This presentation is courtesy of
Non-Woven Adhesives

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ASC Hot Melt Short Course
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Hot Melt Adhesives

- General Hot Melts
  - Applications & Variables
  - HMA Types & Requirements
- Raw Materials
  - Polymers
  - Resins
  - Diluents
- Physical testing of Formulas
Hot Melt Adhesive Definition

- A thermoplastic compound that can bond materials together
- Solid at room temperature & liquid at elevated temperatures
- Applied molten & forms a bond upon cooling to the solid state
What Happens as a Hot Melt Cools?

Time (secs) vs. Temp °C

- LIQUID
- PLASTIC
- SOLID
Why use Hot Melt Adhesives

- Fast setting speed, high production rate
- Short compression time
- More environmental friendly than solvent based adhesives
- Immediate use of product, no drying
Hot Melt Adhesives Functions

- **Wet-out**
  - The adhesive in a liquid phase flows into the substrate - important for adhesion

- **Set-up**
  - After wet-out the HMA solidifies rapidly to gain strength - important for cohesion
HMA Application Variables

- **Application Temperature**: the temperature when the adhesive contacts the primary substrate
- **Add-on Level**: the amount of HMA used
- **Compression**: the force to laminate the substrates
- **Open Time**: the time it takes for the HMA to travel from the application head to the compression zone
Open Time

- Definition: is the time from the nozzle to the compression zone
- It affects the application temperature and the wet-out on the secondary substrate
- Specified by the customer based on each line
Compression

- **Definition:** is the force required to form a lamination between two substrates
- It effects the wet-out on both substrates
- Should be as high as possible
  - "bleed through" issues
Type of Hot Melt Adhesives

- **Elastic**: they require high cohesive strength to hold the elastic strands together under constant stress
- **Construction**: require higher tack to hold a variety of substrates together
- **Multipurpose**: a combination of elastic and construction
- **Positioning**: very good balance between adhesion on specific substrates and transfer resistance
Hot Melt Adhesives Requirements

- **Elastic:**
  - Requires high cohesive strength and moderate adhesion
  - Typically formulated with large amounts of polymer and little plasticizer, usually higher viscosity product

- **Construction:**
  - Requires moderate cohesive strength and excellent adhesion
  - Typically formulated with low amount of polymer and moderate plasticizer, usually lower viscosity product with better cost leverage
Hot Melt Adhesives Requirements

- **Multipurpose:**
  - Requires a balance between cohesion and adhesion
  - Typically formulated with moderate amounts of polymer and moderate plasticizer, a range of viscosity can be achieved

- **Positioning:**
  - Requires excellent adhesion on specific substrates
  - Good balance between adhesion and transfer resistance
  - Typically formulated with specialized raw materials
# Rubber based formulation

<table>
<thead>
<tr>
<th>Raw Material</th>
<th>Quantity</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymer</td>
<td>20-50%</td>
<td>Backbone of adhesive. Provides strength and flexibility</td>
</tr>
<tr>
<td>Resin</td>
<td>25-60%</td>
<td>Provides tack, lowers viscosity, raises Tg and softens</td>
</tr>
<tr>
<td>Oil</td>
<td>10-35%</td>
<td>Reduces viscosity only, processing aid</td>
</tr>
<tr>
<td>Antioxidant</td>
<td>&lt;1%</td>
<td>Heat resistance</td>
</tr>
</tbody>
</table>
Polymer Types

- **Ethylene-vinyl acetate (EVA)**
  - 😊 stability, adhesion, set speed, versatility
  - 😞 Plasticizer resistance, heat resistance

- **Block copolymers (SIS, SBS, rubbers)**
  - 😊 adhesion, flexibility, open time
  - 😞 setting speed (fast - can be a plus), heat stability

- **Olefins**
  - 😊 long open time, good adhesion
  - 😞 stiffness (poor bonding to rigid substrates), compatibility
Properties of EVA based Adhesives

- Good thermal stability and cold resistance
- Wide formulating latitude
- Tend to be stiff and not very elastic
- Good clean application without stringing
Block Copolymers

- **Source**: Hydrocarbons
- **Physical form may be**:
  - Linear di- or tri-blocks
    - Mixtures or only one physical form
  - Branched / Stars
    - Allows formulation of lower viscosity adhesives
    - Higher cost
SBS vs. SIS

At the same molecular weight:
- SBS gives higher viscosity
  - At equivalent molecular weight SBS melt viscosity approximately two times SIS melt viscosity
- SBS provides more stiffness
- SIS gives more tack
- SBS has higher solubility parameter
  - therefore it phase separates more slowly giving a longer open time
Hydrogenation of SBS & SIS

- Hydrogenation of modified SBS → SEBS & SIS → SEPS

- Hydrogenation reduces:
  - entanglement molecular weight
    - decreases elasticity
  - solubility parameter
    - decreases open time

- Hydrogenation increases:
  - Thermal stability
  - Price (approximately x2)
## Properties of SEBS & SEPS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SBS</th>
<th>SIS</th>
<th>SEBS</th>
<th>SEPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Stability</td>
<td>Fair</td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Mid block</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tg</td>
<td>-85</td>
<td>-60</td>
<td>-55</td>
<td>-55</td>
</tr>
<tr>
<td>Solubility Parameter</td>
<td>8.35</td>
<td>8.15</td>
<td>7.75</td>
<td>7.65</td>
</tr>
</tbody>
</table>
Metalloocene Polymerised Olefins

- Exhibit narrow molecular weight distribution
- Broader formulating window
- Allows better control over spraying
- Typically more expensive than conventional olefins
Resins / Tackifiers

- **Natural Sources (trees & paper industry)**
  - Rosin Esters derived from pine tree resins
  - Terpenes formed from orange peel

- **Hydrocarbon base (Oil & gas)**
  - Acyclic and cyclic C5 & C9 hydrocarbons
Rosin Esters

- Used extensively in packaging & IPS applications
  - Skin sensitivity is unclear, so use has been limited in non-woven applications
- Contain high quantities of aromatic compounds providing excellent tack
  - Processing techniques have improved odour and reduced colour. Also raises price and reduces tack
- Good compatibility with all types of HMA
  - Range of softening points available allow formulating latitude
Terpenes

- Extremely good tack and adhesion
  - Typically used for bonding onto difficult plastics which require good heat / cold stability
- Extremely expensive
  - Formed from limonenes which are expensive to extract
  - Not typically price stable
- Strong odour
- Provide formulating latitude
Hydrocarbon Resins

➢ Used extensively in non woven market
  - Good adhesion to both stiff and more flexible substrates

➢ Low odour and colour
  - Key factors in some regions for products used in the hygiene market

➢ Wide formulating latitude
Diluents

- **Plasticizers**
  - Oils
    - Paraffinic & Napthenic
  - Used in rubber and APAO products
    - Low molecular weight liquids
    - Lubricate polymer chains
    - Improve wetting
    - Adjust Tg

- **Waxes**
  - Paraffin, Microcrystalline & Synthetic
  - Used in EVA and APAO products to add crystallinity and offer control of:
    - Rigidity
    - Open time
    - Setting speed
    - Prevent blocking
Adhesive Evaluation & Testing

- Physical Properties
  - Viscosity, tensile strength & softening point
- Thermal Stability
  - Color, viscosity retention
- Rheology
  - Viscoelastic behavior
- End-use Performance Testing
  - Peel Test, Creep Test
Physical testing of HMA

Instron for
- Cohesive strength of adhesive
- Adhesive bond strength
  - Lamination specific
- Shear testing
Physical testing of HMA

➢ Rheology
  - Provides a fingerprint of the adhesive and the neat raw materials
  - Test variables: temperature, frequency and stress
For more information...

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