Building a Bio-based Nylon Intermediates Platform

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Chief Business Officer
ABLC
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End Use Markets For Major Dicarboxylic Acids

- Adipic acid
- Sebacic acid
- Dodecanedioic acid

Polyamide
- N6,6
- N6,10
- N6,12
- others

Polyester polyols

Biodegradable plastic

Thermoplastic polyurethane

Plasticizers

Resins

Fibers

Elastic parts

Adhesives

Foams

Paints/Coatings

Parts

Films

Spray coatings

Thermo-set articles

Ag Covering

Packaging

Home
- carpets
- upholstery
- furniture

Automotive/Transportation
- seats and dashboards
- tire cord
- lubricants
- belts and hoses

Industrial
- commercial carpet
- paints
- coatings
- adhesives

Personal
- packaging
- cosmetics
- flavorings

Recreation
- footwear
- apparel
- camping gear

End Use Markets For Major Dicarboxylic Acids
Current Feedstocks Used for Dicarboxylic acids

- **Adipic Acid**
  - 3,000 KTA
  - 3% CAGR

- **Sebacic Acid**
  - 70 KTA
  - 10% CAGR

- **Dodecanedioic Acid**
  - 40 KTA
  - 8% CAGR

- **Crude Oil**
  - Benzene
  - Butadiene
  - Alkanes

- **Castor Bean oil**
  - Ricinoleic Acid
The Verdezyne Business Platform

*Engineering Organisms & Processes for Cost-effective Renewable Chemicals*

**Feedstock Strategy**
- Non-food plant oils
- Soap stocks and distillates
- Other oil co-products (i.e. PKO, PFAD)

**Proprietary Technology**
- Organisms engineered for yield and selectivity
- Fermentation-based production
- Highest quality products

**Chemical Intermediates**
- Diacids used in fibers, polymers and coatings
- Other organic diacids
- Diamines and diols from diacids
- Acrylic intermediates

**End-Products**
- Nylon and polyesters
- Fibers
- Polyurethanes
- Engineered plastics
- Resins
- Lubricants
- Coatings
- Adhesives
- Corrosion inhibitors
- Transparent Thermoplastics

*Total $70B+ Market*
*Total $1.5T+ Market*

- Using fatty acids from any source to produce chemicals
- Robust yeast platform using industrial fermentation methods

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*Bio-Adipic Acid*
*Bio-Sebacic Acid*
*Bio-Dodecanedioic Acid*
Plant Oils are Worldwide Commodities

Production in Million MTA as of 2012

<table>
<thead>
<tr>
<th>Coconuts</th>
<th>Cottonseed</th>
<th>Palm Oil</th>
<th>Peanut</th>
<th>Olive</th>
<th>Rapeseed</th>
<th>Soybean</th>
<th>Sunflower</th>
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<tbody>
<tr>
<td>Philippines</td>
<td>Indonesia</td>
<td>Colombia</td>
<td>China</td>
<td>EU</td>
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<td>Argentina</td>
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<td>India</td>
<td>Japan</td>
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<tr>
<td></td>
<td></td>
<td>Papua New Guinea</td>
<td>Mexico</td>
<td>Mexico</td>
<td>US</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Thailand</td>
<td>US</td>
<td></td>
<td></td>
<td></td>
<td>US</td>
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</table>
**Cost Advantaged Non-food Feedstock Strategy**

- “Feedstock” is that raw material used by the organism to reproduce, for energy and to produce target chemicals.
- Cost of feedstock can be from 50% to 80% of total cash cost to manufacture.
- Fatty acid based production is advantaged over incumbent petrochemical production and sugars in both **cost** and **volatility**.

### Worldwide major plant oil production (billions of pounds) in 2012

<table>
<thead>
<tr>
<th>Oil Type</th>
<th>Asia</th>
<th>Europe</th>
<th>Americas</th>
<th>Other</th>
<th>World Total</th>
<th>Distillates</th>
<th>PKO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palm</td>
<td>104.1</td>
<td>N/A</td>
<td>2.0</td>
<td>9.2</td>
<td>115.2</td>
<td>5.8</td>
<td>13.1</td>
</tr>
<tr>
<td>Soybean</td>
<td>28.9</td>
<td>4.5</td>
<td>52.2</td>
<td>9.9</td>
<td>95.5</td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td>Rapeseed/Canola</td>
<td>19.7</td>
<td>19.8</td>
<td>6.3</td>
<td>6.9</td>
<td>52.7</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>Coconut</td>
<td>7.0</td>
<td>N/A</td>
<td>0.8</td>
<td>N/A</td>
<td>7.8</td>
<td>0.3</td>
<td></td>
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<tr>
<td><strong>Total</strong></td>
<td>159.6</td>
<td>24.3</td>
<td>61.2</td>
<td>26.1</td>
<td>271.3</td>
<td>10.9</td>
<td>13.1</td>
</tr>
</tbody>
</table>

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**Feedstock Price Volatility**

By-products/co-products: Verdezyne’s preferred feedstocks are the distillates and fatty acids produced in the plant oil refining and fractionation process.
Bio-DDDDA Process Demonstration Timeline

**Process Successfully Piloted** (beyond 400 L at Verdezyne)
- Completed at BEI/MBI in **Q1-2014**
- Process demonstrated at 4,000 L scale
- Over 1 metric ton of Bio-DDDDA produced

**Demonstration campaign underway**
- In progress now at ICM/ChemDesign
- Scheduled to be completed by **Q2-2015**
- Process now demonstrated at 25k L scale
- ~50MT DDDA available for seeding the markets

### Properties of Bio-DDDDA

<table>
<thead>
<tr>
<th>Property</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,12 Dodecanedioic Acid (wt %)</td>
<td>98.6</td>
<td>NA</td>
<td>&gt; 99.4</td>
</tr>
<tr>
<td>Total Nitrogen (ppm)</td>
<td>NA</td>
<td>34</td>
<td>&lt; 21</td>
</tr>
<tr>
<td>Ash (ppm)</td>
<td>NA</td>
<td>2</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>Monobasic Acids (wt %)</td>
<td>NA</td>
<td>0.08</td>
<td>&lt; 0.06</td>
</tr>
<tr>
<td>Iron (ppm)</td>
<td>NA</td>
<td>1</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>Water (wt %)</td>
<td>NA</td>
<td>0.4</td>
<td>&lt; 0.04</td>
</tr>
<tr>
<td>Other Dicarboxylic Acids (wt %)</td>
<td>NA</td>
<td>1</td>
<td>&lt; 0.1</td>
</tr>
</tbody>
</table>

**BEI Facility**

**Bio-DDDDA**

**N6,12 made w/Bio-DDDDA**
**Bio-DDDA Commercialization Timeline**

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>BioNexus Status in Malaysia</td>
<td>Sept – 2013</td>
</tr>
<tr>
<td>Sime Darby $30M investment</td>
<td>April – 2014</td>
</tr>
<tr>
<td>BioXcell selected as the site for 1st commercial plant</td>
<td>Nov - 2014</td>
</tr>
<tr>
<td>Full financing for the commercial plant secured</td>
<td>Q4 - 2016</td>
</tr>
<tr>
<td>Commercial plant scheduled to be commissioned</td>
<td></td>
</tr>
</tbody>
</table>
Summary and Path Forward

Verdezyne technology enables the conversion of plant oil byproducts into high value intermediates

- Engineered industrial yeast strains with robust performance at commercial scale
- Feedstock flexibility allows the conversion of different sources into commercially important chemicals
- High purity DDDA, adipic acid, and sebacic acid are being produced at credible scales from renewable non-food sources
- Other organic acids being piloted as extensions of technology platform
- Kilogram quantity samples of products available now for qualification testing
- Metric ton quantities of Bio-DDDA available starting in Q1-2015
- Construction of commercial facility to commence Q2-2015
Thank You!

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