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Today’s Applications of Hot Melt Adhesives in the Packaging and Converting Markets

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Outline

Introduction
• Raw Material overview
• Critical Adhesive Properties
• Packaging Adhesives
• Graphic Arts Adhesives
• Pressure Sensitive Hot Melts
• Conclusion
Introduction

Hot Melt Adhesive

“a thermoplastic, polymer based adhesive which is applied in the molten state and which functions primarily by mechanical anchorage”
Introduction

Benefits of Hot Melt Adhesives

- Fast Processing
- Environmentally Friendly
- Bond Impervious Surfaces
- Gap-filling
- Safe
- Efficient Shipment and Storage
Introduction

Use of Hot Melts is Growing at 4-5%
Well established in many markets
  Packaging
  Nonwovens
  Graphic Arts
Overtaking solvent based technology
  Tapes and Labels (especially Europe)
  Product Assembly
## Comparison to Other Technologies

<table>
<thead>
<tr>
<th></th>
<th>Hot Melts</th>
<th>Water Based</th>
<th>Solvent Based</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Speed</strong></td>
<td>+++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>Low VOC</strong></td>
<td>+++</td>
<td>+++</td>
<td>-</td>
</tr>
<tr>
<td><strong>Cost Effectiveness</strong></td>
<td>+++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td><strong>Adhesion</strong></td>
<td>++</td>
<td>++</td>
<td>+++</td>
</tr>
</tbody>
</table>
Forms

Pellets
Pillow
Bags
Slats
Cakes
Bricks
drum, pail, and rail car
Some Hot Melt Forms

- Pellets
- Pillow
- Cake/Brick
- Bag
Some Applications

Packaging
Graphic Arts
Nonwovens/Hygiene
Tapes and Labels
Product Assembly
Automotive
Textiles
Equipment

Application Methods
- Nozzle
- Slot Die
- Extrusion
- Wheel
- Screen Printing
- Melt Blown
- Spiral Spray
Equipment

Dispensing

- Drum unloaders
- Pail unloaders
- Melt reservoirs
- Pre-melters
- Vacuum Conveyance
Outline

• Introduction
  ➤ Raw Material overview
• Critical Adhesive Properties
• Packaging Adhesives
• Graphic Arts Adhesives
• Pressure sensitive Hot Melts
• Conclusion
Raw Materials

Knowledge of Raw Materials is Key
- function
- availability
- performance/quality
- cost effectiveness
Raw Materials

Polymer
Tackifying Resins
Wax
Antioxidants
Raw Materials

Role of Polymer

- Controls strength and flexibility
- Heat resistance, shear, impact resistance
- Dictated primarily by polymer type, molecular weight and amount

Polymer Types

- EVA
- Single site catalyzed polyolefins
- EnBA, EMA
- Polyethylene
- Styrene Block Copolymer
- Amorphous Polyolefins
Raw Materials - Polymer Content

- Decreasing
  - Lower Viscosity
- Increasing
  - Higher Viscosity
  - Increase Flexibility
  - Increased Toughness
  - Better Low Temperature Flexibility
Raw Materials

- EVA
  - good flexibility, tensile strength
  - variety of VA contents (14-40%)
  - used in packaging/graphic arts
  - 28% VA is most common
  - compatibility with many waxes
  - compatibility with many tackifying resins
    - rosin derivatives
    - styrenated terpenes
    - terpene phenolics
    - partially hydrogenated hydrocarbons
Raw Materials

Role of Tackifying Resin

• Controls wetting
• Adhesion and tack
• Selection is dictated by softening point, specific adhesion and compatibility with polymer

• Tackifying Resin Types
  • Rosin and Hydrogenated Rosin
  • Rosin Ester
  • C5 and styrenated C5
  • terpene phenolics
  • C9
  • pure monomer (aromatic)
  • hydrogenated hydrocarbon
Raw Materials-
Tackifying Resin Content

Decreasing

• Faster Speed
• Reduced Tack

Increasing

• More Aggressive
• Increased Toughness
Raw Materials

- **Rosin Ester**
  - Glycerol esters (80-85°C Ring & Ball Soft. Pt)
  - Pentaerythritol esters (100-105°C Ring & Ball)
  - Very polar, low acid numbers (3-12)
  - Broad compatibility (SIS, SBS, EVA, EnBA, EMA)
  - Useful for promoting adhesion
  - Can be based on hydrogenated rosin
C 5 and Styrenated C5 Resins
- based on mixed hydrocarbon feedstreams of 5 carbon atoms
- softening points vary from 10°C to 110°C
- aliphatic in character
- residual unsaturation
- compatible with midblock of SIS
- modification with Styrene improves compatibility with SBS and EVA
Raw Materials

• Hydrogenated Hydrocarbon
  • various hydrocarbon feedstreams
    • Dicyclopentadiene (DCPD)
    • aromatic feedstreams (aromatic-> aliphatic)
  • variety of hydrogenation levels
    • low-dark color, higher odor, more polar
    • high-light color, lower odor, more aliphatic
Raw Materials

Role of Wax

- Controls set speed and open time
  - Needs to match production line parameters
- Heat resistance and sub-ambient adhesion
- Dictated primarily by % crystallinity, melt point, and Mw/Mn
- Wax Types
  - paraffin
  - microcrystalline
  - synthetic
  - natural
Raw Materials - Wax Content

Decreasing    Increasing

• Higher Viscosity
• Increased Flexibility
• More Aggressive Bonding

• Lower Viscosity
• Faster Rate of Set
• Less Aggressive Bonding
Raw Materials

- Paraffin Wax
  - highly crystalline
  - low to moderate melt points
  - variety of melt points (100 - 160F)
  - used in packaging and graphic arts
  - allow for good wetting
Raw Materials

• Microcrystalline waxes
  • moderate crystallinity
  • contain some oil
  • variety of melt points and color grades
  • used in packaging
  • provide flexibility
Outline

- Introduction
- Raw Material overview
  ➤ Critical Adhesive Properties
- Packaging Adhesives
- Graphic Arts Adhesives
- Pressure sensitive Hot Melts
- Conclusion
### Critical Adhesive Properties

<table>
<thead>
<tr>
<th>Non-Pressure Sensitive</th>
<th>Pressure Sensitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Viscosity</td>
<td>• Viscosity</td>
</tr>
<tr>
<td>• Color</td>
<td>• Color</td>
</tr>
<tr>
<td>• Peel Adhesion Failure Temperature - Kraft paper (PAFT)</td>
<td>• Mechanical Properties</td>
</tr>
<tr>
<td>• Shear Adhesion Failure Temperature - Kraft paper (SAFT)</td>
<td>• 180° Peel</td>
</tr>
<tr>
<td>• Softening Point (Mettler)</td>
<td>• Loop Tack</td>
</tr>
<tr>
<td>• Substrate Specific Adhesion</td>
<td>• SAFT – Mylar</td>
</tr>
<tr>
<td>• Variety of temperature conditions</td>
<td>• Softening Point (Mettler)</td>
</tr>
<tr>
<td>• Thermal Stability</td>
<td>• Substrate Specific Adhesion</td>
</tr>
<tr>
<td>• Cold Crack</td>
<td>• Variety of temperature conditions</td>
</tr>
</tbody>
</table>
Critical Adhesive Properties

Viscosity

• resistance to flow
• measured at relevant application temperature (250 to 350 °F)
• knowledge of application conditions critical
  • temperature
  • shear rate
• Brookfield Thermosel (low shear)
• Dynamic Mechanical Analysis (low to high shear)
• Capillary Rheometer (high to very high shear)
Critical Adhesive Properties

Molten Color

- Measures color on a numerical scale
- Subjective and quantitative methods
- Several quantitative methods
  - Gardner
  - Saybolt
  - Hunter
  - Yellowness index
Critical Adhesive Properties

Peel Adhesion Failure Temperature (PAFT)

- measures the resistance to deformation in a peel adhesion mode at elevated temperatures
  - temperature ramped from 25 °C at a rate of 25 °C/hr
  - 100 gm weight, 1” x 1”x 0.010” specimen, Kraft paper
  - run in triplicate or more
Shear Adhesion Failure Temperature (SAFT)

- measures the resistance to deformation in a shear mode at an elevated temperature
- temperature ramped from 25 °C at a rate of 25 °C/hr
- 500 gm weight, 1” x 1”x 0.010 “ specimen, Kraft paper
- run in triplicate or more

For Pressure Sensitive HM’s

- Same method except use mylar as substrate
Critical Adhesive Properties

Softening Point

- measure of the temperature adhesive begins to flow
- primarily influenced by melt point of wax or endblock
  Tg of Styrenic Block Copolymer
- Mettler, Ring and Ball methods most popular
METTLER SOFTENING POINT

- Measures the temperature at which the hot melt begins to flow
Critical Adhesive Properties

Substrate Specific Adhesion

- unique to the application of interest
- use actual substrates
- bonds prepared in method to simulate actual production
- test at several different temperatures
  - ambient
  - sub-ambient
  - elevated
- test for bond strength, substrate destruction
Critical Adhesive Properties

Thermal Stability

- used to simulate pot stability of adhesive in melt
- age molten adhesive at typical pot temperature
  - covered
  - uncovered
- determine
  - % viscosity change
  - color change
  - formation of char, edge ring
  - skin, gels
Critical Adhesive Properties

• Cold Crack
  • Resistance to cracking at low temperatures
  • Eva- (45°F down to 15°F), typically about 25°F
  • Rubber based- (30°F down to -10°F)
  • Used predominately in Graphic Arts
    • Measure of how flexible a book spine will be at cold temperatures
COLD CRACK
Critical Adhesive Properties

• Mechanical Properties
  • Ultimate Tensile - This is the maximum force needed to break a dogbone specimen
  • Yield Point - This is the maximum stress a hot melt can withstand before undergoing permanent deformation
  • Elongation at break- This is the distance a given length of sample will stretch before breaking
Critical Adhesive Properties

- Mechanical Properties
  - Young's modulus- This is the ratio of stress over strain at very small stress values
  - Toughness- A combination of high tensile strength and high elongation
  - Flexibility- A combination of low yield point, high elongation and low Young’s modulus
Critical Adhesive Properties

• Loop Tack
  • Measures the aggresiveness of a Pressure Sensitive product
  • Usually measured in ounces
  • Higher force required to pull means product is more aggressive.
  • Can be measured on a variety of surfaces
Loop Tack Testing Equipment
Critical Adhesive Properties

- Peel Testing
  - Measures force required to pull substrate off of a surface when bonded by PSA
  - Usually quantified in pound/in
  - Can be measured at different angles of peel – 180° and 90° are most common.
  - May be measured on a variety of substrates.
Peel Tester Equipment
Packaging Hot Melts

• Applications
  • Case Sealing
    • corrugated
    • waxed board
  • Trayforming
  • Carton Sealing
    • standard bleached sulfate (SBS)
    • fluorocarbon coated
    • film laminated (PP)
  • Heat Seals
  • Container Labeling
Packaging Hot Melts

**Trends in Packaging HMs**
- adhesion versatility
- increased pot life
- lighter color
- lower odor
- lower application temperature
- lower unit cost
  - increased mileage
  - lower maintenance
Packaging Hot Melts

• Case Sealing
  • Typical Requirements
    • Indirect Food Contact Approval CFR 175.105
    • Viscosity <2000 cps, <1000 cps (preferred)
    • Very Fast Set Speed (1-2 seconds compression)
    • High Heat Resistance (PAFT >130°F)
    • Moderate Open Time (2-5 seconds)
Packaging Hot Melts

• Bulk Properties
  • Does formulation adhere to substrate?
  • Does formulation adhere to substrates in the desired temperature conditions?
  • Can the formulation be applied by the equipment that is on the application line?
  • Does formulation have desired heat resistance?
  • Does formulation have the correct open and set times?
  • Does formulation resist thermal degradation adequately?
Case Sealing Line

Compression  Open Time
Waldorf Bond Simulator

- Glue pot
- Compression
- Substrate conveyor
Packaging Hot Melts

• **Select Raw Materials for Optimization**
  • Polymer type(s)
    • MI/viscosity response
  • Tackifying resin type(s)
    • compatibility
    • cost
    • odor
    • softening point
  • Wax type(s)
    • melting point
    • compatibility
Packaging Hot Melt

- Optimized Formula Performance
  - Viscosity @ 350°F: 900 cps
  - Set Speed: 1-2 seconds
  - Open Time: 3-4 seconds
  - PAFT (Kraft): 135°F
  - SAFT (Kraft): 200°F
  - Adhesion to Corrugated (40°F): Fiber Tearing Bond
Heat Seal Application

• The hot melt is pre-applied to a substrate in a web coating process
• The substrate is then mated to another surface, treated with heat and pressure for a dwell time
• The bond is then formed and the container is sealed
Applications for Heat Seal products

- Flexible packaging
  - Lidding
  - Small container sealing
  - Induction seal
  - Wrap around overwraps
  - Blister Packaging
- Carpet Applications
- Automotive Applications
Bottle Labeling Applications

• Adhesive Applied Labels (Semi-PSA or PSA)
  • Roll Fed
    • OPP/PP
    • B&H, Trine Labelers - low viscosity <1000 cps @250F
    • Wrap Around
    • Soft drinks
  • Magazine Fed
    • OPP/PP, Paper
    • Krones Labelers - high viscosity 1200-2500 cps @250 cps
    • Spot Label
    • Soft drinks
Magazine Fed Labeling
Principles of Operation
Roll-Fed Labeling

1.a - Containers enter
1.c - Rotating Starwheel meters containers

4 - Rotating vacuum drum carries glued label
5 - Containers rolled against glued label on drum

3 - Hot-melt adhesive applied to label
2 - Labels cut in precise registration with printed graphic

1.b - Labels supplied in continuous web
6 - Labeled containers exit
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Graphic Arts Hot Melts-
One Shot Bookbinding Adhesives

- Typically EVA-based
- Typically applied at 325 °F to 350 °F
- Demonstrates aggressive bonding
- Performs throughout temperature range of 30 °F to 120 °F
- Fast setting to accommodate rapid line speeds
Graphic Arts Hot Melts - One Shot Hot Melt

- Lay-flat characteristics; The ability or feature, of resistance to snapping shut when released (sometimes referred to as mouse trap index)
- Ink solvent resistance; Solvent from printing ink, when not completely dried can migrate into the hot melt and result in adhesive failure
Graphic Arts Hot Melts-
One Shot Bookbinding Application

Three Wheel Applicator Pot
Graphic Arts Hot Melts -
One Shot Bookbinding Application

Two Wheel Applicator Pot
Graphic Arts Hot Melts-
Two Shot Bookbinding Adhesives

Covering Adhesives

- Demonstrates good adhesion to emulsion primer or hot melt primer
- Demonstrates good adhesion to variety of cover stock materials
- Typically applied at 325 °F to 350 °F
Graphic Arts Hot Melts-
Two Shot Bookbinding Adhesives

Covering Adhesives continued

• Demonstrates aggressive bonding
• Performs throughout temperature range of 20 °F to 130 °F
• Fast setting to accommodate rapid line speeds
Graphic Arts Hot Melts-
OPTIMELT™ Advantages

• Low application temperature hot melt (250 °F to 300 °F)
• Lower VOC’s
• Reduced volatilization of moisture in paper stock resulting in fewer voids
• Less wear on equipment
• Reduced severity of burns
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Different Grades of Hot Melt

- Permanent
- Semi-permanent
- Removable/Repositionable
- Ultra-Removable
- Freezer
Permanent Grade HMPSA

- 180° Peel values above 5#/linear inch.
- Loop Tack values above 4 pounds/in².
- Shear Adhesion Failure Temps above 120°F.
- Both low viscosity and high viscosity versions are available.
Semi-permanent Grade HMPSA

- 180° peel values in the range of 2.5 to 4.0 pounds per linear inch
- Loop tack values in the range of 1 to 3 pounds per square inch
- Shear Adhesion Failure Temps above 130°F
- Both low viscosity and high viscosity versions are available.
Removable/Repositionable Grade HMPSA

• 180° peel values in the range of 1 to 2.5 pounds per linear inch
• Loop Tack values in the range of 0.5 to 3 pounds per square inch
• SAFT values above 140°F
• Both low viscosity and high viscosity versions are available.
Ultra-Removable Grade HMPSA

- 180° Peel values at or below 0.5 #/inch
- Loop Tack values at or below 1 #/in²
- SAFT values above 150°F
- Both low viscosity and high viscosity versions are available.
Freezer Grade HMPSA

- Low Tg
- Tend to have low 180° Peel at or below 3 pounds per linear inch
- Loop Tack values 2 to 4 pounds per square inch
- SAFT values around 130°F
- Viscosity around 5000 cp at 350°F
Tape and Label PSA Hot Melts

• Properties
  • Labeling Products
    • Need to customize for adhesion
    • Make sure product will die cut
    • Wide range of tack levels
  • Tape Products
    • Narrower range of tack than labeling products
    • Specifications on tack level
    • High level of shear resistance
Methods Used For Application

- Slot-die coating
- Roll coating
- Pattern coating
- Spiral spray
- Fiberization
- Screen coating
- Extrusion
Tape and Label PSA Hot Melts

Trends in PSA HMs

- replacement of solvent based PSAs
- higher heat resistance
- improved plasticizer resistance
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➡ Conclusion
Conclusion

• Converting Industry utilizes wide variety of hot melt adhesives
• Hot Melts are mainly non-PSA or PSA
• Adhesive selection is very dependant upon customer needs and production line set up
• Many types of applications and uses for hot melts in the Converting industry
For more information…

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