Two Component Polyurethane Adhesives Having Novel Properties

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Content

• Application of two component polyurethane (PU) adhesives for assembling automotive parts a historic prospective

• New requirements and trends for assembling automotive parts in the transportation industry

• Challenges & gaps in current 2K PU technology

• Advantages of new 2K PU adhesive

• Future application & opportunities

• Conclusion & Future direction
Application of Two Component Polyurethane (PU) Adhesives for Assembling Automotive Parts a historic prospective

- **Past history**
  - Mainly used at Original Equipment Suppliers (OES)
  - Sunroof modules
  - For commercial vehicles e.g. wind deflectors, tractor roofs
  - One component PU adhesives preferred by Original Equipment manufacturers (OEM)

- **Today**
  - Breaking into the OEM-Market e.g. Aston Martin, BMW
  - Two component PU adhesives find applications in the trim (assembly shop) shop

- **In the future**
  - OEM and OES market
  - Adhesives with property profiles tailored for the application e.g. G-Modulus, mechanical strength, elongation
  - Full-structural bonding
New Requirements & Trends in the Transportation Industry

- Increased implementation of composites and advanced plastic materials
- Developing technologies for joining dissimilar materials
- Maintaining fast process assembly

- Retention of adhesive material properties over the service temperature range
- Bonding in general assembly
- No external heating necessary for adhesive curing
- Process Simplification - Eliminate or minimize bonding pre-treatments

Two Component PU adhesives can fulfill the requirements
OEM weight savings target of 25% by using composite versus steel

Assembling different construction of materials have a different Coefficient of Linear Thermal Expansion (CLTE)

Due to the broad CLTE, adhesive must have high modulus, high elongation and broad service-life temp properties

Current 2K PU adhesive showed changes of performance over service temperature

<table>
<thead>
<tr>
<th>Substrate</th>
<th>$\alpha$ in $10^{-6}$ K$^{-1}$ at 20°C</th>
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</thead>
<tbody>
<tr>
<td>Steel</td>
<td>13</td>
</tr>
<tr>
<td>Aluminium</td>
<td>23</td>
</tr>
<tr>
<td>Polyamide</td>
<td>120</td>
</tr>
<tr>
<td>Polyester</td>
<td>80</td>
</tr>
<tr>
<td>Polyester glass fiber in fiber direction</td>
<td>12</td>
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</tbody>
</table>

Unmet Need:
Improve and optimize 2K PU adhesive properties
Advantages of new 2K PU Adhesives

- BETAMATE™ 7000/7050
- BETAMATE™ 7020/7080
- BETAFAORCE™ 9050
- BETAMATE™ 2810
- BETAFAORCE™ 2850

- Increased Modulus/Strength
- Increased Elongation
- Reduced Elongation

New Technology

BETAMATE™ & BETAFORCE™ are Trade Mark of Dow Automotive Systems
Key value proposition for new 2K PU adhesive for composite bonding!

Shear Modulus vs. Temperature

G-Modulus ratio
0°C / 100°C
BM 7014/7064 = 377
BF 7020/7080 = 19.8
BF 2850 = 3.72

New BETAFORCE Technology
Advantages of new 2K PU Adhesives

- **Ultra Fast Curing**
  - 1 MPa after < 60 Sec. (with acceleration)

- **Excellent temperature stability behavior**
  - No significant drop of modulus/ strength
    (-45°C up to + 80 °C)

- **Broad range of mechanical properties**
  - Lap-shear Strength ~ 10 – 28 MPa
  - Elongation 10 - 250 %
  - G-Modul 9 – 400 MPa
  - Open Time 3 – 30 min.

- **Combination of high modulus and high elongation**
- **Mixing ratio 1:1 by volume**
- **Very good bead stability during application**
- **Composites:** CFRP, GFRP, SMC, BMC, PP GF, PP TF, Coated steel, coated Aluminum

**Dow has the ability to Tailor adhesive properties !**
Automotive Lightweight Activities

- First introduced in September 2008
- Bonded in General Assembly
- Reduce mass by 15.4 lbs & lower center of gravity
- Fast cure (50 second cycle time) through induction heating
- Enables change in roof materials for future models

ATZ magazine, Germany

BMW 7-Series General Assembly Roof Bonding
Bonded Lightweight Application Examples

Plastic Hatchback
OEM: Daimler, A-Class
Tier: Peguform

Polycarbonate Panorama roof
OEM: Daimler, smart
Tier: Webasto

Plastic Hatchback
OEM: Daimler, C-Class
Tier: Plastal/ Polytec

Aluminium Roof Module
OEM: BMW, 7.Series

Composite-Crane Cabin
OEM: Liebherr
Tier: CF Maier

Composite Driver cabin
OEM: Daimler, Unimog
Tier: Sortira/ ACE

Target: Weight reduction, design freedom
Conclusions and Future direction

• Due to the unique mechanical properties and excellent service life temperature properties this new two component PU adhesive opens new field of broad applications in the automotive and transportation industry.

• This improved adhesive technology allows tailored properties in a short period of time.

• The automotive & transportation industry will continue to strive for lightweight vehicles and this creates new application for two component PU adhesives.
Back up Slides
<table>
<thead>
<tr>
<th></th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td><strong>One Component</strong></td>
<td>- Simple process</td>
<td>- Curing depends on moisture diffusion &amp; temperature</td>
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<td>- Reliable application</td>
<td>- Cure can not sufficiently accelerate</td>
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<td>- Only one material</td>
<td>- Low handling strength in short time</td>
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<td>- No static or dynamic mixing</td>
<td>- Curing from outside to the inside</td>
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<td><strong>Two Component</strong></td>
<td>- Property profile adjusted – freedom of design</td>
<td>- Two Materials (Components)</td>
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<tr>
<td></td>
<td>- Higher mechanical properties</td>
<td>- Curing independant on moisture diffusion</td>
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<tr>
<td></td>
<td>- Faster curing</td>
<td>- More complicated application</td>
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<tr>
<td></td>
<td>- Higher handling strength</td>
<td>- Mixing ratio must be corrected</td>
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<tr>
<td></td>
<td>- Cures simultaneously</td>
<td>- Mixing quality must be guaranteed</td>
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Automotive Lightweight Activities

- Various US, European & Asian automotive OEMs are assembling bonded Aluminum roof

- Automotive OEMs are focused on reduced vehicle weight to improve fuel efficiency by using new lightweight hybrid substrates mix

- European automotive OEMs are investigating painted FRP roof assemblies

- Electric powered vehicle focus using bonding lightweight composite material structure with 2K PU adhesive

- OEMs plan to bond plastic based lift gate for lightweight purposes