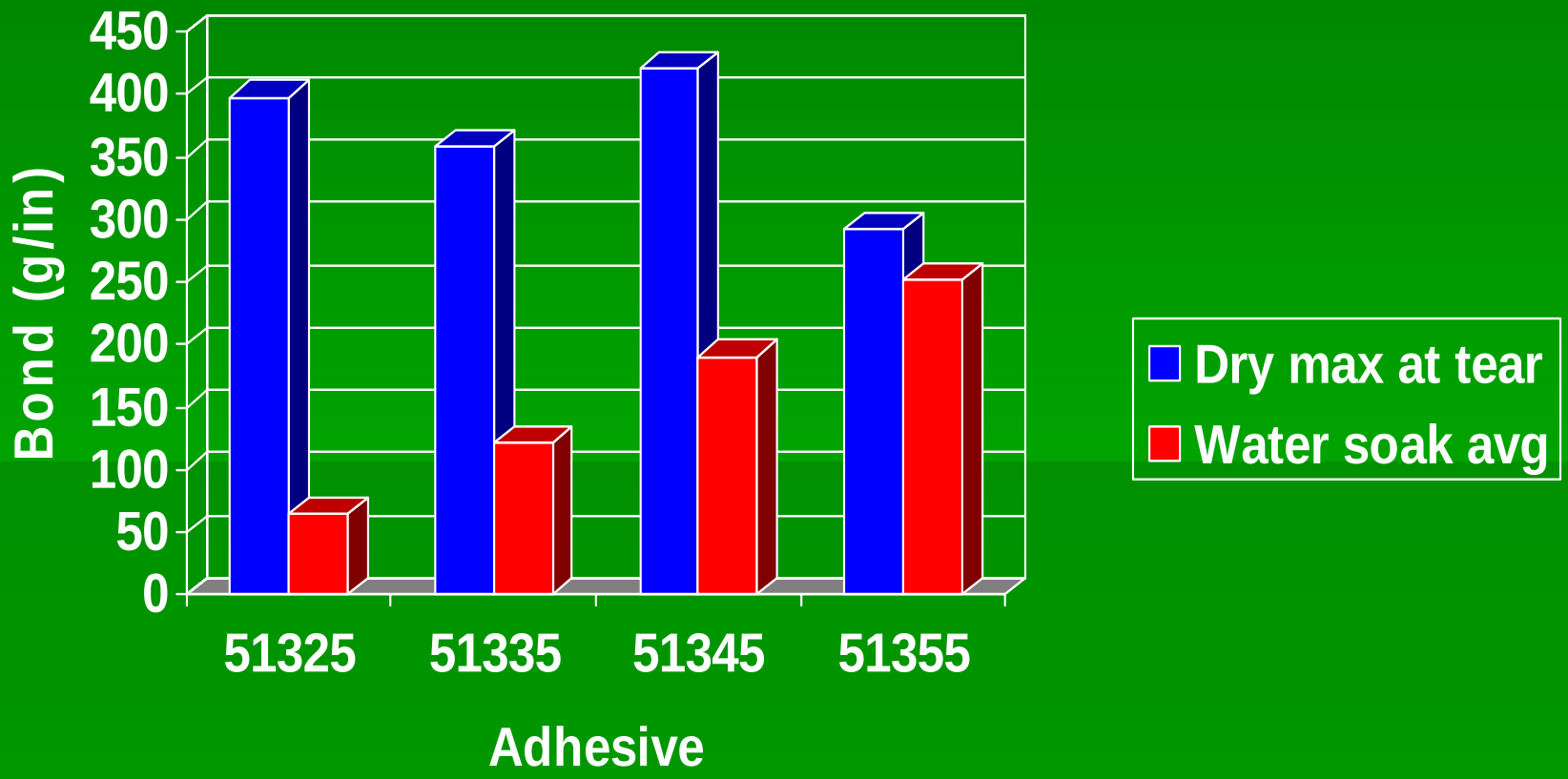
EB Lamination Study: Substrate Combinations

- PET (0.48 mil)/Al foil (1.0 mil)
- PET (0.48 mil)/LLDPE (2.0 mil)
- Chem Treated PET (0.48 mil)/LLDPE (2.0 mil)
- oPP (0.75 mil)/LLDPE (2.0 mil)
- oPP (0.75 mil)/metallized oPP (0.70 mil)

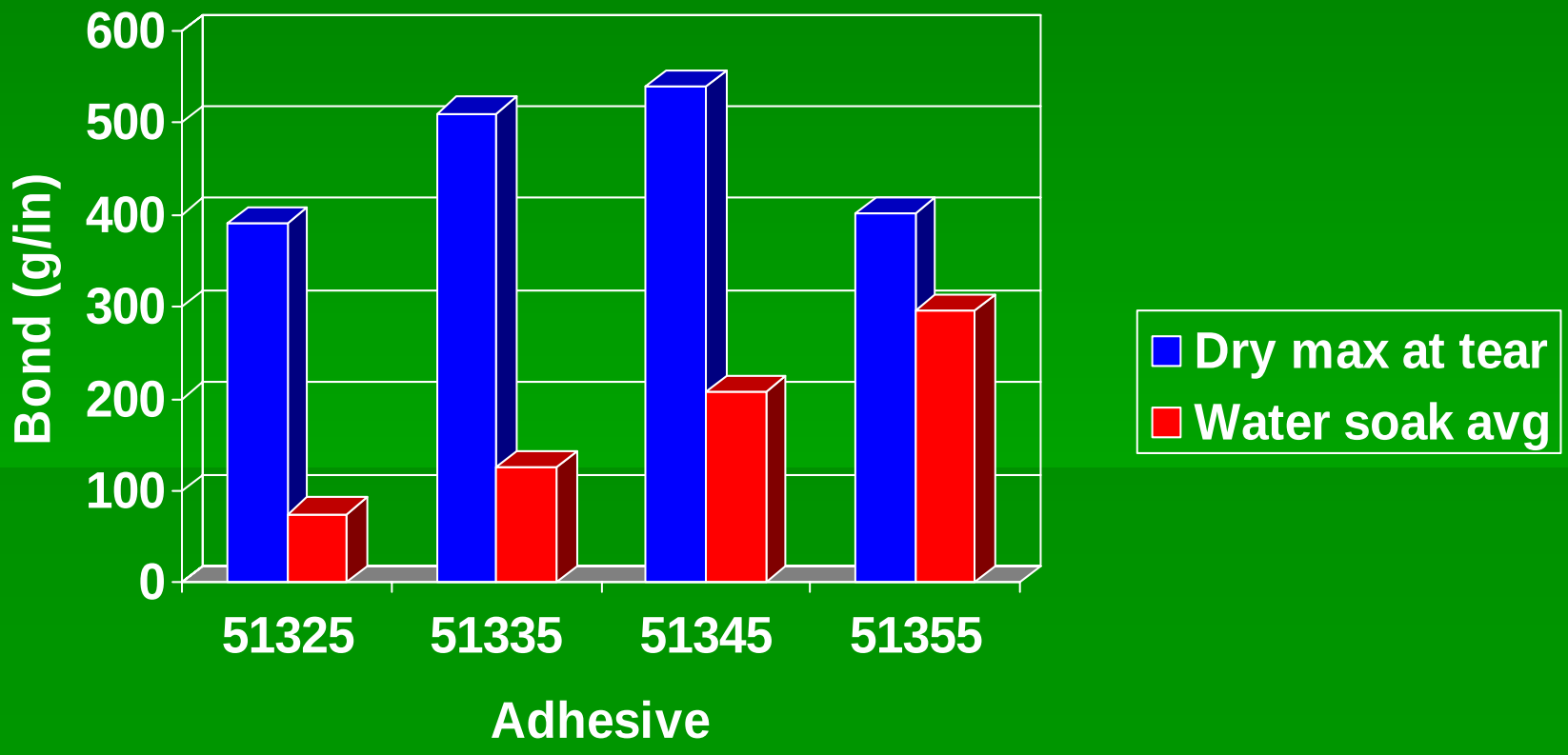
EB Lamination Study: Application, Curing, and Testing

- Off-set gravure coater at room temperature
- 1.3 +/- 0.2 pounds/3000 ft^2
- Corona treatment on metallized PET only, other films were pretreated by the manufacturer
- 3.0 Mrads @ 110 kV
- T-peel @ 10 in/min

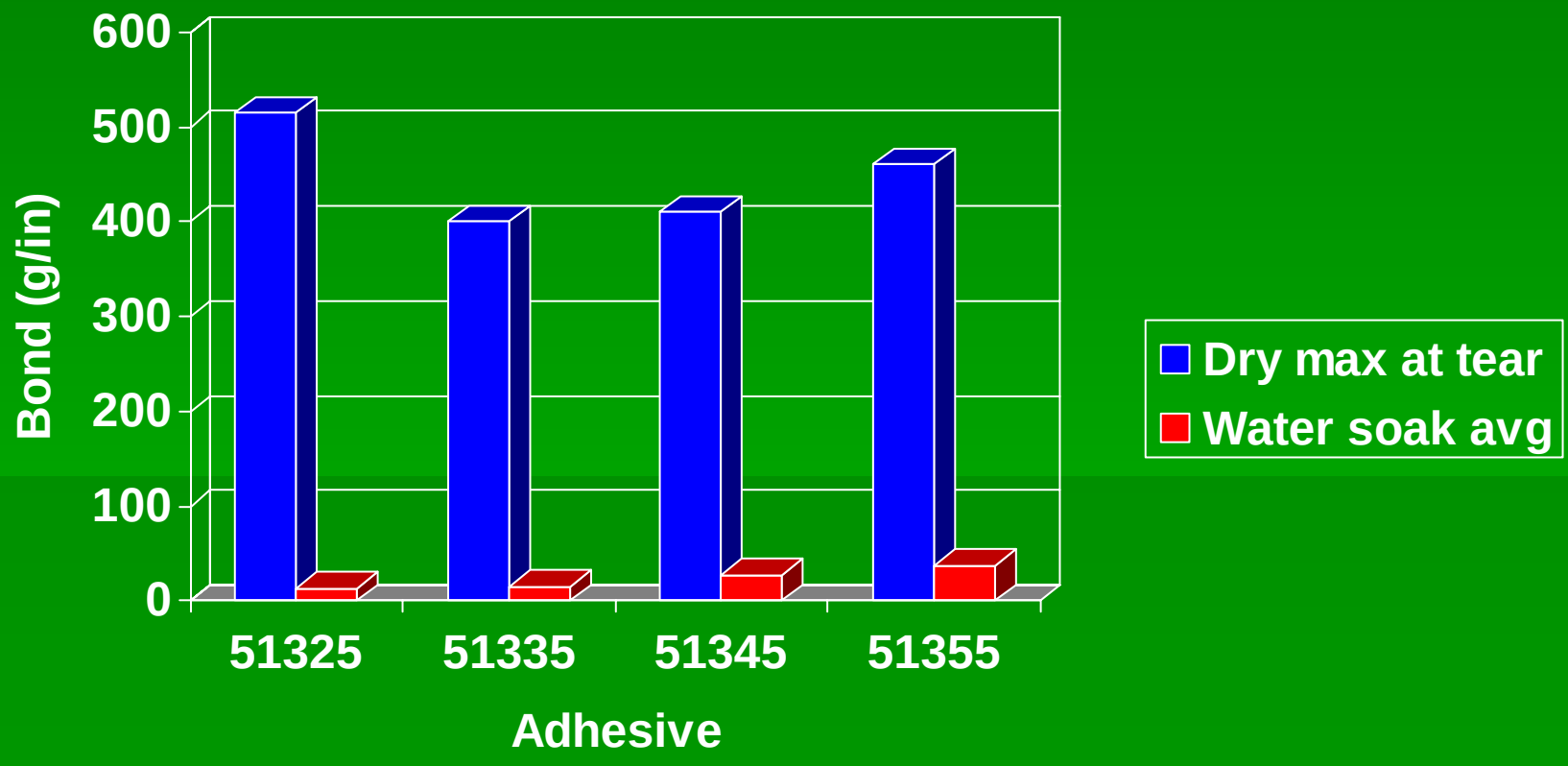
Dry and Wet Bond Strength: PET/Aluminum Foil



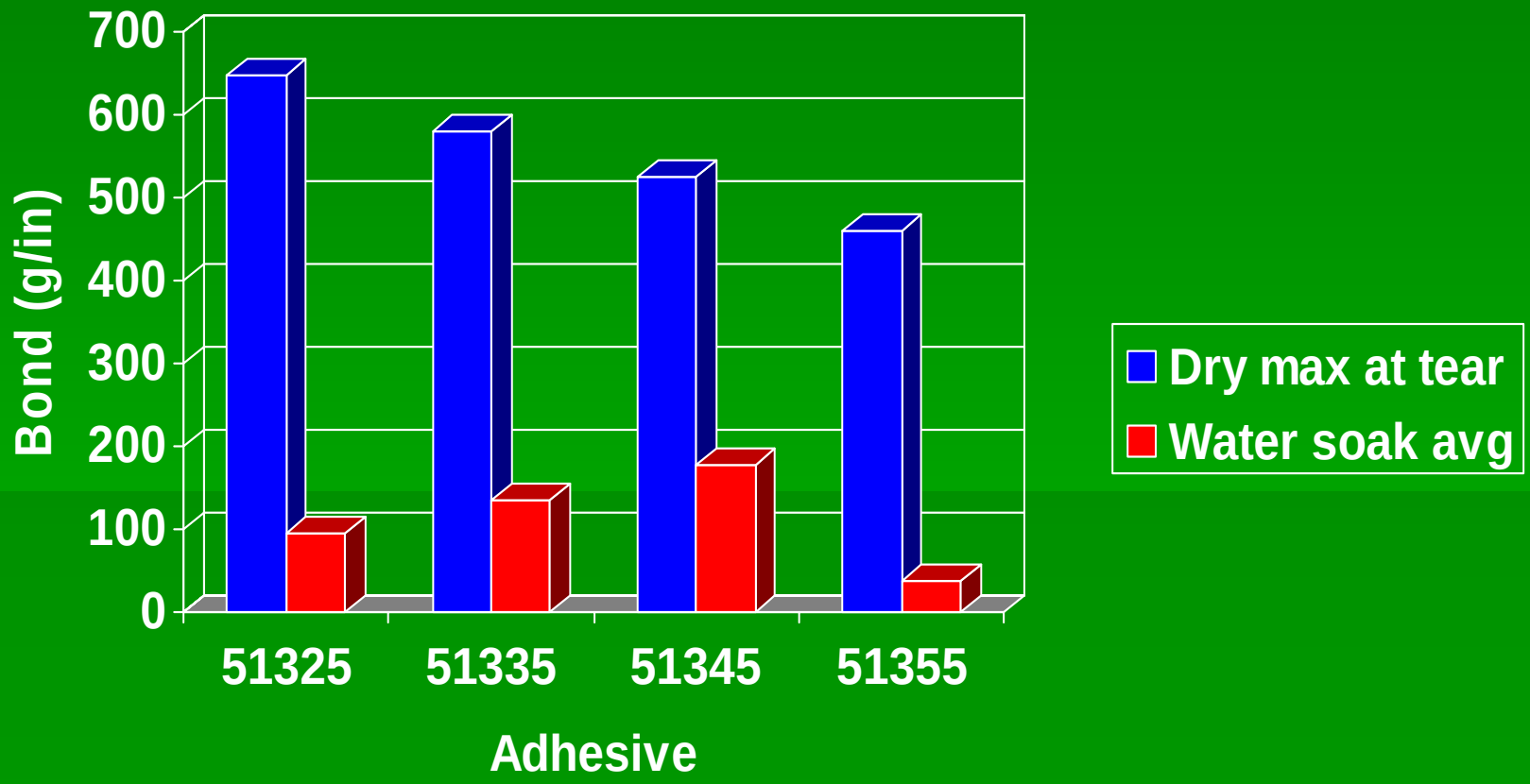
Dry and Wet Bond Strength: Chemical Treated PET/LLDPE



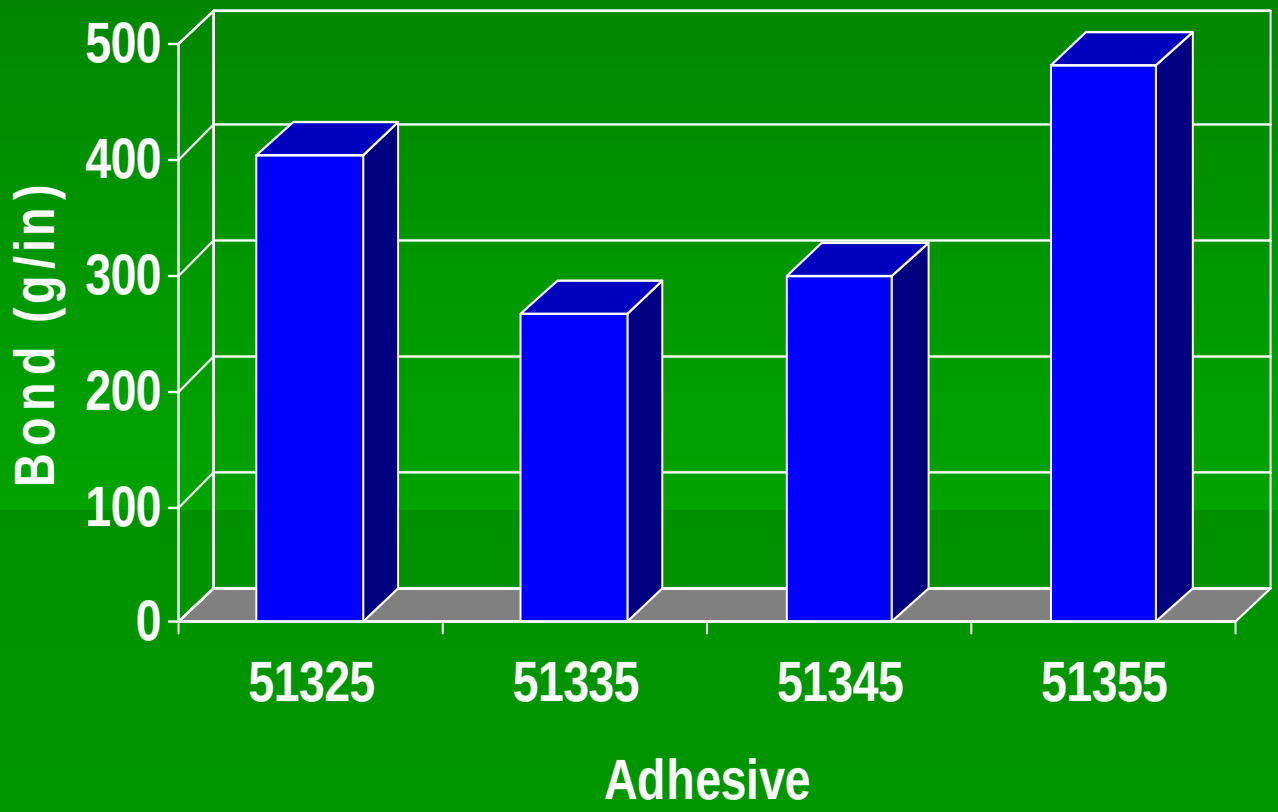
Dry and Wet Bond Strength: PET/LLDPE



Dry and Wet Bond Strength: oPP/LLDPE



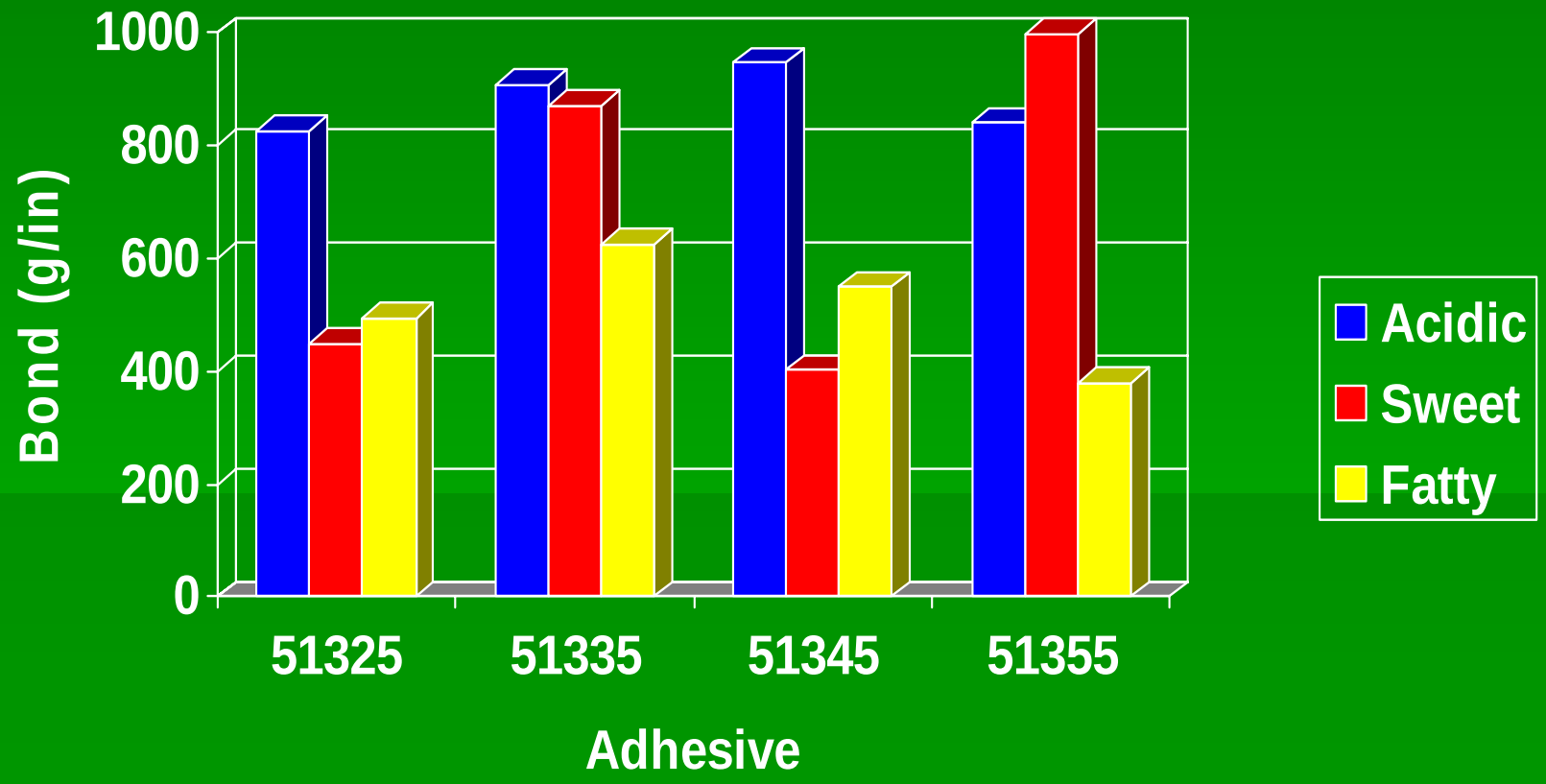
Dry Bond Strength: oPP/metallized oPP



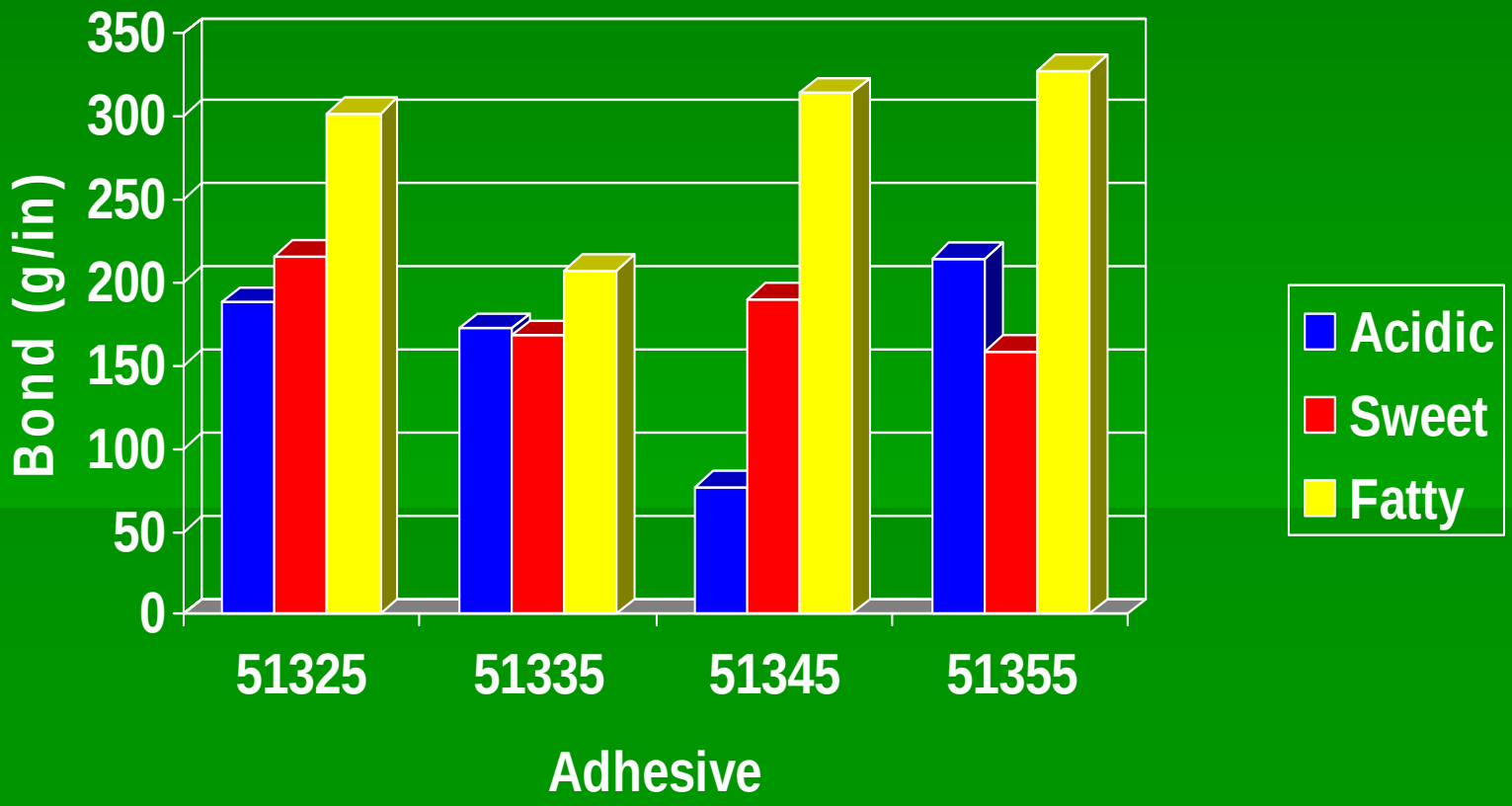
Food Product Resistance

- Food Products
  - Acidic: Sunny Delight™
  - Sweet: 50% Corn Syrup
  - Fatty: Corn Oil
- Conditions – two weeks room temperature and refrigerated in heat sealed pouches
- Testing - T-Peel sections of pouches immediately after opening

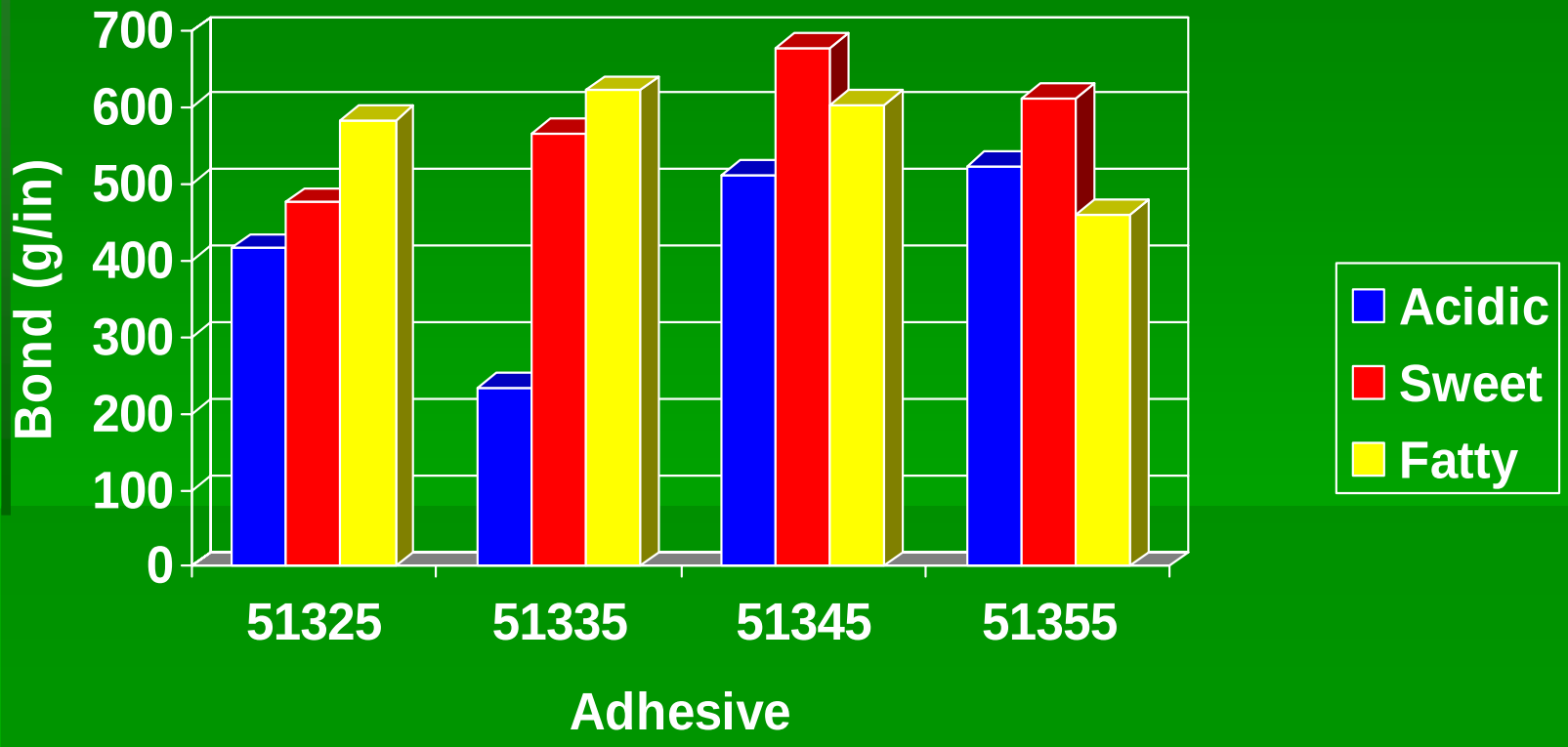
Food Product Resistance: Chemical Treated PET/LLDPE



Food Product Resistance: PET/LLDPE



Food Product Resistance: oPP/LLDPE



Bond Performance Summary

- EB Cured adhesives with Tg's near the use temperature exhibit excellent bonding properties
- The Tg of the cured adhesive affects the maximum bond strength at tear
- The optimum adhesive Tg depends on the substrates that are used.
- The wet bond strength increases with the hydrophobic composition of the adhesive
- Much higher water soak bonds are achieved with chemical treated PET compared to corona treated PET
- Good dry bonds and food product resistance are achieved with corona treated PET

Conclusion

Given the processing advantages and performance properties shown in this study, EB laminating adhesive technology may merit consideration in a variety of flexible packaging applications

Future Work

- Migration Study: Preliminary studies with these adhesives indicate that there are multiple combinations of substrates, food types, and end-use conditions that result in no detectable migration of adhesive components. A detailed study is in progress.
- Printing Ink Study: Preliminary studies have shown excellent bonding with a variety of commercial laminating inks. A detailed study is in progress.

Thank You

Questions?