Advancing the Sustainability of SMC & BMC Composites

SPE Thermoset TOPCON

Thomas Ebeling

May 10
Disclaimer Slide

Before using a product sold by a company of the LyondellBasell family of companies (“LyondellBasell”), users should make their own independent determination that the product is suitable for the intended use and can be used safely and legally. LyondellBasell MAKES NO WARRANTY, EXPRESS OR IMPLIED (INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE) OTHER THAN AS AGREED TO BY LyondellBasell IN THE PRODUCT SALE CONTRACT.

LyondellBasell prohibits or restricts the use of its products in certain applications. For further information on restrictions or prohibitions of use, please contact a LyondellBasell representative.

Users should review the applicable Safety Data Sheet before handling the product. Adsyl, Akoafloor, Akoalit, Alastian, Alathon, Alkylate, Amazing Chemistry, Aquamarine, Aquathene, Avant, Catalloy, Circulen, Clyrell, CRP, Crystex, Dexflex, Duopac, Duoprime, Explore & Experiment, Filmex, Flexathene, Fueling the power to win, Glacido, Hifax, Hiflex, Hipolene, Histif, Hostacom, Hostalen PP, Hostalen ACP, Hyperzone, Ideal, Indure, Integrate, Koattro, LIPP, Lucalex, Luflexen, Lupolen, Luposim, Lupostress, Lupotech, Metocene, Microthene, Moplen, MoReTec, MPDIOL, Polybatch, Polywhite, Polyblak, Nerolex, Nexprene, Petrothene, Plexar, Polymeg, Pristene, Prodflex, Pro-fax, Punctilious, Purell, Qestron, Refax, SAA100, SAA101, Sequel, Softell, Softell Textile, Spherilene, Spheripol, Spherizone, Starflex, Stretchen, Superflex, TXA, Tebog, TX-Hydro, Toppyl, Trans4m, Tufflo, Ultrathene, Vácido and Valtec, are trademarks owned and/or used by the LyondellBasell family of companies.


The statements in this presentation relating to matters that are not historical facts are forward-looking statements. These forward-looking statements are based upon assumptions of management which are believed to be reasonable at the time made, and are subject to significant risks and uncertainties. Actual results could differ materially based on factors including, but not limited to, the ability to comply with the terms of our credit facilities and other financing arrangements; the costs and availability of financing; the ability to maintain adequate liquidity; the ability to implement business strategies; availability, cost and price volatility of raw materials and utilities; supply/demand balances; industry production capacities and operating rates; uncertainties associated with the U.S. and worldwide economies; legal, tax and environmental proceedings; cyclical nature of the chemical and refining industries; operating interruptions; current and potential governmental regulatory actions; terrorist acts; international political unrest; competitive products and pricing; technological developments; risks of doing business outside of the U.S.; access to capital markets; and other risk factors. Additional factors that could cause results to differ materially from those described in the forward-looking statements can be found in our financial reports, which are available at www.lyondellbasell.com on the Investor Relations page.
About LyondellBasell
LyondellBasell is a strong, global company delivering outstanding performance

**LEADING**

- Producer of polypropylene compounds globally
- Licensor of polyolefin technologies globally
- Producer of polyethylene in Europe
- Producer of polypropylene in Europe
- Producer of oxyfuels in Europe and North America

**GLOBAL**

Every day, our employees work around the clock to safely advance solutions to our world’s biggest challenges.

**DIVERSE**

The company’s products, materials and technologies are advancing sustainable solutions for food safety, access to clean water, healthcare and fuel efficiency in more than 100 international markets.

**GROWING**

- Improved reliability of our first world-scale Hyperzone HDPE plant
- Expanded in China with integrated cracker JV and PO/SM JV
- Expanded in North America with Louisiana Integrated PE JV
- Building the world’s largest PO/TBA plant
- Launched our Circulen portfolio of polymers that provide circular and sustainable solutions

As a leader in the global chemical industry, LyondellBasell strives every day to be the safest, best operated and most valued company in our industry.

---

(1) Source: LyondellBasell and IHS Markit. Note: Product rankings are as of December 31, 2021.
LyondellBasell has the scope and scale to serve global markets

Manufacturing sites & joint ventures in 21 countries

19,100 employees

Sales in >100 countries

Note: Information as of December 31, 2021.
LyondellBasell delivers innovative products and solutions in five key areas

<table>
<thead>
<tr>
<th>CHEMICALS</th>
<th>POLYMERS</th>
<th>ADVANCED POLYMERS</th>
<th>FUELS</th>
<th>TECHNOLOGIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>We produce the chemical building blocks for:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Furniture / household goods</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Coatings / adhesives / cleaners</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Cosmetics / personal care products</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Industrial fluids</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Fuel additives</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Our versatile plastic resins are used to create a variety of products including:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Rigid and flexible packaging</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Textiles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Automotive parts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Healthcare</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Pipe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Agricultural films / irrigation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Our diverse portfolio is used to create customizable products including:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Automotive parts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Differentiated packaging</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Electronics / appliances</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Building and construction materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Oil field services</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Aerospace</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Pipe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Agriculture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Wire and cable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Our refinery in the U.S. produces:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Gasoline / fuel components</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Low-sulfur diesel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Jet fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>We license our state-of-the-art manufacturing and process technologies:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Polyolefin catalysts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Petrochemical process licenses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Advanced Polymer Solutions product portfolio

LyondellBasell delivers innovative solutions through our key material technologies:

- **Thermoplastic resins produced using base polyolefins with various components like fillers and reinforcements, and pigments and additives**
- **Specializing in the design and manufacture of high-performance plastic compounds and resins to meet demanding applications**
- **Size reduction technology to deliver powders to suit many markets and applications such as Oil & Gas and Rotomolding**

- **Polypropylene Compounds**
- **Engineered Polymers**
- **Specialty Powders**

- **Engineered Composites**

- **Color Concentrates**

- **Masterbatches**

- **A diverse thermoset portfolio of BMC, SMC, TMC and our Quantum Engineered Structural Composites for industrial to niche markets**

- **Offering a wide color portfolio paired with custom color matching for your most challenging color and additive application**

- **Enhanced additive concentrates that improve the appearance and performance of resins across many processes**
Engineered Composites Division of LyondellBasell

Engineered Composites from LyondellBasell are transforming industries through a global portfolio dedicated to innovation and sustainability.

- Sheet Molding Compounds (SMC)
- Bulk Molding Compounds (BMC)
- Quantum Engineered Structural Composites (ESC)

Application Areas:
- Mobility
- Aerospace
- Agriculture
- Building & Construction
- Energy
- Electrical
Typical markets & applications

**Automotive**
- Forward Lighting
- Sensor Brackets
- Body Panels
- Liftgates
- Interior Trim
- Heat Shields

**Aerospace & Defense**
- General Aviation
- Military Aviation
- Tertiary Parts
- Secondary Structures

**Heavy Duty Truck/ Agricultural**
- Valve Covers
- Body Panels
- Oil Pans
- Throttle Bodies

**Building & Construction**
- Electrical Boxes
- Circuit Breakers
- Wall Panels
- HVAC Housings
- Door & Window Skins
- Infrastructure

**Energy**
- Centralizers
- Frac Plug Components
- Valves
- Bipolar Plates
- Energy Storage

**Other**
- Snowboard Bindings
- Helmets
- Small Appliances
- Structural Medical Devices
- Pump housings

**Company Confidential**
Sustainability in the Composite World
Early Sustainability in Composite Materials

Early Weaponry
- Mongolian composite curved bow
- Japanese samurai sword

Early Aerospace
- Late 1930’s – early 1940’s: Gordon Aerolite
- Demonstration fuselage for Spitfire
- Phenolic and flax cured under pressure

Early Automotive
- 1941 Henry Ford “Soybean Car” concept vehicle
- Significantly reduced vehicle weight
- Soybean fiber in a phenolic resin
Historical Perspectives on Composites Environmental Impact

Use
- Composites high strength / weight ratio allows weight reduction
- Part integration facilitates cost & weight reduction
- Increased use lifetime positive impact on environment
- Fuel efficiency in transportation provides positive impact on environment

Resources
- Use of bio-based materials viewed as inherently better
- Nature provides extensive sources of promising fibers
- Extensive research generates interest, challenges w/compatibility & economics
- Synthetic fibers much more widely used

End of Life
- Grinding & reusing as filler possible but challenges not trivial
- “Un-zipping” cross links & reusing resin impossible
Life Cycle Assessments in Composite Materials

- Resources
- Material processing
- Product manufacturing
- Distribution
- Use
- End of life
Global Megatrends Influencing Sustainability

- Population Growth & Urbanization
- Climate Change
- Resource Use
- Demographics & Social Change
Our Program Areas

GLOBAL CHALLENGES

PLASTIC WASTE  CLIMATE CHANGE  THRIVING SOCIETY

END PLASTIC WASTE IN THE ENVIRONMENT

Collaborative partnerships across the value chain that tackle plastic at source:
- Alliance to End Plastic Waste
- Operation Clean Sweep
- Venture investments

ADVANCE THE CIRCULAR ECONOMY

Technology development and business model innovation:
- Mechanical recycling
- Advanced (molecular) recycling
- Renewable feedstocks

ADDRESS CLIMATE CHANGE

Greenhouse gas emissions reductions from own operations and value chain:
- Carbon reduction program
- Renewable electricity
- Low carbon technology
- Scope 3
- Climate risk

GROW SUSTAINABLE SOLUTIONS

Products and solutions that contribute toward circularity and sustainability:
- Circulen polymers: mechanically recycled, advanced (molecular) recycled and renewable-based products

ENHANCE OUR WORKPLACE, OPERATIONS AND COMMUNITIES

Social and environmental issues important for how we operate:
- Safety
- Resource use
- DEI
- Sustainable procurement
- Community investment

OUR PILLARS
Our future focused sustainability goals

**ENDING PLASTIC WASTE**

2MMT\(^1\)

2 millions metric tons of recycled and renewable-based polymers will be produced and marketed annually by 2030.

**FOR EVERY $**

we invest in venture funds that address the plastic waste challenge, we help catalyze another 5 dollars from co-investors.

**ZERO**

plastic pellet loss to the environment from our facilities

**ADDRESSING CLIMATE CHANGE**

**NET ZERO**

greenhouse gas emissions from operations by 2050\(^2\)

**42%**

absolute scope 1 and 2 greenhouse gas emissions reduction from operations by 2030\(^3\)

**30%**

absolute scope 3 greenhouse gas emissions reduction by 2030\(^3\)

**50%**

minimum of electricity procured from renewable sources by 2030\(^4\)

**SUPPORTING A THRIVING SOCIETY**

**ZERO**

incidents, injuries and accidents

**ACHIEVE**

gender parity in senior leadership globally by 2032

**INCREASE**

the number of people from underrepresented groups in U.S. senior leadership roles to reflect the general population ratio by 2032

**ASSESS**

a minimum of 70% of our key suppliers globally using sustainability criteria by 2025

---

\(^1\) 2 millions metric tons

\(^2\) Our 2050 net zero goal includes scope 1 and 2 emissions

\(^3\) Our 2030 goal includes scope 1 and 2 emissions

\(^4\) Related to 2020 levels
LyondellBasell Engineering Composites Examples
EC Example #1 – Bio Materials as filler or reinforcement

Bio Reinforcement
- Flax
- Hemp
- Jute
- Wheat Straw
- **Soy**
- Chicken Feathers
- Switch Grass
- Micro Cellulose

Challenges
- Moisture absorption
- Polymerization inhibition
- Temperature sensitivity

Benefits
- High specific strength & stiffness
- Low carbon footprint

<table>
<thead>
<tr>
<th>Composition of the soy bean</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>42%</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>33%</td>
</tr>
<tr>
<td>Oil</td>
<td>20%</td>
</tr>
<tr>
<td>Hull</td>
<td>5%</td>
</tr>
</tbody>
</table>
EC Example #2 – Bio source & recycle containing resins

**Feedstock**
- Vegetable oils
- Lignocellulosic biomass
- Strach rich residue
- Soybean Cake
- Sugarcane bagasse
- Industrial recycle
- Post-consumer recycle

**Challenges (to composite compounder)**
- Cost
- Availability
- Limited “Green” content in final product

**Benefits**
- Ease of use
- Low carbon footprint

- **Propylene Glycol** – Produced from renewable feedstocks such as soy or corn instead of petroleum.
  - Identical chemical structure as petroleum-sourced PG;
  - Meets same specifications as petroleum-sourced PG.

- **Terephthalic Acid** – Sourced and produced from a post-industrial stream of recycled polyethylene terephthalate.
  - Purge material from the PET manufacturing process that is created during start-up/shut-down or other process upsets.
Leadership in Energy and Environmental Design (a.k.a. LEED) is the world’s most used rating system for the design, construction and operation of high-performance green buildings.

- **Rapidly Renewable Materials category**
  - Reduce the use and depletion of finite raw materials and long-cycle renewable materials.
  - Made from agricultural products harvested within 10-year or shorter cycle.

- **Recycled Content category**
  - Reduce impacts resulting from extraction and processing of virgin materials.

- **LEEDS for every project**
  - Building Design and Construction
  - Interior Design and Construction
  - Building Operations and Maintenance
EC Example #2 – Bio source & recycle containing resins

### Net-Molded Shape Test Results

<table>
<thead>
<tr>
<th>Property</th>
<th>Method</th>
<th>Control SMC</th>
<th>Premi-Glas 3501</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength (MPa)</td>
<td>ASTM D638</td>
<td>57</td>
<td>75</td>
</tr>
<tr>
<td>Tensile Auto Young's Mod (MPa)</td>
<td>ASTM D638</td>
<td>13,000</td>
<td>14,800</td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>ASTM D638</td>
<td>0.86</td>
<td>1.03</td>
</tr>
<tr>
<td>Flex Strength (MPa)</td>
<td>ASTM D790</td>
<td>140</td>
<td>163</td>
</tr>
<tr>
<td>Flex Auto Young's Mod (MPa)</td>
<td>ASTM D790</td>
<td>9,870</td>
<td>10,200</td>
</tr>
<tr>
<td>Notched Izod (J/m)</td>
<td>ASTM D256</td>
<td>481</td>
<td>578</td>
</tr>
<tr>
<td>Un-notched Izod (J/m)</td>
<td>ASTM D4812</td>
<td>717</td>
<td>923</td>
</tr>
<tr>
<td>Arc Resistance (seconds)</td>
<td>ASTM D495</td>
<td>180+</td>
<td>192</td>
</tr>
<tr>
<td>Flammability (@ 2.3 mm)</td>
<td>UL 94 V-0</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Flammability (@ 2.3 mm)</td>
<td>UL 94-5V</td>
<td>Pass</td>
<td>Pass</td>
</tr>
</tbody>
</table>
EC Example #3 – Use of Reclaimed Material
EC Example #3 – Use of Reclaimed Material

- Molding
- Lighting Components
- BMC Compounding
- Grind Lens Scrap
- Solvate as Shrink Additive
EC Example #4 – Recovered Composite Fiber

Recycling Methods
- Mechanical
- Thermal
- Chemical
- High Voltage Fragmentation

Process and Applications Development for Recycled Mixed-Stream Composites
- PA16-0349-6.29-01
- US Department of Energy
- Establish viability of recycled composite parts using fibers reclaimed through controlled pyrolysis

EC Studied use of Carbon & Glass fibers in BMC
- Strength negatively impacted, minimized w/use of compatibilizer
- Stiffness little if any loss
- Encouraging results for core applications
EC Example #5 – Stacking Technologies

“Stacking” Scenarios/Options

- Bio Reinforcement/Filler + Bio Resin
- Bio Resin + Reclaimed Material
- Recycled Fiber + Recycle Containing Resin
- Recycled Fiber + Reclaimed Material

Challenges

- Mechanical properties
- Cost
- Interactions & impact on processability

Benefits

- Strength negatively impacted, minimized w/use of compatibilizer
- Stiffness little if any loss
- Carbon footprint

<table>
<thead>
<tr>
<th>Property (units)</th>
<th>Method</th>
<th>Control Average</th>
<th>Control Stdev</th>
<th>Exp. Average</th>
<th>Exp. Stdev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength (MPa)</td>
<td>ASTM D638</td>
<td><strong>84.5</strong></td>
<td>10.7</td>
<td><strong>58.7</strong></td>
<td>8.82</td>
</tr>
<tr>
<td>Flexural Strength (MPa)</td>
<td>ASTM D790</td>
<td><strong>170</strong></td>
<td>31.7</td>
<td><strong>144</strong></td>
<td>12.3</td>
</tr>
<tr>
<td>Flex Mod (MPa)</td>
<td>ASTM D790</td>
<td><strong>9080</strong></td>
<td>927</td>
<td><strong>7480</strong></td>
<td>792</td>
</tr>
<tr>
<td>Izod (J/m)</td>
<td>ASTM D256</td>
<td><strong>527.7</strong></td>
<td>1.42</td>
<td><strong>528.6</strong></td>
<td>0.74</td>
</tr>
<tr>
<td>Notched Izod (J/m)</td>
<td>ASTM D4812</td>
<td><strong>527.4</strong></td>
<td>1.45</td>
<td><strong>527.4</strong></td>
<td>1.11</td>
</tr>
</tbody>
</table>
Thank you for listening.

For more information, please email us or visit our website.