Designing Novel Olefin Polymers for Hot Melt Adhesive Applications

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Accelerating the movement of new product development from lab concept to commercialization

- Collaboration with value chain partners to understand unmet needs
  - Example: Hygiene nonwoven construction adhesives drivers
    - Lower application temperatures - wider application window
    - Greater mileage – higher peel with less add-on
    - Low odor

- Identify possible technology to meet needs
  - Novel polyolefin technology capable of producing previously unachievable properties
  - Lab scale experiments to identify new technology range

- Screening of candidate polymers to narrow focus
  - Develop lab-scale screening experiments to identify candidates
  - Compatibility testing with additives to determine breadth of component selections for tackifiers, waxes and oils
  - Designed experiments to identify prototype compositions

- Application testing to confirm performance
  - Pilot scale adhesive production, application tests and adhesive performance testing
  - Validation of processing and performance attributes on commercial scale equipment
Moving from concept to candidates

- New polymerization technology greatly expands the achievable product space
- Products with melt viscosities from 1,500 to 18,000 cps at 190 °C are possible
- Screening experiments suggest polymers with low RBSP and needle penetration are optimum for hygiene
- Target polymers have RBSP range of 120-130 °C, hardness of 20-30
- Scale-up 2 new polymers on low and high end of viscosity range for further testing
Tackifier compatibility with new polymers

- Hydrocarbon tackifiers with 2% or less aromaticity are most compatible with the polymers.
- Tackifiers with high molecular weight have reduced compatibility with the new polymers.
- \( T_g \) measurements are based on 1:1 blends of resin and tackifier.
- Basing compatibility on objective characteristics \( T_g \) and composition reduce dependence on subjective tests like cloudiness.
- Highly hydrogenated and fully aliphatic tackifiers are most compatible with the new olefin polymers.
Developing a prototype

- **Range of components**
  - New Polymer 2: 50-75%
  - Tackifier: 25-50%
  - Wax: 0-3%
  - Oil: 0-5%

- **Test for**
  - Minimum spray temperature
  - Spray pattern
  - 24-hr room temp. peel
  - 4-hr 38 °C peel
  - 30-day aged peel

- **Model for maximum peel and minimum spray temperature**
**Analysis of experimental results**

- Runs yielded peel results ranging from 80-160 grams/25 mm
  - Peel results above 120 grams/25 mm are favorable
  - Above 150 grams/25 mm peel substrate failure begins to dominate
  - Several high-peel formulas ran at 140 °C on lab equipment which indicates machinability at lower temperatures on full-speed lines

- Addition of oil to the formula was generally detrimental
  - Addition of even low levels of oil (1-2%) caused 20% loss of adhesion compared with similar formulas with only polymer, tackifier and wax
  - Using oil helped low temperature processing

- Two formulas identified with superior properties
  - 53% new polymer 2, 45% tackifier, 2% Fischer-Tropsch wax
  - 60% new polymer 2, 40% tackifier
  - High polymer content
  - Low tackifier demand
  - Simple formula – 3 components maximum
Confirmation on pilot-scale applicator at 130 °C

38% New polymer 1
45% tackifier
7% wax 10% oil

60% New polymer 2
40% tackifier

B-APO based adhesive

53% New polymer 2
45% tackifier
2% wax

M-PE based adhesive

SBS based adhesive

NO RUN
ADHESIVE NOT MELTED

NO RUN
ADHESIVE NOT MELTED
Spray patterns at 130 °C

- **38% New polymer 1**
  - 45% tackifier
  - 7% wax 10% oil

- **60% New polymer 2**
  - 40% tackifier

- **B-APO based adhesive**
  - NO RUN
  - ADHESIVE NOT MELTED

- **53% New polymer 2**
  - 45% tackifier
  - 2% wax

- **M-PE based adhesive**
  - NO PATTERN
  - NO RUN
  - ADHESIVE NOT MELTED

- **SBS based adhesive**
  - NO RUN
  - ADHESIVE NOT MELTED
# Process window comparison

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**At application Temperatures**

- **SBC based commercial HMA**
- **New Polymer 1 prototype HMA**
- **b-APO based commercial HMA**
- **mPE based commercial HMA**
- **New Polymer 2 prototype HMA**

**Commercial Rubber Based HMA Control**

- Commercial Rubber Based HMA
- Commercial mPE Based HMA
- Commercial b-APO Based HMA
- Aerafin™ 180 based HMA
- Aerafin™ 17 based HMA

**New Polymer**

- New Polymer 1 prototype HMA
- New Polymer 2 prototype HMA

**Summit 4 Hole**

- Summit 4 Hole Continuous
- Summit 4 Hole Intermittent

**Contact Slot**

- Contact Slot Continuous
- Contact Slot Intermittent
Industry standard nozzle (continuous) at 400 m/min and 3 gsm add-on

Peel Strength at 140 °C Application Temperature

- New Polymer 1 based prototype
- New Polymer 2 based prototype
- Commercial mPE based HMA
- Commercial SBC based HMA

Peel Strength at 160 °C Application Temperature

- New Polymer 1 based prototype
- Commercial b-APO based HMA
- New Polymer 2 based prototype
- Commercial mPE based HMA
- Commercial SBC based HMA
Peel Strength for New Polymer 2, Butene-APO and Rubber-based HMAs
Spray Temperature of 150°C
Odor Panel Evaluation
Ranking 1 to 5; 1 being best

- Eastman Aerafin™ 17 Polymer
- mPE
- b-APO
- SEBS
- SIS

Evaluated using multiple observers and blind samples
Eastman new polymer 2 based HMA prototype

- Broad operating window
- Applicator flexibility

- Enables superior peel strength to SBC based:
  - Instantaneous peel strength
  - 24 hour peel strength
  - Body temperature peel strength
  - 2 week aged at elevated temperatures
  - One month aged peel strength

- Continues to offer low odor compared to SBC and B-APO
- 10 months from first lab experiment to pilot trials and customer introduction