High Performance Extrusion Coating EVA with Low Temperature Activation

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Learning Outcomes

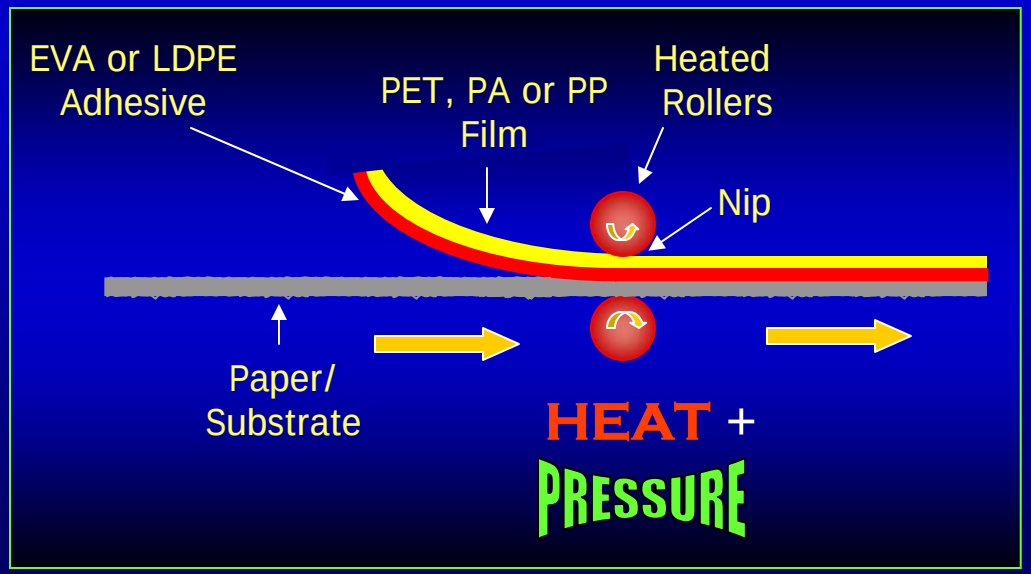
- Introduce AT Plastics, div of Celanese
- Understand the effects of increasing %VA content in EVA resins
- Specifically compare the adhesion performance of 16% VA and 28% VA lamination films
- Troubleshoot typical difficulties encountered when extrusion coating EVA's with very high %VA content

AT Plastics, div of Celanese

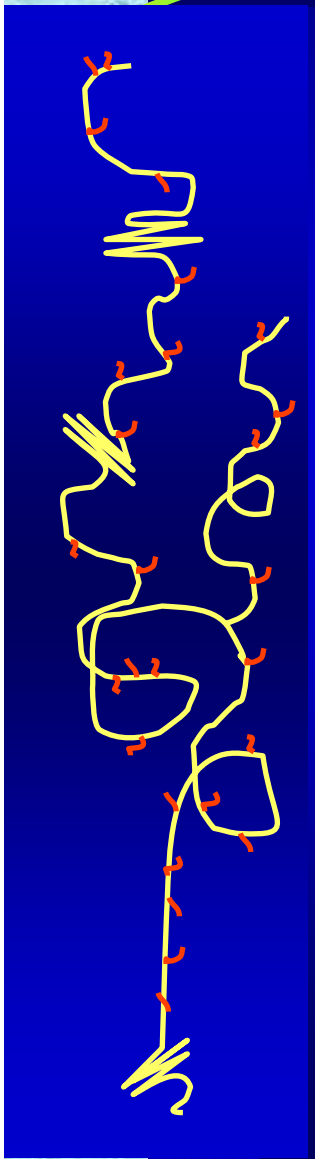
- Celanese (www.celanese.com)
  - $6 Billion diversified chemical company with many JVs in China
- AT Plastics' Facility in Alberta, CANADA
- Five High Pressure Autoclave Reactors
  - 145 kt annual capacity (EVA & LDPE)
- Focus on Specialty Polymers (LDPE & EVA)
  - LDPE with melt index up to 2200
  - EVA grades from 6% VA to 40% VA
- Excellent access to rail and ship ports
  - Ship to Asia from of Port of Vancouver
- Technical Service Centre
  - Located in state of the art Celanese facility in Kentucky, USA
- Represented in China by Cahota

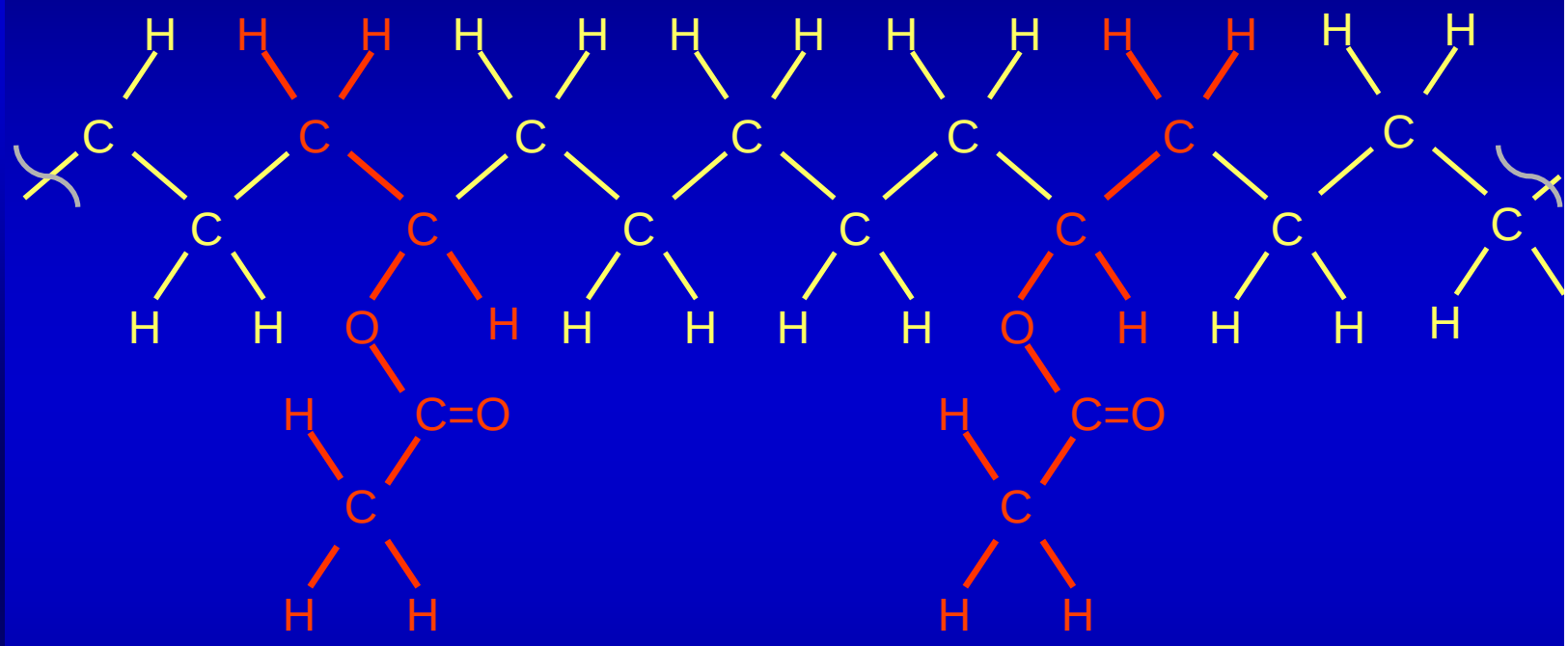
Introduction

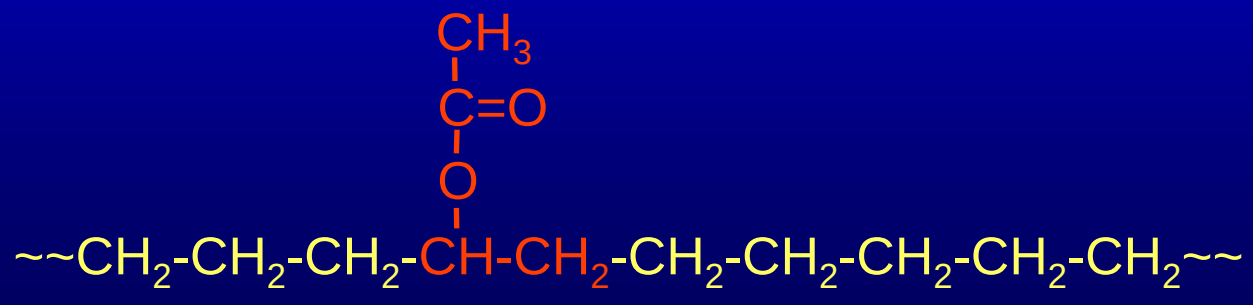
- What is Thermal Lamination Film ?
  - Step 1: LDPE or EVA is extruded onto substrate film (nylon, PET, BOPP)
  - Step 2: Film laminated to substrate stock
    - E.g. posters, school products, signs, book covers
- EVA is the established adhesive resin in the thermal lamination market
  - Versatile adhesion
  - Good processability
  - High gloss
  - Typically 15-18% vinyl acetate content



The EVA Copolymer Structure

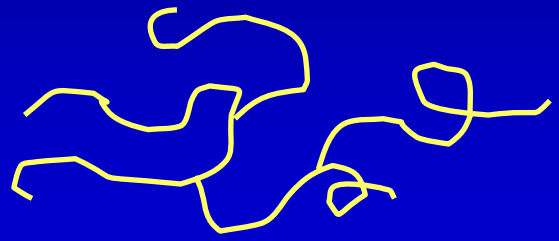


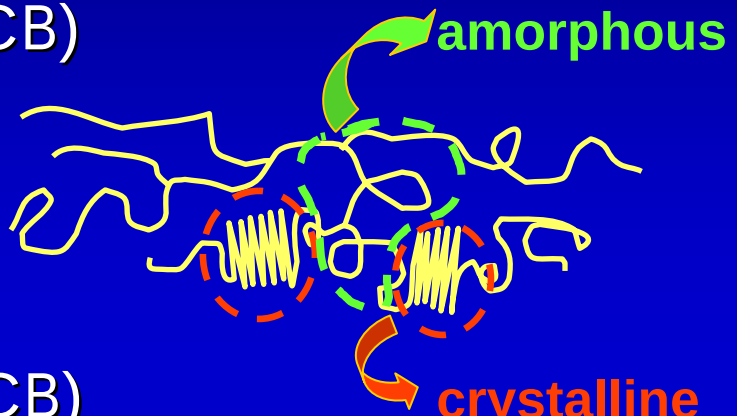




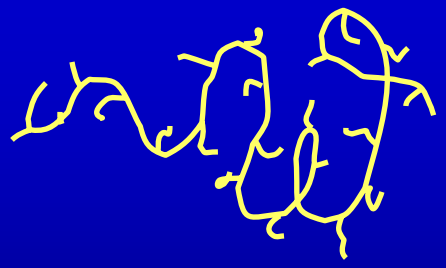
Polymer Chain Branching in EVA's

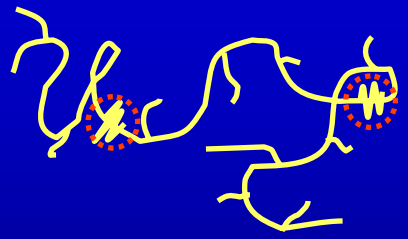
- Long chain branching (LCB)





- Short chain branching (SCB)





- Net effect: Reduced crystallinity with increasing %VA (SCB)

Effect of Increasing % of VA

➔ Polymer properties:

- More short chain branching
- Less crystalline
  (More amorphous)
- Lower melt temperature
- More elastic as solid
- Greater flexibility
- Higher clarity and gloss
- Higher density
  - (VA unit weighs more than Ethylene unit)
- Increased polarity
  - VA more polar than ethylene
- Increased toughness

Effect of Increasing % of VA

➔ **Application properties:**

- Better adhesion to polar substrates
  - Aluminum Foil
- Increased tackiness (Coeff of Friction)
  - "Blocking" - Pellets may stick together in a warm environment or under a heavy load
  - Wound film blocking concerns
    - Need good tension control
  - Molten resin sticking to chill rolls
- Lower seal initiation temperature
  - Due to lower melt temperature and softening point
- Increased tendency to degrade or form gels during extrusion
  - Generates acetic acid and "vinegar" odour
  - Acetic acid promotes crosslinking and gels

Property comparison 16% & 28% VA

EVA Property	16% VA	28% VA
Density	936 kg/m^3	948 kg/m^3
DSC Melt Temp	89 °C	70 °C
VICAT Soften Temp	62 °C	43 °C
Tensile strength	9 MPa	8 MPa
Elongation	700%	850%

Materials

Lamination Films:

- Thermal Lamination Film from two suppliers
  - EVA extrusion coated on primed PET and corona treated
- Two Extrusion Coating Resins
  - Ateva® 2821A = 28%VA, 25MI → call it **28**
  - Ateva® 1641 = 16%VA, 28MI → call it **16**
- Supplier "K" Structures: 0.25 mm PET / 0.5 mm EVA
  - **16K** dynes=42 CoF=1.2
  - **28K** dynes=42 CoF=1.5
- Supplier "L" Structures: 0.25 mm PET / 1 mm EVA
  - **16L** dynes=44 CoF=1.1
  - **28L** dynes=44 CoF=2.6

Materials

Substrates:

- Glossy paper substrates
- Offset Ink (solid print)

- Soy-based ink (solid print)

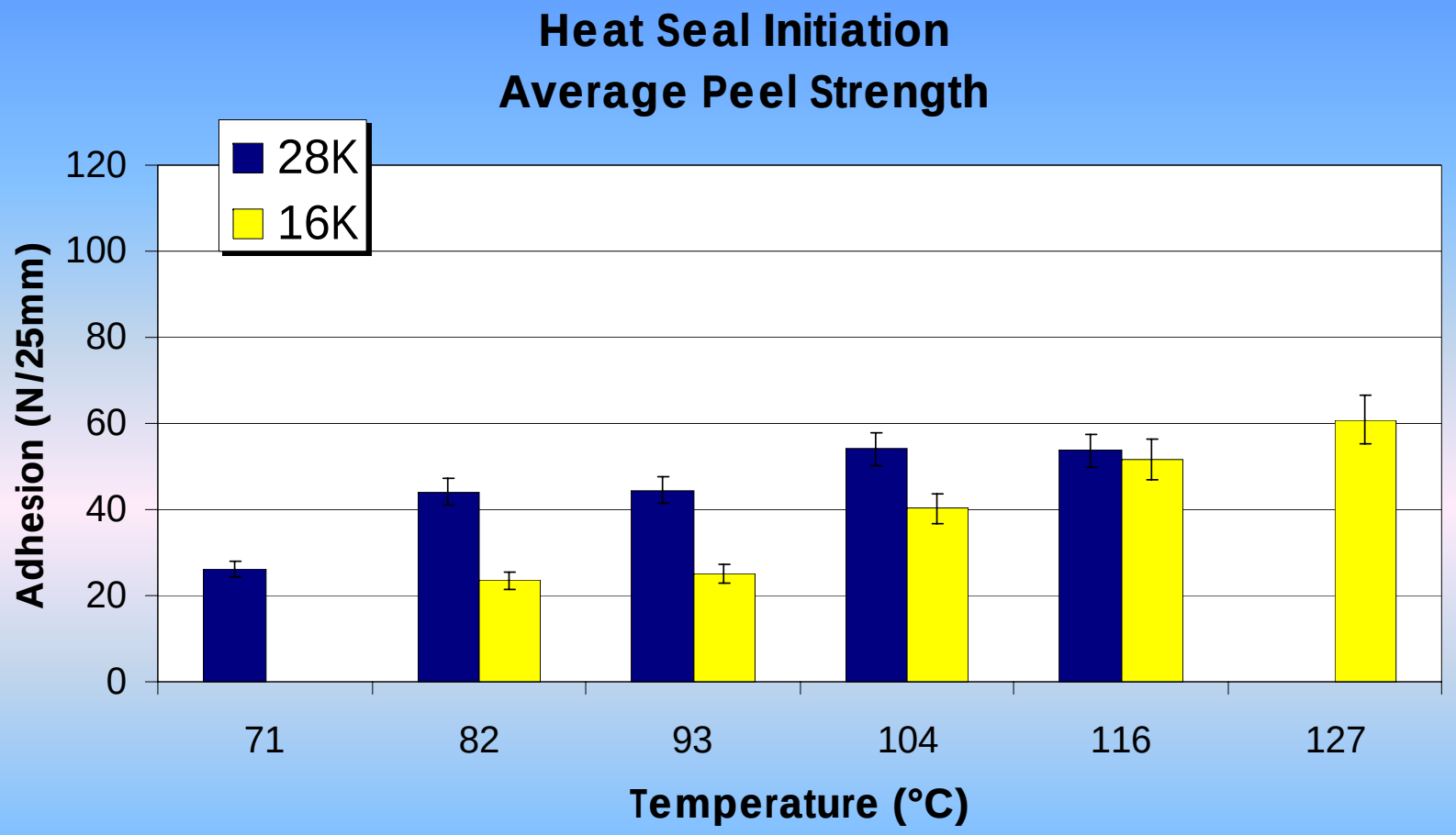
- Prints were about 1 month old and sealed in foil pouch

Heat Seal Activation Comparison

Method:

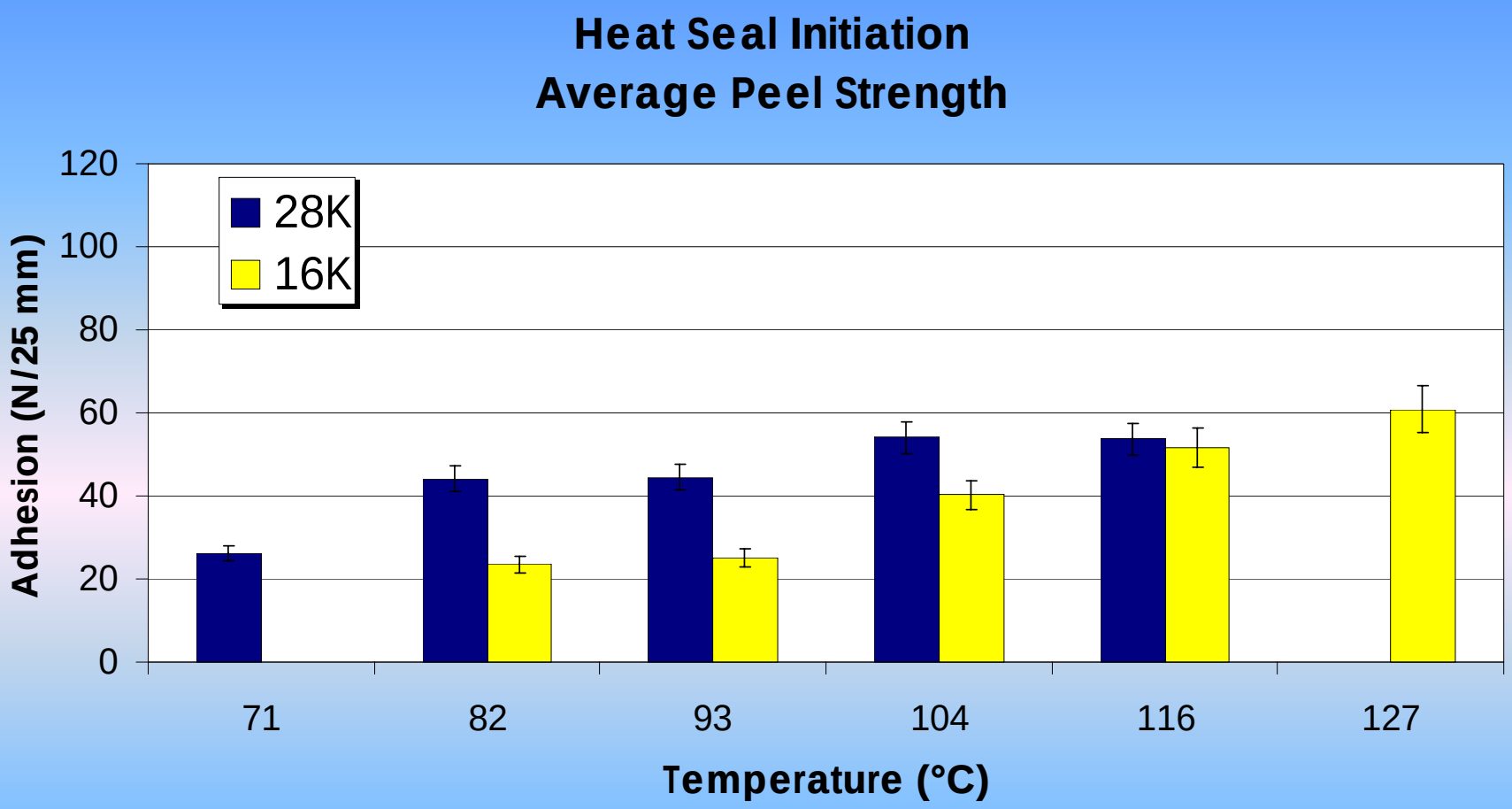
- Heat seal film adhesive to adhesive
- 10 mm heat seal bars
- 138 kPa, 0.5 sec dwell
- Vary temperature from 71-127 °C
- Cut 2.5 cm strip and peel 180° on tensiometer @ 27 mm/min

Heat Seal Activation – 16% & 28% VA



Supplier K Film: 0.25 mm PET/0.5 mm EVA

Heat Seal Activation – 16% & 28% VA

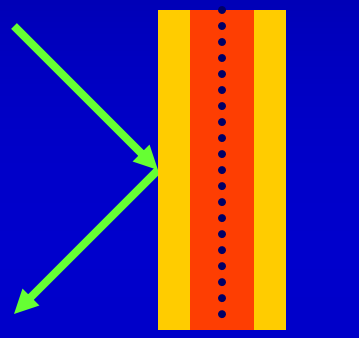


Supplier L Film: 0.25 mm PET/1 mm EVA

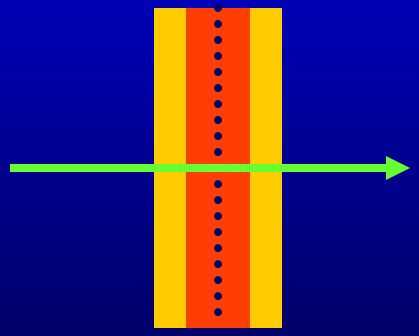
Optical Property Comparison

Method:

- Heat seal film adhesive to adhesive
- Measure 45° gloss at surface of sealed structure
  - Although mainly influenced by PET gloss, adhesive resin has an effect
- Measure haze through sealed structure
- Two temperatures selected
  - Common lamination temperature for 28% EVA ~93°C and for 16% EVA ~115°C

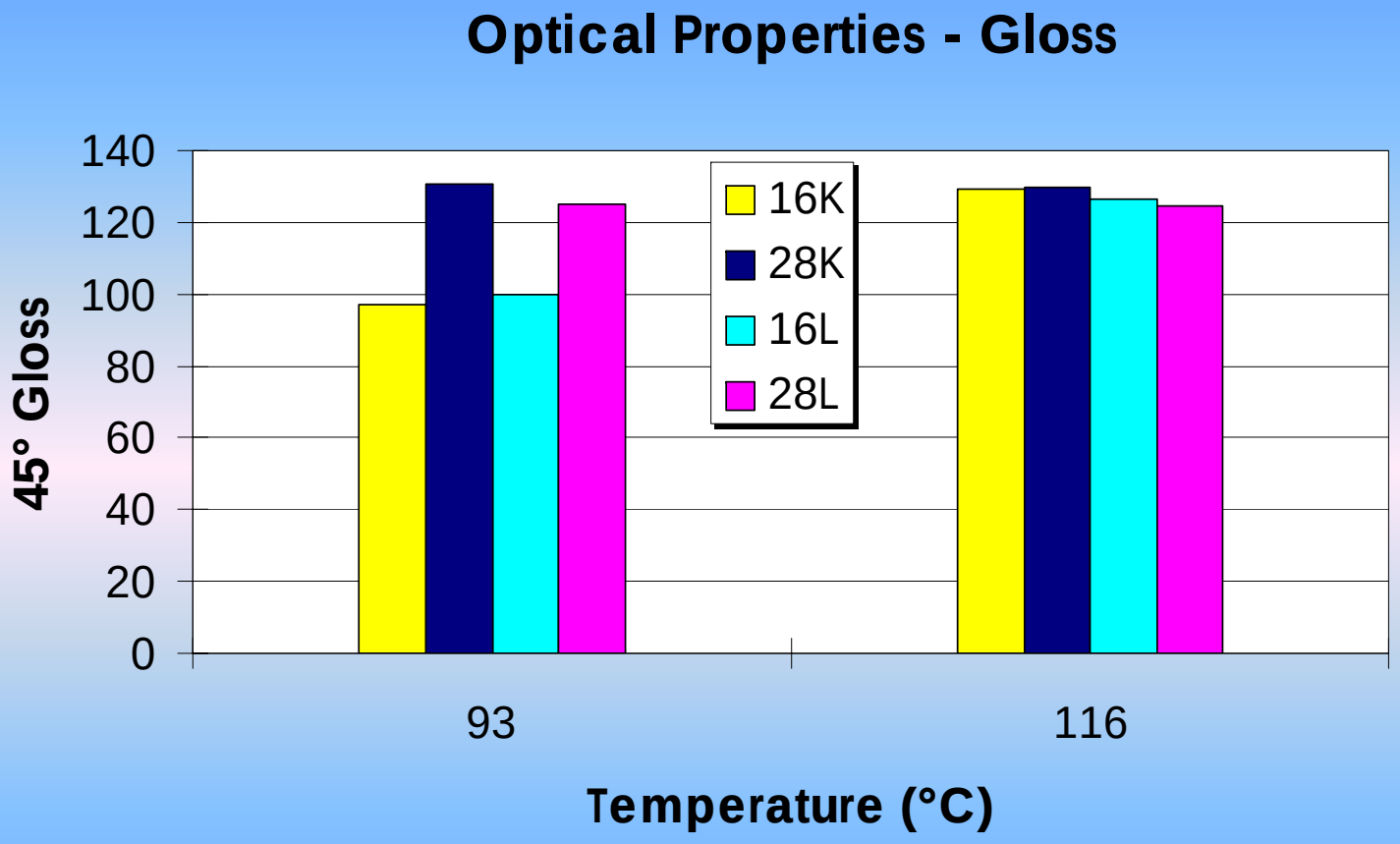


45° gloss

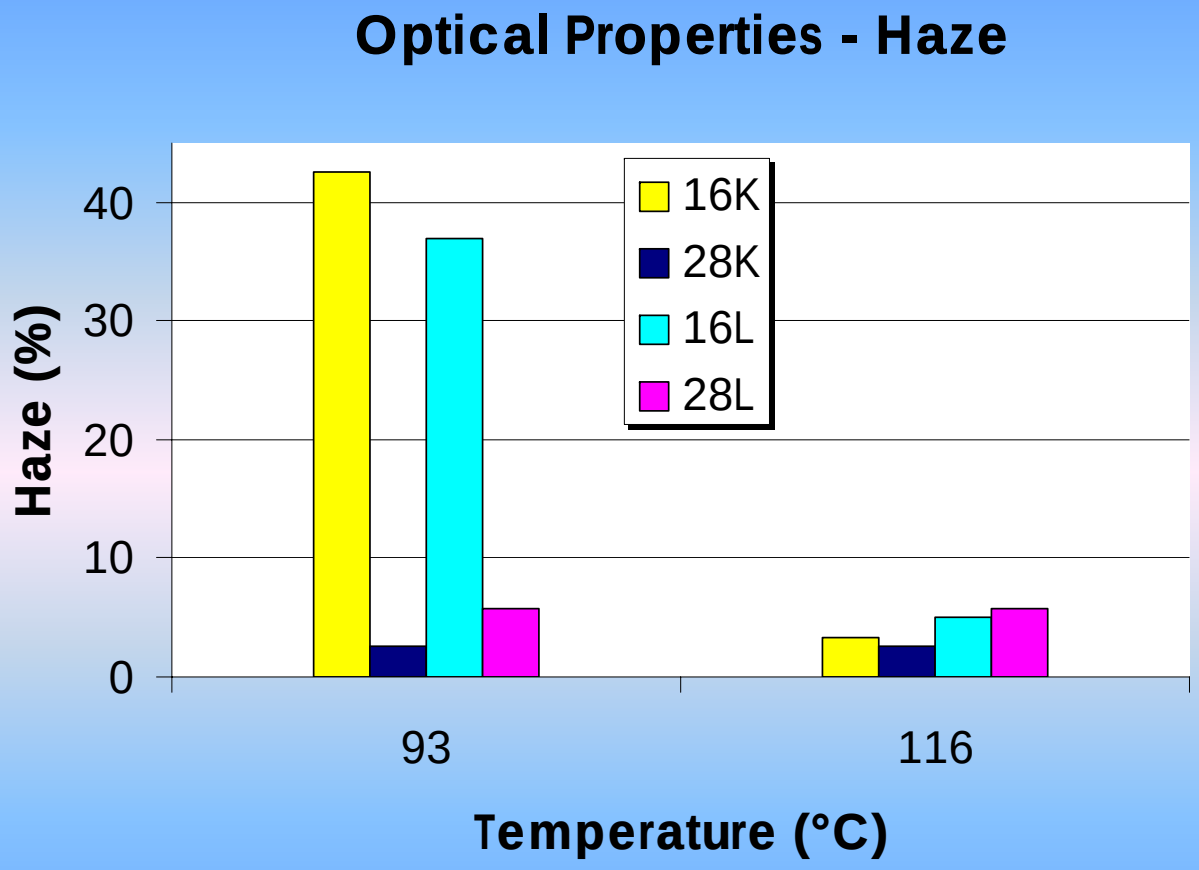


Haze

Heat Seal Gloss Comparison



Heat Seal Haze Comparison



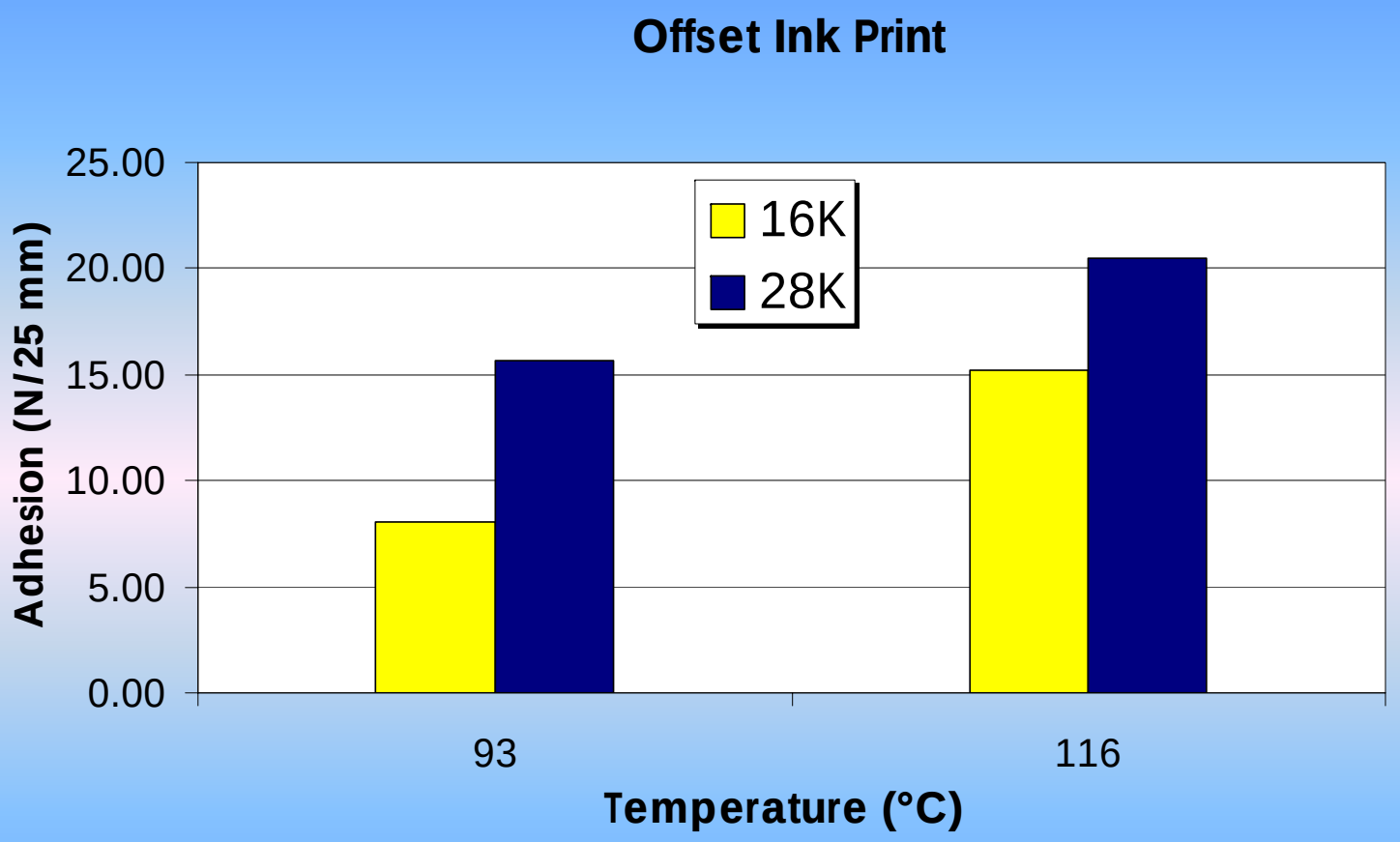
Adhesion to Printed Substrates

Method:

- Desktop pouch laminator
  - Constant speed and pressure
  - Vary temperature from 71-127 °C
- Samples then peeled 1 hour after the lamination
- Cut 25 mm strip and peel on tensiometer 127 mm/min
  - 180° Peel Configuration
  - Max. load and average load between limits recorded
  - Peel strength reported in N/25 mm

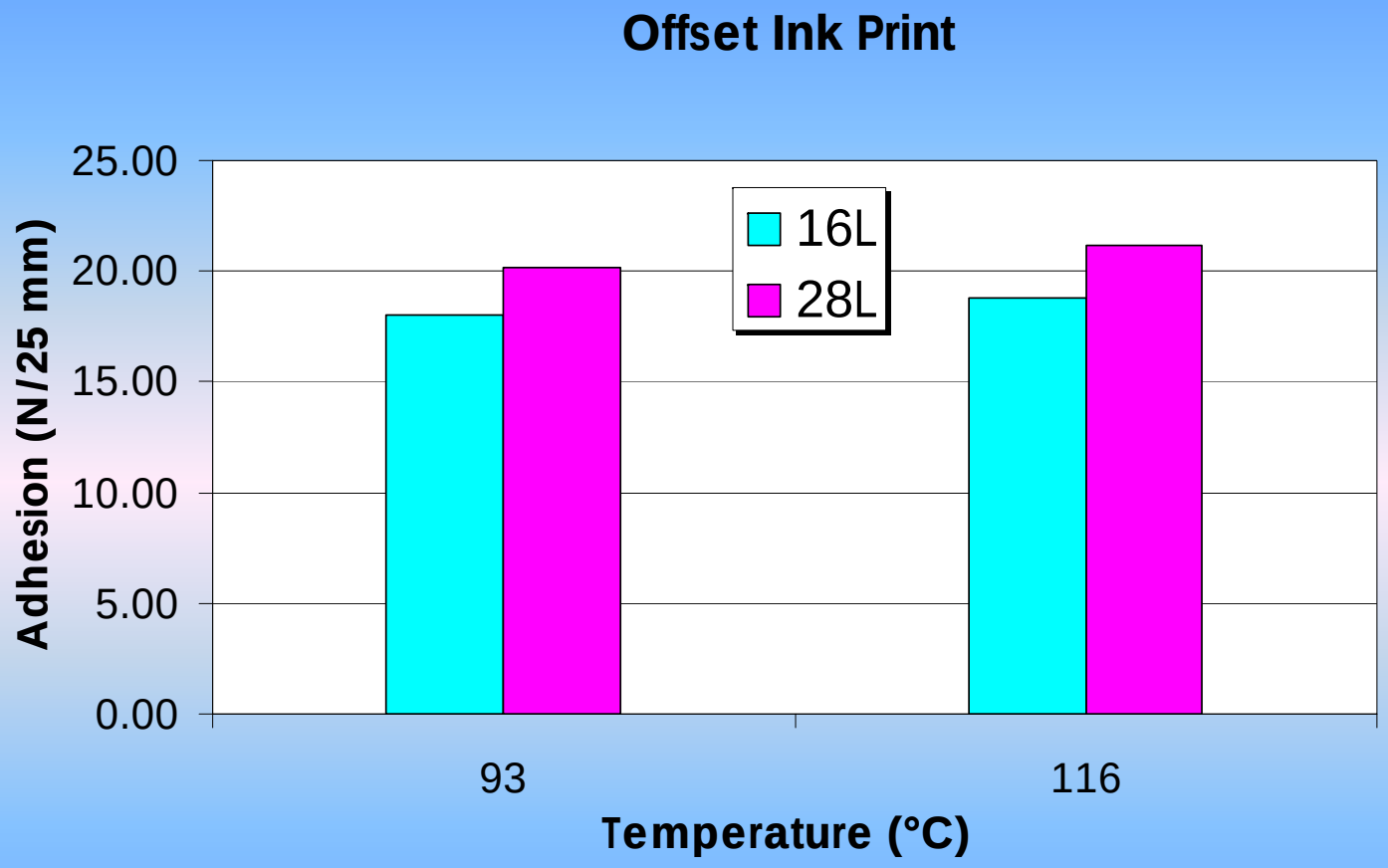
0-5 = poor, 5-10 = fair, 10-15 = good, 15+ = excellent

Results on offset ink



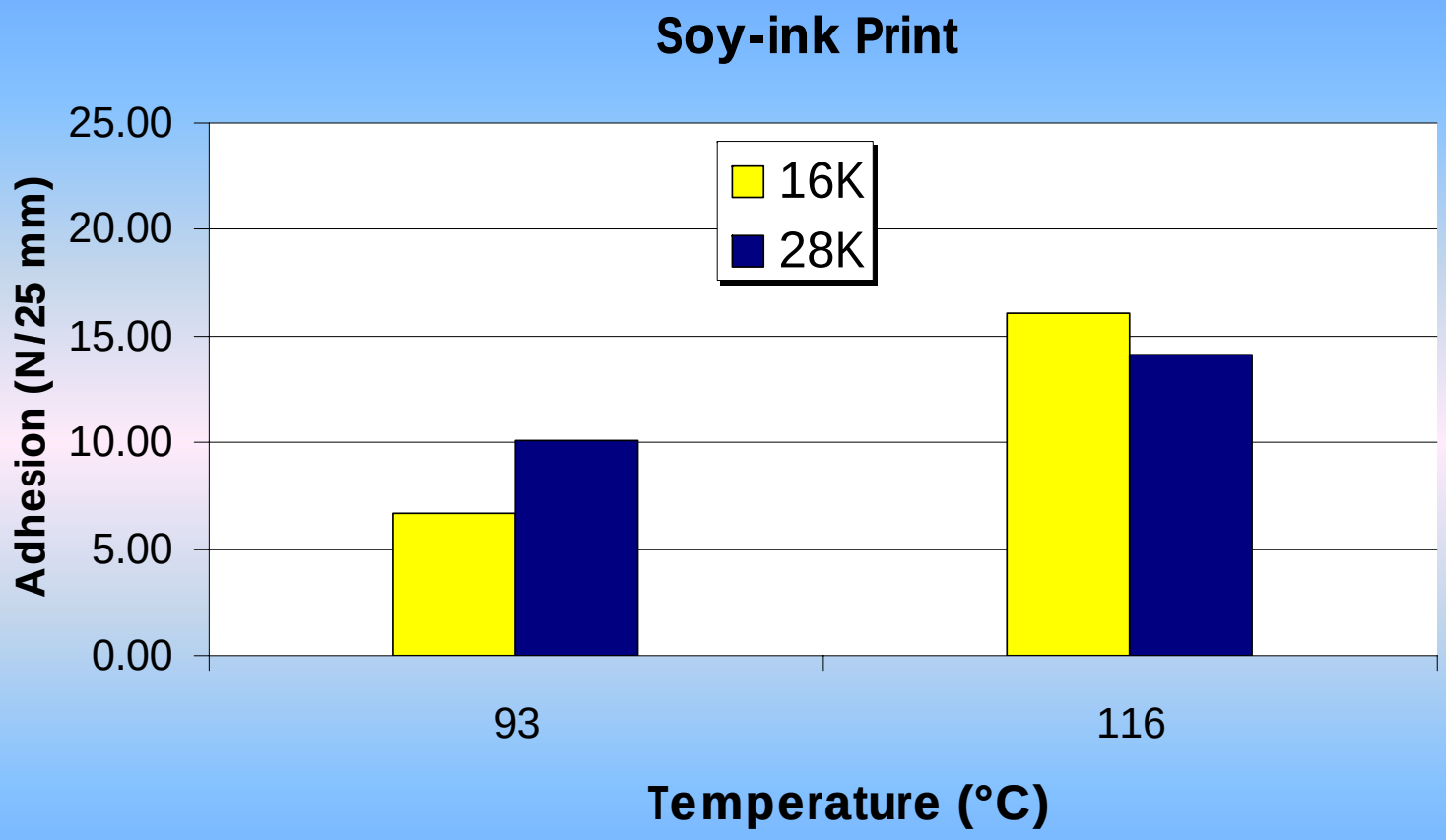
Supplier K Film: 0.25 mm PET/0.5 mm EVA

Results on offset ink



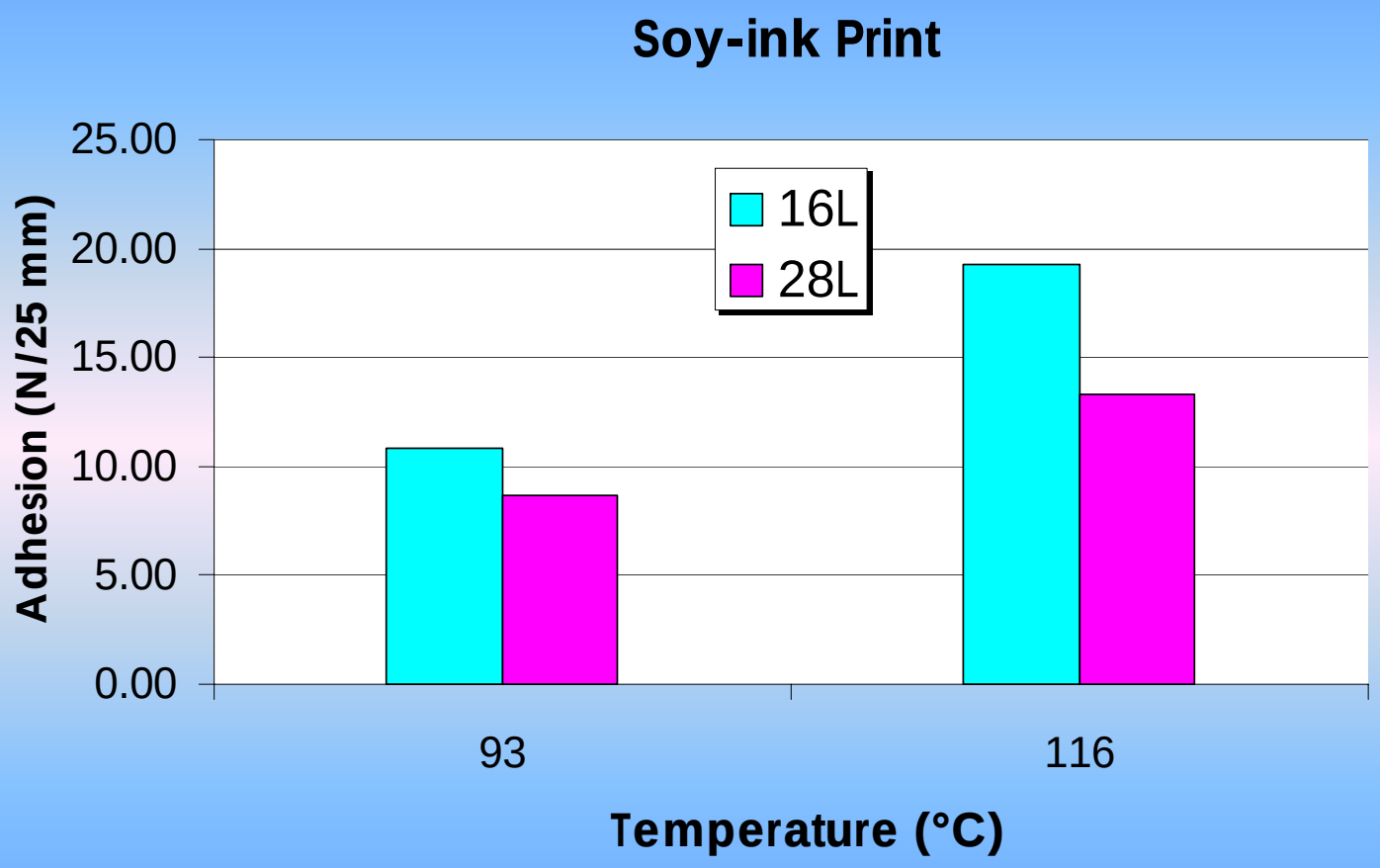
Supplier L Film: 0.25 mm PET/1 mm EVA

Results on soy-based ink



Supplier K Film: 0.25 mm PET/0.5 mm EVA

Results on soy-based ink



Supplier L Film: 0.25 mm PET/1 mm EVA

Processing Guidelines for 28% EVA's

- Extrude 28% EVA's at lower temperature
  - Melt Temp for 16% EVA's typically 225 °C
  - Melt Temp for 28% EVA's recommended at 215 °C
    - To minimize gels after long run times
- Minimize Chill Roll Sticking
  - Heat of melt - Could reduce melt temperature. However, watch for lowered adhesion properties.
  - Temperature of chill roll - Reduce chill roll temperature. Watch for condensation.
  - Efficiency of chill roll - Should use purified water to prevent fouling. Check for fouled water system.

Processing Guidelines for 28% EVA's

- Minimize Chill Roll Sticking
  - Degree of wrap around chill roll - More wrap will allow more cooling. However, if too much wrap around, chill roll water does not have time to recover, and gradually warms up. ("recovery time of chill roll")
  - Angle of pull-off - steeper angle may help
  - Chill roll release agent in resin - Not usually used because of adhesion. Acts like slip agent, and migrates to interface.
  - Overcoat width - Sometimes resin is overcoated beyond edge of substrate film. Reduce if possible.
- Minimize Wound Roll Blocking
  - Careful control of tension
  - Can use lower tension because of higher surface tack

Concluding Remarks

- Difference in melt/softening temperature: 20 °C
- Difference in heat seal activation: 8 °C
  - MI difference may play a role
  - Adhesive thickness plays a role in bond strength
- Optical properties of 28% EVA superior to 16% EVA at 93 °C
  - Just above melt temperature of 16% EVA at 93°C
- Optical properties similar at 115 °C
  - Optical properties depend on quench rate
  - Fast solidification of melt allows less time for crystallization
  - Less crystallinity results in better gloss and lower haze

Concluding Remarks

- Adhesion to offset ink
  - Both 16% EVA and 28% EVA adhesion improves with increasing temperature
  - 28%EVA superior to 16% EVA at each temperature
- Adhesion to soy ink
  - Increasing temperature improved adhesion for each film
  - 16% EVA adheres better at 115 °C
  - 28% EVA adheres better at 93 °C but no advantage over 16% EVA at 115 °C

Contact Information

Stephen Tseng

President of Cahota, Agent for AT Plastics in China

Beijing Office

86-10-58702140/41/42 stephen@cahota.com

Paul Rossignoli

Market Development Manager for AT Plastics

Regional Office in USA

614-873-0688 prossignoli@atplastics.com