Acrodur® Natural Fiber Composites
New opportunities with thermoplastic binder

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BASF Corp., Dispersions and Pigments
11 Sep, 2015
Overview

- What is Acrodur®
- Established Types of Acrodur®: **Thermoset** (Duroplastic)
- New grades of Acrodur®: **Thermoplastic**
- Processing
- Advantages in performance
- Summary
What is Acrodur®?

- Fiber bonding technology with the capability to:
  - Produce Durable Composites with **rigidity / stiffness** advantages
    - **Lightweighting** at comparable performance, up to 40% (vs. ABS)
      — or —
    - **Higher performance** at the same weight
  - With high **thermo-mechanical stability** (up to 220 degree C)
  - Enabling **high share of renewable** content (75-85%)
  - At **minimized emission** (FOG, VOC)
  - Creating **new design** opportunities
What is Acrodur®?

- Acrodur is chemistry designed as a binder for fibrous composites including:
  - Natural Fibers:
    - Bast type fibers (Hemp, Jute, Kenaf, Flax, Sisal)
    - Cotton fibers: Shoddy, recycled Denim
    - Grass fibers like Bamboo
    - Wood fibers
  - Synthetic fibers: Glass, PET
  - Carbon Fibers
  - Hybrids
Established binder grades: Thermoset

Solutions & Dispersions
Two versions, dissolved in water

Polyester
Polycarboxylic acid + Polyalcohol
Grades 950L, 3530 (Solutions).

Latex-modified polyester
Polycarboxylic acid, modified with a latex component + Polyalcohol
Grades 3515, 3558 (Dispersions).
Established grades: Thermoset Processing

Applications – Fiber Mat Impregnation

Thermosetting - Crosslinking into cured state (irreversible)
# New Grades: Thermoplastic

## Thermoset binders

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Tg [°C]</th>
<th>Solids [%]</th>
<th>pH value</th>
<th>Viscosity [mPas-s]</th>
<th>Low VOC</th>
<th>FA free</th>
<th>Long Shelf Life</th>
<th>Product key properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrodur 950 L</td>
<td>-</td>
<td>50</td>
<td>~3.5</td>
<td>~1300²</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>Hard, brittle</td>
</tr>
<tr>
<td>Acrodur DS 3530</td>
<td>-</td>
<td>50</td>
<td>~3.5</td>
<td>~225²</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>Hard, brittle</td>
</tr>
<tr>
<td>Acrodur DS 3558</td>
<td>25¹</td>
<td>50</td>
<td>~3.5</td>
<td>~900</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>Hard, visco-plastic</td>
</tr>
<tr>
<td>Acrodur DS 3515</td>
<td>90¹</td>
<td>50</td>
<td>~3.5</td>
<td>~550</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>Hard, visco-plastic</td>
</tr>
</tbody>
</table>

All our thermoset binders are suitable for both wood fibers (blow line impregnation) as well as bast fibers (Foulard impregnation). Resulting prepregs provide a high B-stage stability. Flame retardants and pigments can easily added to the binders.

## Thermoplastic binders

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Tg [°C]</th>
<th>Solids [%]</th>
<th>pH value</th>
<th>Viscosity [mPas-s]</th>
<th>Low VOC</th>
<th>FA free</th>
<th>Long Shelf Life</th>
<th>Product key properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrodur Power 2750</td>
<td>100</td>
<td>50</td>
<td>~3.5</td>
<td>~200</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>Hard, visco-plastic</td>
</tr>
<tr>
<td>Acrodur Power 4444</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thermoplastic binder is suitable for bast fibers (Foulard impregnation). Resulting prepregs provide a high storage stability and allow thermoplastic processing. Flame retardants and pigments can easily added to the binder.
Types of Processing: Thermoset

**Raw materials**
- Bast fibers
- Wood fibers
- Acrodur

**Processing**
- Hot Press

**Composites**
- Established process
- Outstanding thermo-mechanical stability

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BASF
We create chemistry

150 years
Types of Processing: Thermoplastic

Raw materials
- Bast fibers + Acrodur
- Wood fibers + Acrodur

Processing
- Pre Heat
- Cold Press

Composites
- Fits in established cold mould process
- High thermo-mechanical stability
Types of Processing: Future Combined Compression and Back Injection Molding

**Raw materials**
- Bast fibers
- Wood fibers
- Acrodur

**Processing**
- Prepreg
- Thermoplast

**Composites**
- Efficient process of back injection moulding
- Increased light weight potential
- High thermo-mechanical stability
Types of Processing: Comparison and Options

<table>
<thead>
<tr>
<th>Thermoset Composites</th>
<th>Thermoplastic Composites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>Type 1</td>
</tr>
<tr>
<td>Hot Press</td>
<td>Hot Press</td>
</tr>
<tr>
<td>Type 2</td>
<td>Type 2</td>
</tr>
<tr>
<td>Pre Heat</td>
<td>Pre Heat</td>
</tr>
<tr>
<td></td>
<td>Type 3</td>
</tr>
<tr>
<td></td>
<td>Pre Heat</td>
</tr>
</tbody>
</table>

Solution / Dispersion Grades

New Thermoplastic Grades
Advantages of Acrylic Binders vs. PP

- Weight reduction
- Lower Binder Content
- Higher Fiber Reinforcement
- Versatility
  - Processing
  - Nonwoven Construction
- Additive Options
  - Flame Retardants
  - Pigmentation
  - Other additives, easily applied
## Acrylic NF Composites vs. NF/PP: Flexural Bend Test

<table>
<thead>
<tr>
<th>Sample</th>
<th>Density (g/L)</th>
<th>Area Weight (gsm)</th>
<th>Modulus (MPa)</th>
<th>Spec. Modulus (MPa/(g/L))</th>
<th>Stiffness (N/mm)</th>
<th>Strength (MPa)</th>
<th>Peak Load (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NF/PP</strong></td>
<td>854</td>
<td>1454</td>
<td>4127</td>
<td>4.8</td>
<td>4.1</td>
<td>37</td>
<td>36</td>
</tr>
<tr>
<td><strong>Thermoplastic Acrodur</strong></td>
<td>814</td>
<td>1366</td>
<td>5164</td>
<td>6.3</td>
<td>4.9</td>
<td>44</td>
<td>42</td>
</tr>
</tbody>
</table>

**Notes:**

- **Flexural Testing Conditions:**
  - Specimen Width = 50mm
  - Span = 100 mm
  - Crosshead Speed = 50mm/min

- Mean of Selected Parameters (n=10, 5 machine direction, 5 cross direction)
- Samples were conditioned for 3 days at 25 C and 50 % RH
- NF/PP fibers in 50/50wt ratio
- Fibers for Acrodur were 70/30 wt ratio NF/PET @ ~1000gsm (from same supplier as NF/PP)

**Note:** This is with 70% NF/30% PET and performance improvement can increase with higher NF content
Acrylic NF Composites vs. NF/PP: Specific Modulus

Natural Fiber Composites: Binders

Acrylic binder shows 30% or more increased specific modulus
Acrylic NF Composites vs. NF/PP: Flex Strength

Acrylic binder shows 20% or more increased flex strength
Acrodur® Composites: Summary

• New grades allow for various processing options: Thermoset, Thermoplastic in hot or cold press.

• New thermoplastic grades allow cost effective cold press processing, low cycle times, achieving same significant weight reduction (20% or more) and achieve higher thermo-stability vs. polypropylene.

• Acrylic water-based binders have long shelf life, and highly adjustable options for desired applications.

• Increased natural content (75%) and low VOC behavior makes this material a high-sustainability choice.

• Combination of compression and back-injection molding has further potential for design and strength/weight performance.
# Contact Details
If you want to learn more about BASF’s Acrodur®

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We create chemistry