A New Approach to Lightweighting

Sustainable Nonwoven Composites in the Automotive Industry

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Agenda

- Automotive Innovation driving demand for new materials
- Benefits aligned with needs
- Formulation and Production
- Properties
- Carbon Footprint
- Customizability

Why nonwoven composites in automotive?

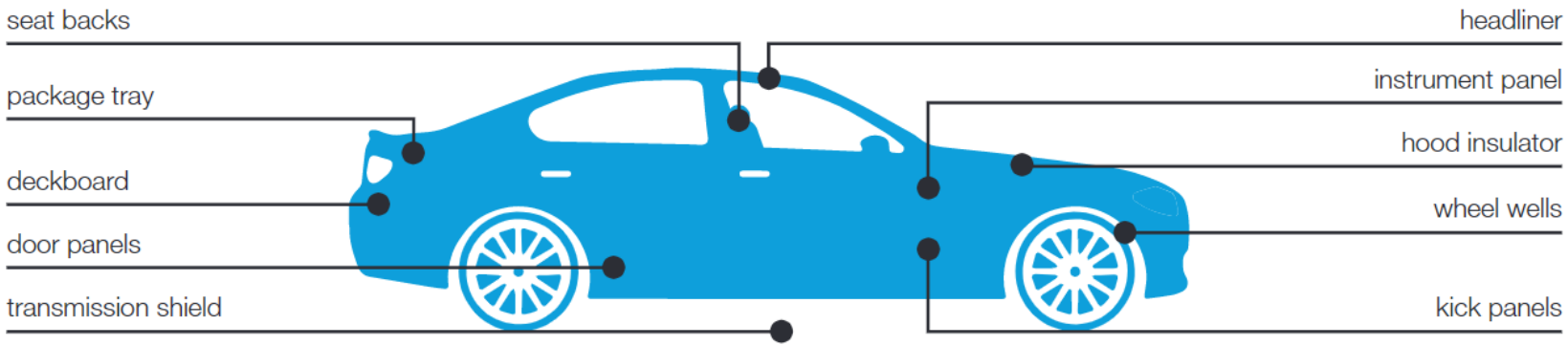
Overall innovation focused on Electric Vehicles (EVs)

- All-new design of EV means qualifying all-new materials
- New needs and requirements (different structures, components, noises/vibrations, etc)

New requirements

- Focus on improving fuel efficiency
- Improving Carbon footprint
- Use of renewable materials
- Flexibility in processing conditions
- Customizable properties (color, flame retardant)

Automotive applications



Current technology (PP, PE, other thermoplastics) doesn’t meet new automotive requirements

BASF Acrodur resin for nonwoven composites

Fiber bonding technology enables

- Waterbased emulsion or solution is easy to handle and environmentally friendly
- Lightweighting at comparable rigidity / stiffness performance
- Higher performance at the same weight vs thermoplastics
- Increase thermo-mechanical stability (up to 220 °C)
- Increase renewable content (75-85%)
- Minimize emissions (FOG, VOC)
- Create new design opportunities

Sustainable, nonwoven composites provide improvements throughout the vehicle

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Acrodur resin compatible with various natural nonwoven

Maximizing the physical properties of the final product depends on enhancing the interfacial adhesion between the fiber surface and the polymer matrix

BASF Acrodur resins have more flexibility on nonwoven selections than a hydrophobic thermoplastic.

Acrodur has strong interfacial interactions with a wide variety of fiber types

- Bast type fibers (Hemp, Jute, Kenaf, Flax)
- Cotton fibers (Shoddy, recycled Denim)
- Grass fibers (Bamboo)
- Wood fibers
- Synthetic fibers (Glass, PET)
- Carbon Fibers
- Hybrids

Jute nonwoven

BASF binders have enhanced adhesion to natural fibers due to Hydrogen bonding

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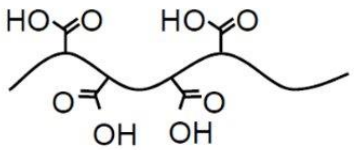
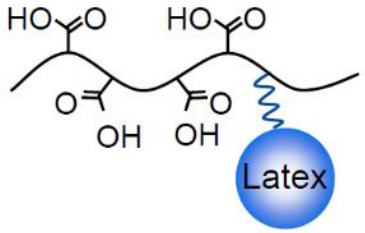
Versatility of Acrodur resin

- WB Emulsion or Solution with Zero VOC capability
- Formaldehyde-free with less health and safety concern
- Range of viscosity 300 – 2500 cps
- Easy to handle, non-flammable
- Easy to incorporate additives, dilute

Acrodur® solutions
Conform to requirements for high thermal resistance.

Acrodur® emulsions
Conform to requirements for high thermal resistance and flexibility.





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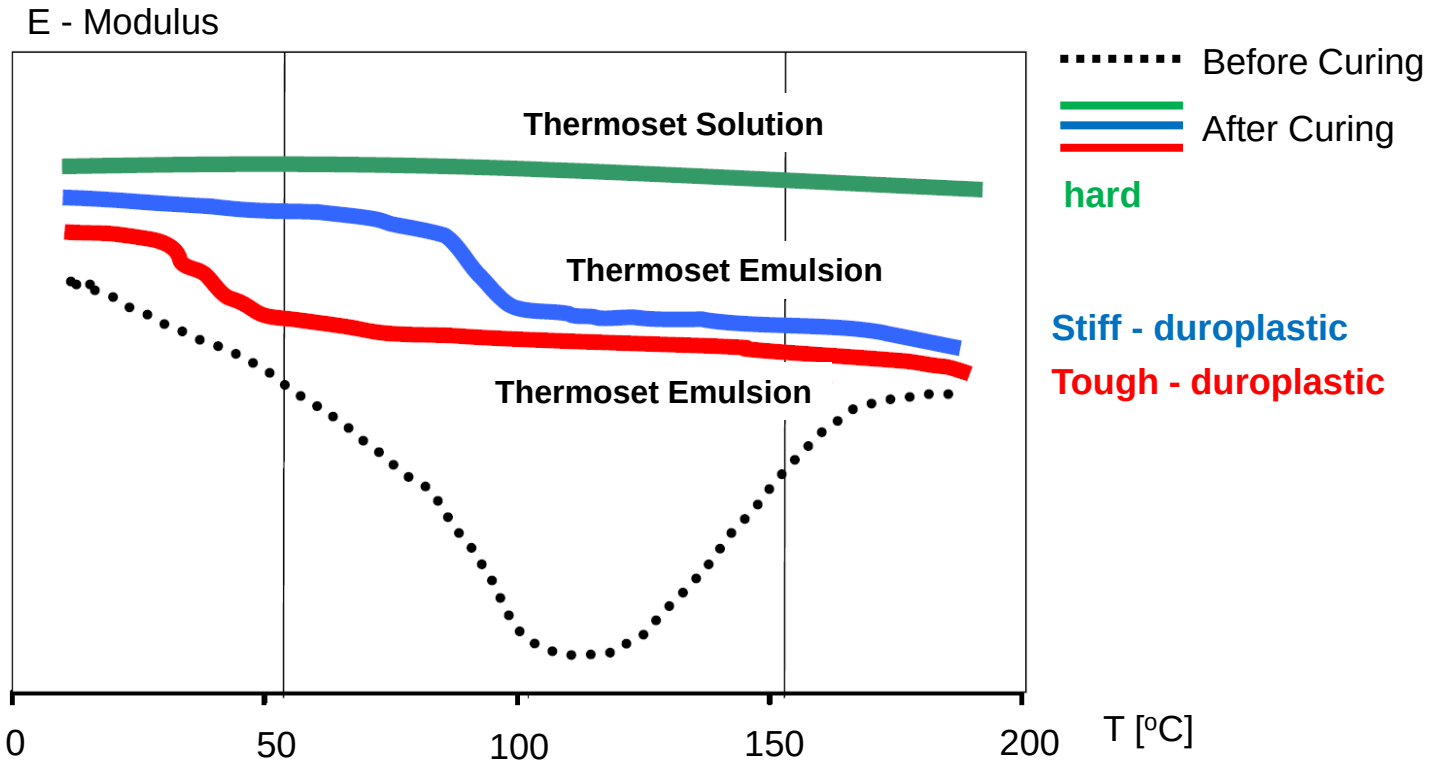
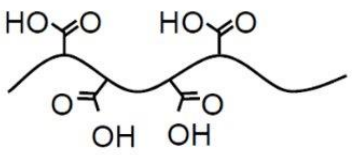
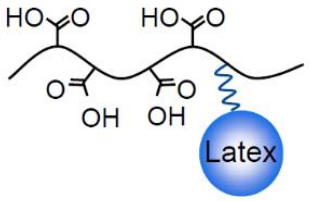
Acrodur available as thermoplastic or thermoset

Thermoset Binder Mechanical Performance







Acrodur can be molded and operated similar to NF/PP, GF/PP nonwovens

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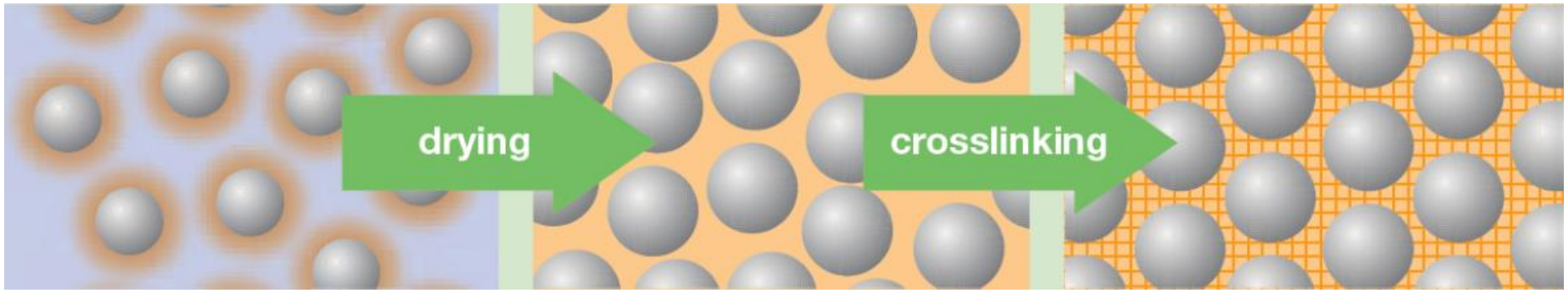
Curing mechanism of thermoset Acrodur



Acrodur dispersion

- Core shell structure
- Good wet-out at fiber surface

Film formation

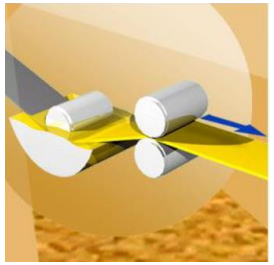
- Water phase evaporates
- Two-phase thermoplastic film at room temperature

Cured film/ network

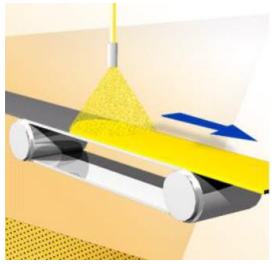
- Heat causes "shell" phase to crosslink

Multiple application processes for adding Acrodur to Nonwoven

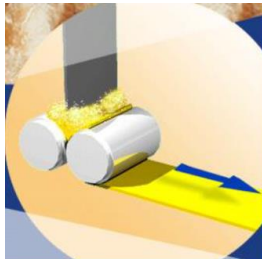
Applications – Fiber Mat Impregnation



Bath



Spray

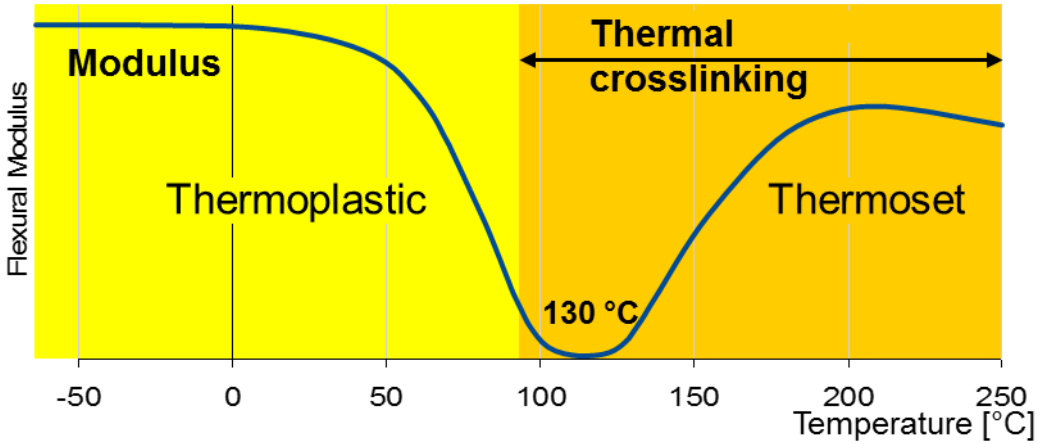


Foam

Foam Impregnation

- **BASF Resin Density ~ 1000 – 1200 g/L**
- **Foam Density for Impregnation: 100 – 250 g/L**
- **Lower density ---- More area**

Thermosetting - Crosslinking into cured state (irreversible)



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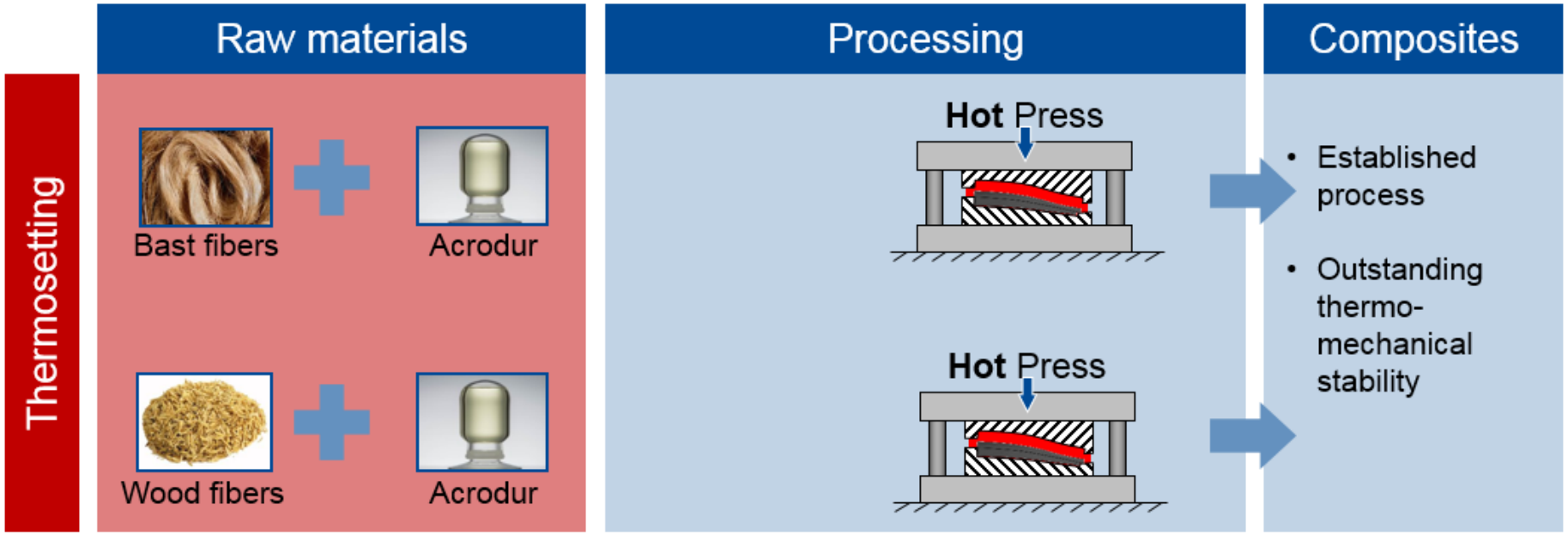
Processing of Nonwoven Composites with Acrodur

Thermoset



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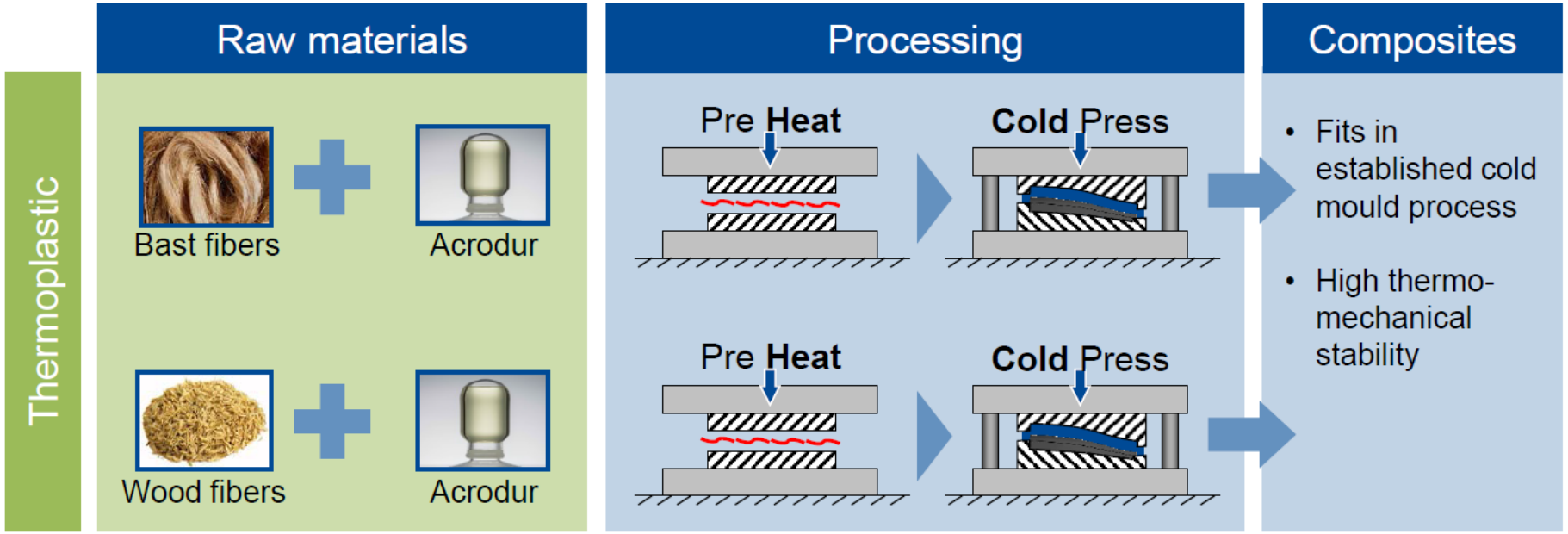
Processing of Nonwoven Composites with Acrodur

Thermoplastic



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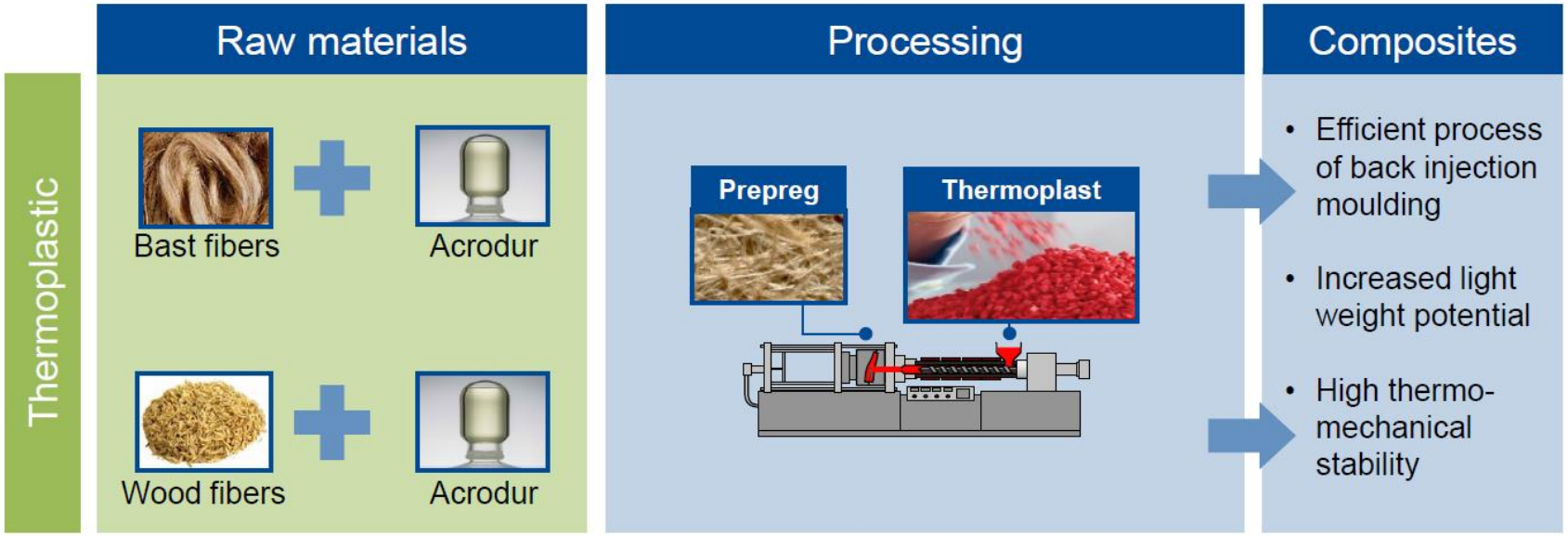
Processing of Nonwoven Composites with Acrodur

Thermoforming with Back Injection



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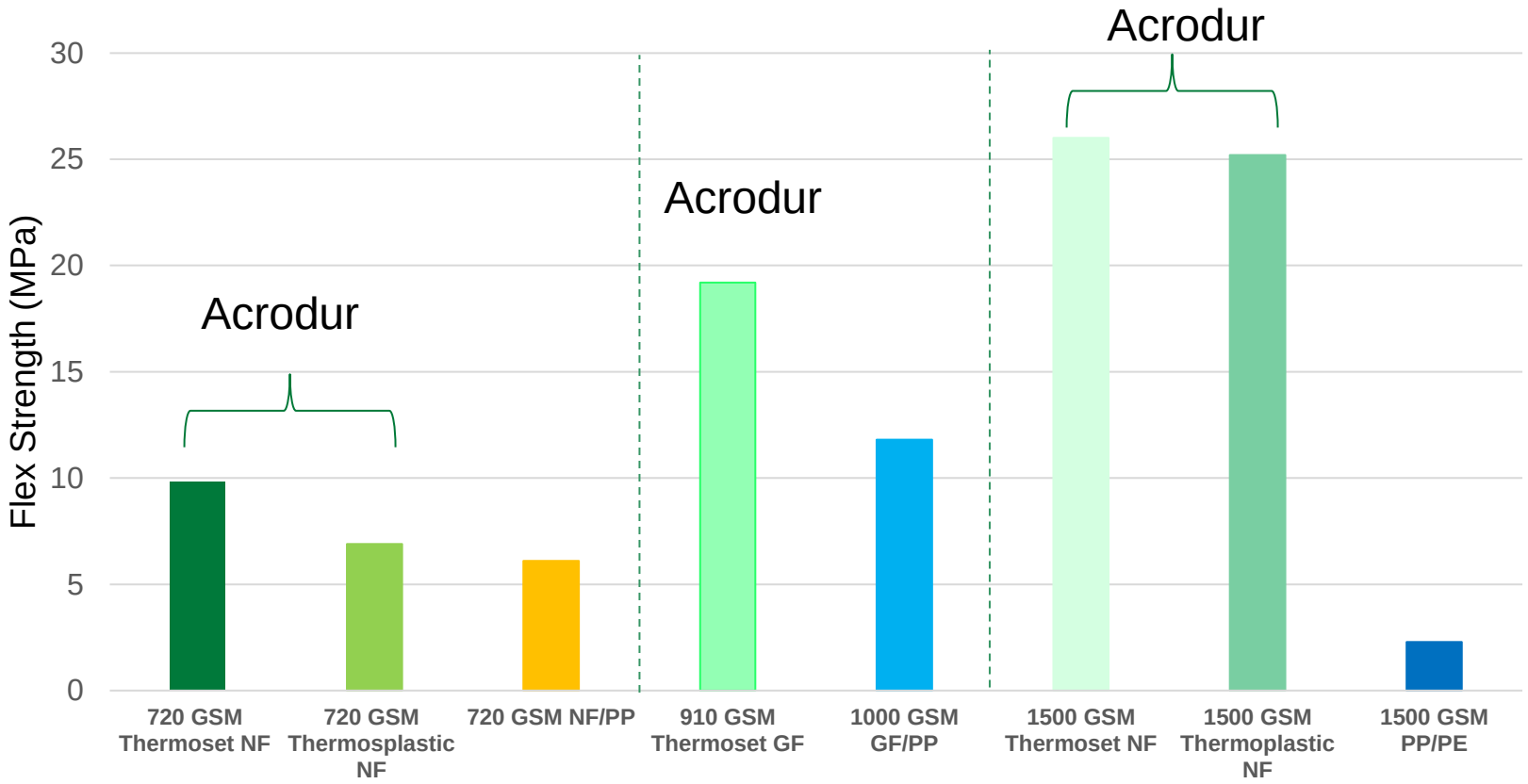
Properties at a Glance

Flexural Properties

- Tested at room temperature
- Composites with Acrodur and control samples have similar NF or GF content
- Acrodur content in the composites is ~ 30%
- Flexural Properties were evaluated by SAE J949



Flex is **10%** higher at lower weights, and **10x** PP/PE composites

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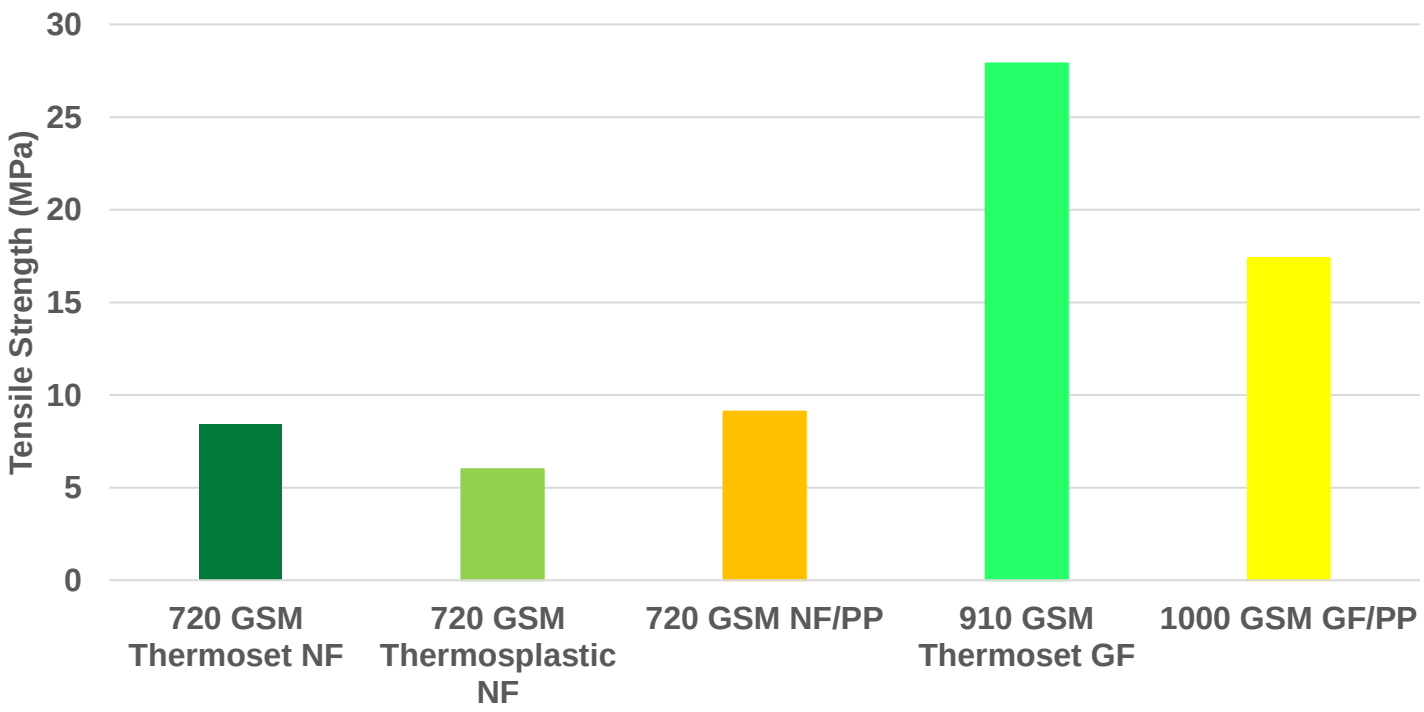
Properties at a Glance

Tensile Properties

- Tested at room temperature
- Composites with Acrodur and control samples have similar NF or GF content
- Tensile Properties were evaluated by ASTM D1037



Lighter samples didn't demonstrate significant differences in resin
Heavier samples showed 60% increase in tensile strength

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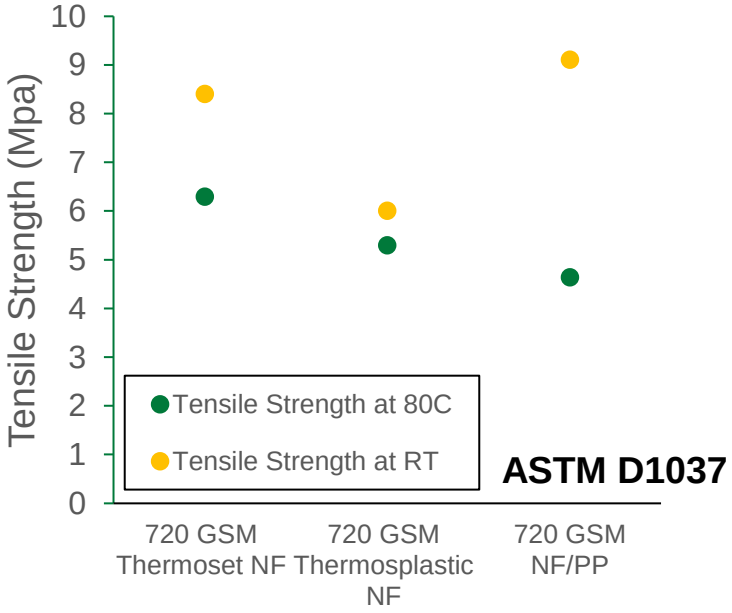
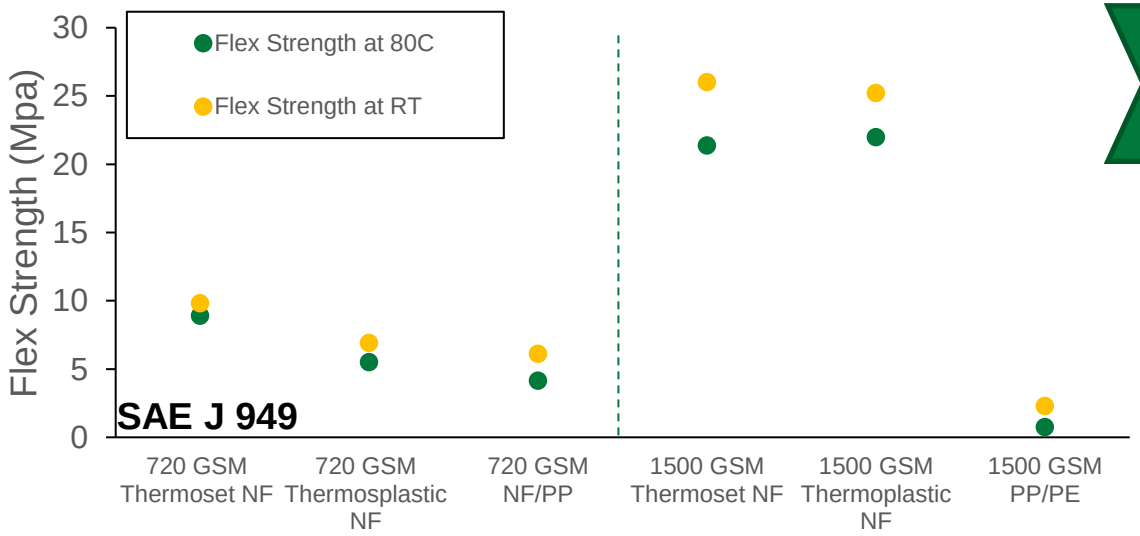
Properties at a Glance

Thermal Stability



- **Acrodur has higher tensile strength at a given weight**
- **PP samples lost 50% of tensile strength at 80 C**



- **Flex strength of PP samples decreased 30% for lighter samples at 80 C**
- **Heavier PP/PE samples had <3 MPa, and dropped to <1 MPa at 80 C**
- **Acrodur is more than 10x the flex strength of PP/PE samples**

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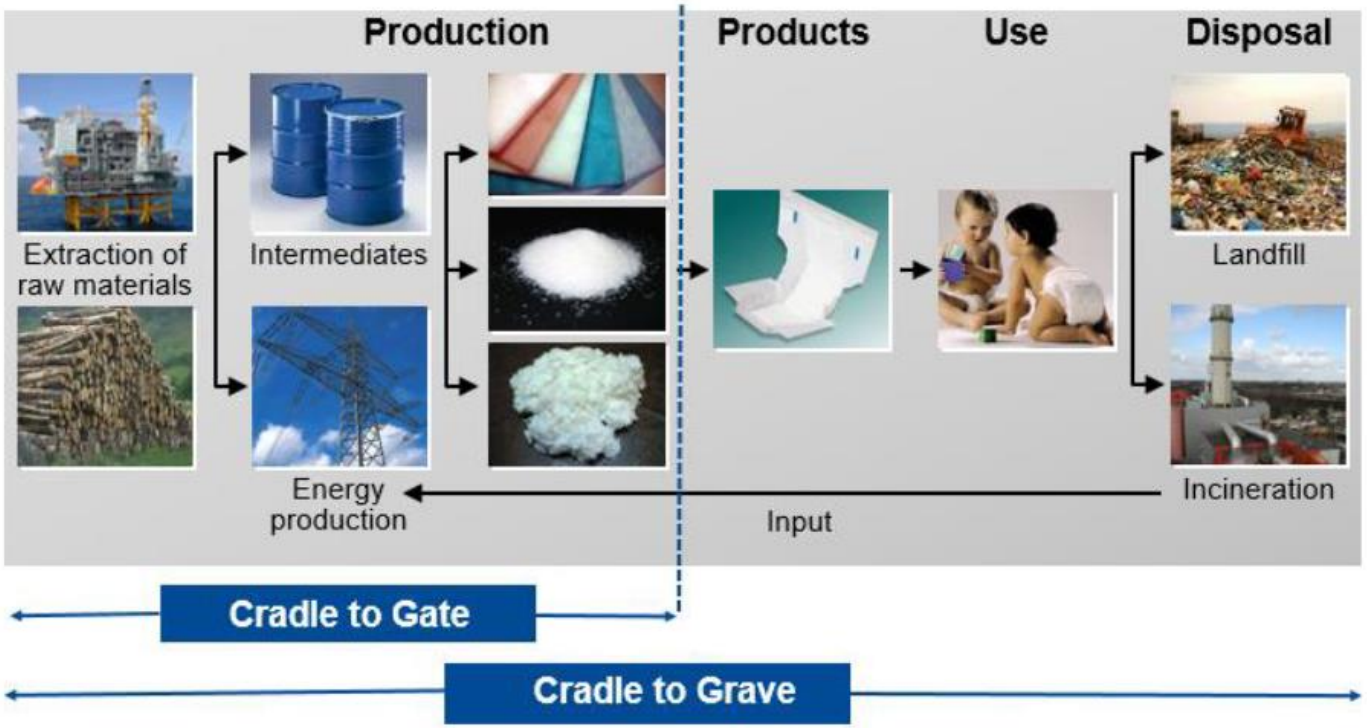
Life Cycle Assessment -

Study Summary – Impact to Carbon Footprint along the Lifecycle



Acrodur/NF Analysis

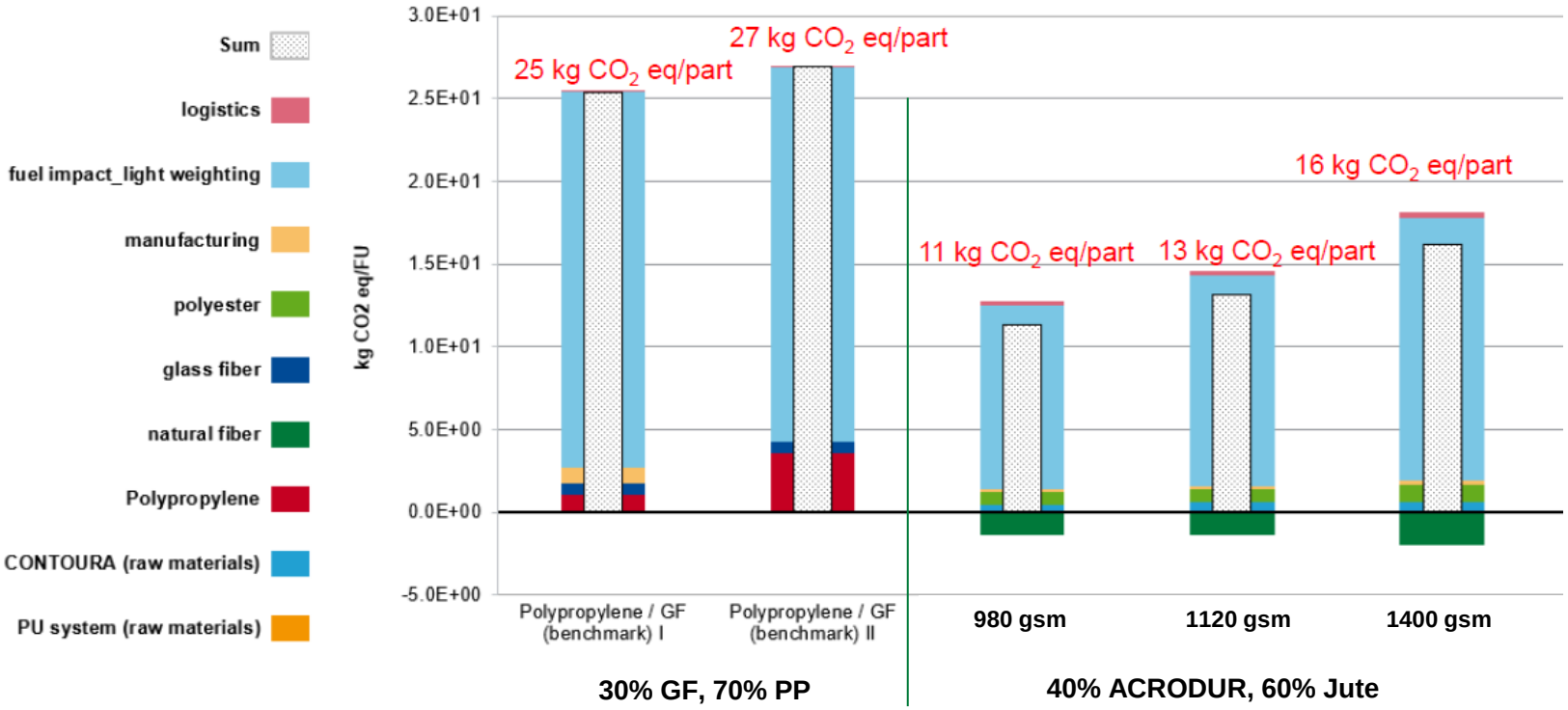
- 60% Jute fiber from Bangladesh, 40% Acrodur 3515 from Germany
- Manufacturing data from Tier 1 partners
- Final part weights: 980 gsm, 1120 gsm, 1400 gsm

Polypropylene benchmark

- 70% PP, 30% glass fiber
- Two manufacturing efficiencies separated into I and II

Bruce Uhlman, LCACP, CLE, ISSP
Manager, Applied Sustainability

Life Cycle Assessment Results
Carbon Footprint, including USE phase



>50% reduction in Carbon Footprint
Extensive Details along entire process – raw materials, production stages, in use

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Flame retardancy and microbial resistance

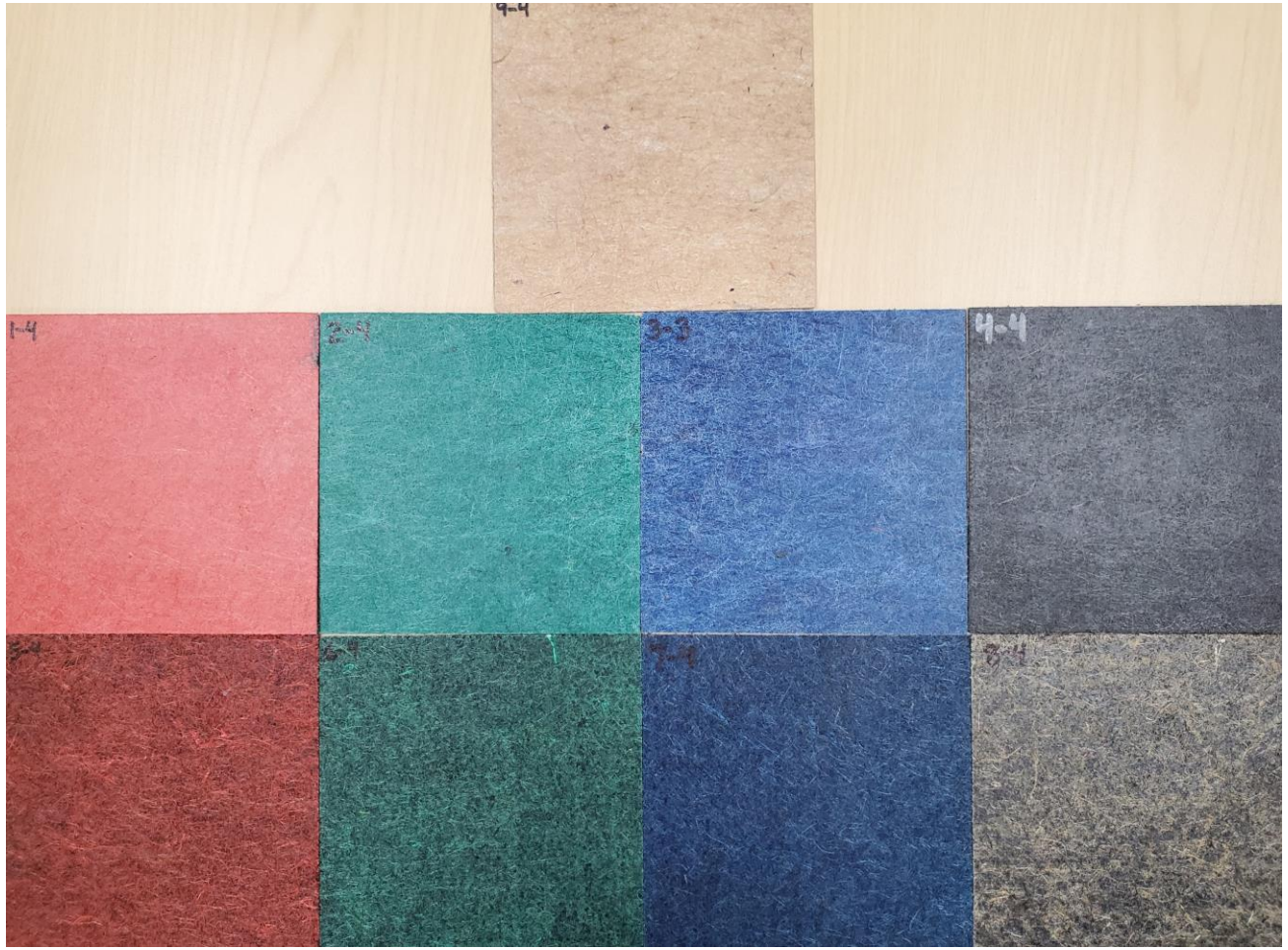
Flame retardants can be added in the Acrodur formulation to pass critical automotive flame resistance tests, such as FMVSS 302

Antimicrobial additives can be added in the Acrodur formulation to pass ASTM G21

Fail

Pass

Ability to customize color for interior A surfaces



Pigment can be added to Acrodur formulations

No need to color after pressing

Summary

Light-weighting: 20-60% lighter than polypropylene at same mechanical performance

Sustainable materials: up to 75% renewable content with natural fibers

No solvents and no added formaldehyde

Thermoset and Thermoplastic binders available for different molding process

Customize performance and aesthetic features through formulations

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Moldability

Ability to handle different shapes, draws, bends