Capa® polycaprolactone polyols
For high performance
2K waterborne PU coatings

Version 1 – March 2010
What are Capa® caprolactones?

We offer 3 product lines:

- **Capa® monomer**
  - One grade
  - 99.9% purity

- **Capa® polyols**
  - Di, tri, tetra-functional polyols
  - 300 – 8000 g/mol

- **Capa® thermoplastics (TP)**
  - 10 000 – 80 000 g/mol
Main applications of Capa® caprolactones

- Capa® monomer
  - Resin modifications

- Capa® polyols
  - Coating resins and coating formulations
  - Cast elastomers
  - TPU and adhesives

- Capa® thermoplastics (TP)
  - Toe puffs & counters
  - Biodegradable packaging
  - Hot-melt adhesives ...
Benefits of Capa® polyols in 2K waterborne PU formulations

- 100% solids, low viscosity polyols, liquid at room temperature
  ⇒ easy to mix as such in a selection of acrylic polyols emulsions
  ⇒ positive impact on VOC

- Capa® polyols are aliphatic polyesters
  ⇒ excellent resistance to oxidative and UV attacks

- Highly transparent materials, with excellent optical properties
  ⇒ positive impact on film appearance (higher gloss, lower haze)

- Flexibility/toughness particularly at low temperatures
  ⇒ outstanding impact resistance
  ⇒ best-in-class for abrasion resistance
Capa® polyols in 2K waterborne PU formulations: principle

- Capa® polyols are essentially hydrophobic and their hydrophobic character increases with increasing molecular weight.

- Introduction into water is hence limited due to the surface tension between Capa® polyol and the aqueous phase, leading with increasing volume fraction to a coarse particle size distribution of Capa®.

- Surfactants coming from the acrylic polyol emulsion reduce the surface tension between the two immiscible phases, helping to emulsify the Capa® polyol as fine droplets into the waterborne formulation.
Easy mixing with acrylic polyol emulsion, keeping very narrow particle size

Blends of Setaqua 6516 (Nuplex) + Capa 3050

A fair amount of Capa® 3050 can be easily introduced into the acrylic polyol emulsion, without any impact on the particle size distribution.
Addition of Capa® leads to a VOC reduction of the ready-to-use 2K PU coating

Clearcoat formulation based on Setaqua 6516 (Nuplex) + 3 different Capa polyols, crosslinked with Easaqua X D 401 at NCO/OH = 1.2
Viscosity : 25 s DIN 4

Replacement of some acrylic polyol emulsion by Capa® leads to a VOC reduction of the formulation up to 10%
Addition of Capa® quantity needs to be adjusted depending on drying time required.

Drying time: T1

Clearcoat formulation based on Setaqua 6516 (Nuplex) + 3 different Capa polyols, crosslinked with Easaqua X D 401 at NCO/OH = 1.2
Viscosity: 25 s DIN 4

Replacement of 8% of the acrylic polyol emulsion by Capa® 3050 has limited influence on the drying time of the coating.
Addition of Capa® improves the film appearance.

The three Capa® grades tested all lead to higher gloss and lower haze.

Drying: 30' @ 60°C
Addition of Capa® improves the scratch resistance of the coating

The three Capa® grades tested all lead to a better resistance towards permanent scratches (up to 50% improvement with Capa® 4101)
Addition of Capa® improves the coating flexibility

Reverse impact resistance (ASTM)

<table>
<thead>
<tr>
<th>% Capa® / total resins</th>
<th>0%</th>
<th>8%</th>
<th>13%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capa 3031</td>
<td></td>
<td>60</td>
<td></td>
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<tr>
<td>Capa 3050</td>
<td></td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Capa 4101</td>
<td></td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>

Drying: 30' @ 60°C

Addition of Capa® tremendously improves the impact resistance of the coating
Conclusion

➢ Capa® liquid triols and tetrol can be easily added in acrylic polyol emulsions to prepare 2K waterborne PU coatings, leading to the following benefits

➢ Lower VOC

➢ Better film appearance:
  – Higher gloss level
  – Significantly improved haze
  – Good leveling

➢ Better mechanical properties:
  – Best-in-class scratch resistance
  – Tremendous improved impact resistance
Thank you for your attention
Typical CAPA® Diol Structure

Neo Initiated Capa Polyol
Typical CAPA® Triol Structure
Typical CAPA® Tetrol

\[
\begin{align*}
&\text{H} - \overset{\text{O}}{\text{O}} - (\text{H}_2\text{C})_5 - \overset{\text{O}}{\text{O}} - \overset{\text{O}}{\text{O}} - (\text{H}_2\text{C})_5 - \overset{\text{O}}{\text{O}} - H \\
&\text{H} - \overset{\text{O}}{\text{O}} - (\text{H}_2\text{C})_5 - \overset{\text{O}}{\text{O}} - \overset{\text{O}}{\text{O}} - (\text{CH}_2)_5 - \overset{\text{O}}{\text{O}} - H
\end{align*}
\]
# Characteristics of Capa® grades used in the study

<table>
<thead>
<tr>
<th>Grade</th>
<th>Type</th>
<th>Initiator</th>
<th>Mw</th>
<th>OH %</th>
<th>Viscosity at 23°C (mPa.s)</th>
<th>Acid value (mg KOH/g)</th>
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<tbody>
<tr>
<td>Capa® 3031</td>
<td>Triol</td>
<td>TMP</td>
<td>300</td>
<td>17.0%</td>
<td>1320</td>
<td>&lt; 1.0</td>
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<tr>
<td>Capa® 3050</td>
<td>Triol</td>
<td>TMP</td>
<td>540</td>
<td>9.4%</td>
<td>1190</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>Capa® 4101</td>
<td>Tetrol</td>
<td>Penta</td>
<td>1000</td>
<td>6.6%</td>
<td>1850</td>
<td>&lt; 1.0</td>
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</table>
# Coating formulations

<table>
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<tr>
<th>Product</th>
<th>100/0</th>
<th>92/8</th>
<th>92/8</th>
<th>92/8</th>
<th>87/13</th>
<th>87/13</th>
<th>Function</th>
</tr>
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<tbody>
<tr>
<td>Setaqua 6516</td>
<td>86.10</td>
<td>79.21</td>
<td>79.21</td>
<td>79.21</td>
<td>74.90</td>
<td>74.90</td>
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<td></td>
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<td>Polycaprolactone</td>
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<td>Capa 3050</td>
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<td></td>
<td>6.89</td>
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<td>Capa 4101</td>
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<td>BYK 028</td>
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<td>0.45</td>
<td>0.45</td>
<td>Defoamer</td>
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<td>BYK 346</td>
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<td>0.45</td>
<td>0.45</td>
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<td>Polycaprolactone</td>
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<td>Water (demin.)</td>
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<td>13.00</td>
<td>13.00</td>
<td>13.00</td>
<td>13.00</td>
<td>13.00</td>
<td>Wetting agent</td>
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<td>100</td>
<td>100</td>
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<td></td>
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<tr>
<td>Easaqua X D 401</td>
<td>22.62</td>
<td>42.74</td>
<td>32.95</td>
<td>31.79</td>
<td>55.33</td>
<td>39.41</td>
<td>Isocyanate cross-linker</td>
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<td>BGA</td>
<td>1.41</td>
<td>2.67</td>
<td>2.06</td>
<td>1.99</td>
<td>3.46</td>
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<td>Solvent</td>
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<table>
<thead>
<tr>
<th>Function</th>
<th>100/0</th>
<th>92/8</th>
<th>92/8</th>
<th>92/8</th>
<th>87/13</th>
<th>87/13</th>
<th>87/13</th>
</tr>
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<tbody>
<tr>
<td>Solids content</td>
<td>42.1%</td>
<td>44.4%</td>
<td>43.1%</td>
<td>43.5%</td>
<td>45.2%</td>
<td>44.6%</td>
<td>44.3%</td>
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<tr>
<td>VOC</td>
<td>128.8 g/l</td>
<td>125.0 g/l</td>
<td>121.7 g/l</td>
<td>121.3 g/l</td>
<td>123.8 g/l</td>
<td>118.9 g/l</td>
<td>116.0 g/l</td>
</tr>
<tr>
<td>NCO/OH</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Water (demin.) dilute to 25 s DIN4
Method: Scratch resistance

- Equipment: Taber Scratch Tester
- Principle: the coating is scratched by the indenter with a progressive increased load
- Evaluation by observation of the trace left by the indenter on the film:
  - No scratch observed: Elastic deformation of the film
  - Smooth scratch: Plastic deformation of the film which recovers by a slow reflow at temperature higher than Tg
  - If the scratch shows fractures or if the film is destroyed: Fracture deformation of the film which remains even after slow reflow at T > Tg
- Measured: Critical load for plastic/fracture transition