Novel PUA Hybrid Chemistry for Elastomeric Roof Coatings

Steven Zhang, Associate Scientist
Dow Chemical Company

Work team: Justin Chen, Steven Zhang, Joe Rokowski, Log Ravisanker
Basics of Elastomeric Roof Coatings

For Sustainable Cool Roofs

- **Key Attributes:**
  - Thick & White
  - UV Resistant
  - Elastic & Tough
  - Water & Dirt Resistant
  - Safe & Easy to Apply
  - Cost Effective
  - Low VOC
Background

- **Project Scope**
  - Develop innovative binder technologies to improve the Dirt Pickup Resistance (DPUR) and water resistance of elastomeric roof coatings

- **Strategic Fit**
  - Align with the market trends in Energy Efficiency for Green Building in emerging market which is related to government regulation development
  - Leverage DCC expertise in elastomeric roof coatings and knowledge of formulation development, and product/customer experience in NAR
  - Enhance Dow’s leading position in ERC application area and meet customer requirements
Market Demand for New ERC Binder

- Not common to claim as reflective coatings due to inferior dirt pickup resistance
- Water resistance is critical
- Cost of new product with improved DPUR and water resistance are expected not to be higher than 30% (Roof Expert) and 25% (other 3 customers)
Preliminary Product Definition

- Water based one pack ERC coating based on new binder technology
- High DPUR from long term durability and lab test
- Improved water-swell performance and ponding resistance
- Good weather aging durability
- Easy to formulate and apply
Typical Chemistry for ERC

Chemistry of ERC for improved DPUR

- BA + MMA + AA
- Flurocarbon
- n-CH3(CH2)11-SH
- Core/shell
- Low Tg
- High Tg
- Hydrophobic / Lotus effect
Polyurethane vs. Acrylic Chemistry

<table>
<thead>
<tr>
<th>Feature</th>
<th>Polyurethane</th>
<th>Acrylic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oligomeric diol soft segments are flexible</td>
<td>• Extensive hydrogen bonding of hard segments result in strong cohesion</td>
<td></td>
</tr>
<tr>
<td>Extensive hydrogen bonding of hard segments result in strong cohesion</td>
<td>• High abrasion resistance, superior toughness</td>
<td></td>
</tr>
<tr>
<td>High abrasion resistance, superior toughness</td>
<td>Solvent and chemical resistance, high cost</td>
<td></td>
</tr>
<tr>
<td>Solvent and chemical resistance, high cost</td>
<td>Linear copolymer emulsion</td>
<td></td>
</tr>
<tr>
<td>Excellent weather resistance, good durability</td>
<td>Affinity to pigments</td>
<td></td>
</tr>
<tr>
<td>Affinity to pigments</td>
<td>Lower cost</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clear Film</th>
<th>Elongation at break, %</th>
<th>Tensile Strength, MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic</td>
<td>700-1000%</td>
<td>1.0-3.0MPa</td>
</tr>
<tr>
<td>Polyurethane</td>
<td>500-1000%</td>
<td>11-40 MPa</td>
</tr>
</tbody>
</table>
New PUA hybrid emulsions demonstrated excellent dirt resistance, water resistance and mechanical performance with relatively high cost.
Clear Film Performance at PU/PA Ratio

- Adjust PU/PA ratio to balance performance and cost
PUA/PA Blend with soft PA

PUA blend with soft PA

**Composition**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PUA1</td>
<td>Crosslinkable PUA</td>
</tr>
<tr>
<td>PA1</td>
<td>Log Tg acrylic emulsion</td>
</tr>
</tbody>
</table>

*Increase crosslinking*
PUA blend with *hard* PA

<table>
<thead>
<tr>
<th>Composition</th>
<th>Tg/C</th>
</tr>
</thead>
<tbody>
<tr>
<td>BZ05-157 High Tg acrylic emulsion</td>
<td>50</td>
</tr>
<tr>
<td>HS01-24 High Tg, crosslinkable acrylic emulsion</td>
<td>50</td>
</tr>
<tr>
<td>PUA8 crosslinkable PUA</td>
<td></td>
</tr>
</tbody>
</table>

- By blending with PUA, the high Tg PA emulsion can form film without using *coalescent*.
- Could probably enhance the flexibility of PA film.
Paint Performance – Dirt Pickup Resistance

SDC exposure
- After 6 months outside exposure in SDC, PUA ERC films pickup less dirt compared with pure acrylic films
- Lab results of PUA ERC films via GB standard showed lower reflectance drop rate compared with control

Outside exposure after 6 months (March - September)
Water Resistance Performance

- Water ponding resistance of PUA_ERC on cement panels, no Blistering or Bubbling was seen.

- Significantly reduced water swelling for PUA at different PVC level.
At high PVC, the elongation drops significantly with normal PUA.
PUA Modified with Acid Monomer

- Significant in elongation
  With acid monomer

- Remain DPUR and water resistance performance
Other Types of Acid Monomers

<table>
<thead>
<tr>
<th></th>
<th>Water Swelling Ratio / %</th>
<th>DPUR / %</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUA</td>
<td>7.93</td>
<td>11.4</td>
</tr>
<tr>
<td>PUA W/ Acid A</td>
<td>5.24</td>
<td>12.2</td>
</tr>
<tr>
<td>PUA W/ Acid B</td>
<td>6.09</td>
<td>14.3</td>
</tr>
</tbody>
</table>

- Process improvement

---

2014 Roof Coatings Manufacturers Association
International Roof Coatings Conference
Mechanism of Crosslinking

Zinc Ammonium Complex

WET STATE

Evaporation of Water and Ammonia

DRY FILM
Outlook

- PUA demonstrated outstanding performance in many performance index than traditional acrylic emulsions;
- A way to mitigate “contradictive effect”
- A big challenge to balance performance-cost
Shanghai Dow Center (SDC)
Acknowledgements

SDC R&D: Yujiang Wang, Shouxue Guo, Tong Sun, Shaoguang Feng

DERC team: Jiadong Zhong
Contact Information

Steven Zhang
Associate Scientist
Dow Chemical
+86 21 38511130
jzhang25a307@dow.com
Questions?