Innovations and Applications of New Hybrid Adhesives

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Agenda

1. Cyanoacrylate Adhesives
2. Epoxy Adhesives
3. Hybrid Structural Instant Adhesives
4. Conclusion
Cyanoacrylate Adhesives
Instant Adhesives (CA)

- Usually one-component products
- Recently two-component products were developed and commercialized
- Cyanoacrylate rapidly polymerizes at room temperature to form a rigid thermoplastic material
Cyanoacrylate Adhesives
Benefits and Limitations

- **Benefits**
  - Fixture time in seconds, full cure in 24 hours
  - Excellent adhesion to most substrates
    - Metals, plastics, elastomers, porous substrates
  - Wide range of viscosities of products to choose from
  - Excellent bond strength in shear and tensile mode

- **Limitations**
  - Gap filling capabilities (< 0.25 mm)
  - Brittle, low impact strength
  - Poor resistance to polar solvents
  - Blooming
Epoxy Adhesives
Structural Adhesives

- One or two-part structural adhesives that cure at room temperature
  - Two-part epoxy systems
  - Copolymer – formed by resin and hardener
  - Polymerize when mixed together
  - Forms thermoset polymers
- One-part epoxy
  - Pre-mixes that utilize a heat cure
Epoxy Adhesives
Benefits and Limitations

- **Benefits**
  - Structural bonder
  - High cohesive strength and toughness
  - Good heat and environmental resistance
  - Excellent depth of cure, can fill large gaps

- **Limitations**
  - Long fixture time
  - Low bond strength on some plastics and elastomers
Benefits and Limitations of Cyanoacrylate and Epoxy Adhesives

Benefits of Cyanoacrylates
- Fixture time in seconds, full cure in 24 hours
- Excellent adhesion to most substrates
  - Metals, plastics, elastomers, porous substrates
- Wide range of viscosities of products to choose from
- Excellent bond strength in shear and tensile mode

Limitations of Epoxies
- Long fixture times
- Low bond strength on some plastics and elastomers
Benefits and Limitations of Cyanoacrylate and Epoxy Adhesives

Benefits of Epoxies
- Structural bonder
- High cohesive strength and toughness
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Limitations of Cyanoacrylates
- Gap filling capabilities (>0.25 mm)
- Brittle, low impact strength
- Poor resistance to polar solvents
- Blooming
Hybrid Structural Instant Adhesives

- Cyanoacrylate-epoxy hybrid adhesives
- Highest combination of critical attributes in one product
- First instant adhesive suitable for structural applications
- Opens new application areas
Hybrid Structural Instant Adhesives
Features and Properties

- Bond various substrates
- Fast fixture time
- Impact resistant
- High temperature resistance
- Moisture and chemical resistance
- Excellent gap-fill property
- Flexible
Lap shears of steel or aluminum or polycarbonate were bonded and fully cured at room temperature.

The lap shears were pulled apart at room temperature to measure the shear strength.
## Hybrid Structural Instant Adhesives

### Speed And Gap Filling Capabilities

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Cyanoacrylate Epoxy Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero Gap Fixture Time</td>
<td>60 - 90 seconds</td>
</tr>
<tr>
<td>Gap Fixture Time</td>
<td></td>
</tr>
<tr>
<td>1 mm</td>
<td>3 - 7 minutes</td>
</tr>
<tr>
<td>2 mm</td>
<td></td>
</tr>
<tr>
<td>5 mm</td>
<td></td>
</tr>
</tbody>
</table>

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Innovations and Applications of New Hybrid Adhesives
Elongation, at break, ISO 527-3

- Cyanoacrylate/Epoxy Hybrid: 60%
- Typical CA Product: 0%
**Typical Performance of Cured Material**
Cured for 168 hours @ 22 °C **Shear Strength**, Lap Shear Strength, ISO 4587

<table>
<thead>
<tr>
<th>Material</th>
<th>Shear Strength (N/mm²)</th>
<th>(psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel (grit blasted)</td>
<td>17</td>
<td>(2,420)</td>
</tr>
<tr>
<td>Aluminum</td>
<td>7.6</td>
<td>(1,100)</td>
</tr>
<tr>
<td>Aluminum (etched)</td>
<td>13</td>
<td>(1,900)</td>
</tr>
<tr>
<td>Zinc dichromate</td>
<td>9.1</td>
<td>(1,320)</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>15</td>
<td>(2,120)</td>
</tr>
<tr>
<td>ABS</td>
<td>5.2</td>
<td>(750)</td>
</tr>
<tr>
<td>Phenolic</td>
<td>3.2</td>
<td>(480)</td>
</tr>
<tr>
<td>Polycarbonate</td>
<td>6.9</td>
<td>(1,000)</td>
</tr>
<tr>
<td>Nitrile</td>
<td>0.7</td>
<td>(100)</td>
</tr>
<tr>
<td>Wood (cak)</td>
<td>4.8</td>
<td>(700)</td>
</tr>
<tr>
<td>Epoxy</td>
<td>9.1</td>
<td>(1,320)</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>0.5</td>
<td>(72)</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>0.6</td>
<td>(87)</td>
</tr>
</tbody>
</table>

**Materials:**
- Aluminum
- Rubber
- Steel
- Abs
- Polycarbonate
- Acrylic
Hybrid Structural Instant Adhesives
Impact Resistance

- Lap shears of mild steel or aluminum were bonded and fully cured at room temperature.
- Then lap shears were tested on a impact resistance tester at room temperature to measure the side impact resistance.
Lap shears of Grit-Blasted Mild Steel (GBMS) were bonded and fully cured at room temperature. Then they were exposed to 120, 150 and 180°C for 1000 hours. Lap shears were pulled apart at room temperature to measure the shear strength.
Lap shears of Grit-Blasted Mild Steel (GBMS) were bonded and fully cured at room temperature. Then they were immersed in boiling water for the time indicated. Lap shears were pulled apart at room temperature to measure the shear strength.
Lap shears of Grit-Blasted Mild Steel (GBMS) were bonded and fully cured at room temperature. Then exposed to 65°C and 95% relative humidity for times shown. Lap shears were pulled apart at room temperature. The % retention is shown.
Hybrid Structural Instant Adhesives
Chemical and Solvent Resistance

Chemical/Solvent Resistance

<table>
<thead>
<tr>
<th>Environment</th>
<th>°C</th>
<th>100 h</th>
<th>500 h</th>
<th>1000 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>22</td>
<td>90</td>
<td>75</td>
<td>70</td>
</tr>
<tr>
<td>Water</td>
<td>60</td>
<td>80</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Motor oil</td>
<td>40</td>
<td>120</td>
<td>130</td>
<td>130</td>
</tr>
<tr>
<td>Unleaded gasoline</td>
<td>22</td>
<td>95</td>
<td>100</td>
<td>105</td>
</tr>
<tr>
<td>Ethanol</td>
<td>22</td>
<td>85</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Isopropanol</td>
<td>22</td>
<td>100</td>
<td>100</td>
<td>95</td>
</tr>
<tr>
<td>Water/glycol 50/50</td>
<td>87</td>
<td>50</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>98% RH</td>
<td>40</td>
<td>85</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>95% RH</td>
<td>65</td>
<td>95</td>
<td>85</td>
<td>65</td>
</tr>
</tbody>
</table>

- Lap shears of Grit-Blasted Mild Steel (GBMS) were bonded and fully cured at room temperature.
- Then they were aged under conditions indicated shown above.
- Lap shears were pulled apart at room temperature. The % of initial strength is shown...
Hybrid Structural Instant Adhesives
Uses and Applications

- Where the combination of **speed, toughness, moisture resistance** and **gap filling** is required
- Where outdoor use, **UV protection** and **low blooming** is required
- Where standard cyanoacrylates prove to be too brittle
- Where high moisture and temperature **resistance is demanded**
- For structural applications **demanding speed, ease of use** and **bonding of multiple substrates** including **plastics**
Conclusion

- New hybrid structural instant adhesives were developed
- New hybrid adhesives combined benefits of both cyanoacrylate and epoxy adhesives
  - Bond a variety of substrates
  - Fast fixture time
  - Impact resistant
  - High temperature resistance
  - Moisture and chemical resistance
  - Excellent gap-fill property
  - Flexible
Thank you!