Olefinic Synthetic Pathways and Biobased Products

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Recent business milestones

- Commercial scale BDO: 5M lbs in 5 weeks
- Licensed by #1 producer
- Validation of platform for more processes

BASF
The Chemical Company

Genomatica
sustainable chemicals
Versalis: JV for butadiene
Process technology for on-purpose butadiene from biomass

- A united approach
- Biomass to polymer-grade butadiene
- Versalis to build first commercial plants
- $20M to Genomatica for funded development
- Shared licensing revenues

biomass → Fermentable sugars (C5+C6) → butadiene → elastomers
Versalis aims to be the first to license the process and build commercial plants.

Licensees capitalize and build their own plants.
A brief history of rubber
What issues are we trying to address?
The unexpected opportunity

Companies invested downstream of raw materials need a strategy to contend with uncertain supply and volatility.

- Shift to light feed
- Less C4s extracted
- Limited access to NR
- Few substitutes available
- Increasing mobility
- Growth in BRIC middle class
- Swings in C4s price
Lighter feeds impacting cracker investments

7 world-scale crackers planned in the US, along with 7 planned expansions of existing facilities

New crackers 2016-2017:
- Dow Chemical
- ExxonMobil Chemical
- Chevron Phillips Chemical
- Formosa Plastics
- Sasol
- Shell Chemicals
- Occidental Chemical

Source: ICIS, AFPM 2013: US ramps up cracker project slate on shale boom, 22 Mar 2013, Joseph Chang
Current climate promotes growth and opportunities

Light Naphtha Cracking Yields
- Ethylene 27.9%
- Butadiene 4.5%

Ethane Cracking Yields
- Ethylene 78%
- Butadiene 2.5%

Source: Platts
Perspective on Sustainability from Tire Industry

The Tire Industry Project includes eleven companies (Bridgestone, Continental, Cooper, Goodyear, Hankook, Kumho, Michelin, Pirelli, Sumitomo, Toyo and Yokohama) representing 70% of the world’s tire manufacturing capacity.

- Beneficial use of end-of-life tires
- Evaluation of ingredients
- Impacts of tire and road wear
- Dependency on fossil fuels
- Tire rolling resistance
- Availability of raw materials
On-purpose olefins: addressing the need

<table>
<thead>
<tr>
<th>Customer Needs</th>
<th>Solution</th>
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<tr>
<td>Access to new butadiene supply</td>
<td>Process technology from new feedstock</td>
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<tr>
<td>Balancing supply with demand</td>
<td>On-purpose production of ingredients</td>
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<td>Economic viability</td>
<td>Access to new raw materials reduces dependency on fossil fuels</td>
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<td>Help with establishing the new value chain</td>
<td>Partnerships to develop and commercialize</td>
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<td>...and renewable.</td>
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Thank You

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