Advancements in Renewable Chemical Manufacturing and Commercialization

BIO Pacific Rim Summit
December 2014

Cenan Ozmeral, Ph.D.
President and CEO
1. PTTGC’s Green Strategy
2. Myriant’s Portfolio
3. Partners
4. Conclusions
Myriant Corporation

The Company

• Formed in 2009
• HQ in Quincy, MA
• R&D in Woburn, MA
• Commercial plant in Lake Providence, LA
• >100 employees (R&D, engineering, manufacturing & sales)

Recent Updates

• Myriant has been acquired by PTT Global Chemicals (GC)
• Joins NatureWorks and Emery as the third major investment by PTTGC in the green chemicals industry
• Myriant will maintain its brand, local organization and board
• Myriant is executing on its strategy with support form PTTGC
Corporate Structure: PTTGC
Myriant’s Transition from Start-Up

Major Asian Conglomerate

- $17.6 B Revenue (2013)
- Focused on technology and innovation
- Develop new products
- Create a strong IP portfolio
- Expansion of technology and know-how
- Company globalization with culture diversification

Strong technology integration for the production of sustainable “green” chemicals
1. Thailand’s largest ethane-base cracker with integrated aromatics and refining businesses
2. Highly competitive cost structure with pricing arrangement for gas feedstock based upon equitable return on investment for both PTT and PTTGC
3. Fully integrated petrochemical and refinery operations with diversified product portfolio covering full hydrocarbon chain
4. Strong footprint in fast growing regions with 5 operating countries worldwide
5. Committed to operational excellence targeting best in class/first quartile business efficiency
6. PTT’s Chemical Flagship

Profile
- Incorporated on October 19, 2011 from the amalgamation of PTTAR and PTTCH
- 2013 Sales: $17.9 bn; EBITDA: $1.8bn
- Asset size: $13.7 bn (as of 31/12/2013)
- Foreign Limit <= 37%
- Dividend Policy >= 30%
- Total petrochemical capacity: 8.75 MTA
- Total distillation capacity: 280 KBD
- Number of employees: 5,660 persons

Top 5 Shareholders As of Mar. 4, 2014
1. PTT 48.89%
2. NVDR 9.05%
3. STATE STREET BANK EUROPE LIMITED 2.84%
4. STATE STREET BANK AND TRUST COMPANY 1.92%
5. HMC POLYMERS COMPANY LIMITED 1.85%
Diversified Product Portfolio and End Markets

Full range of product offering reduces business volatility and provides future opportunities to expand to High Volume Specialties and other new products.

<table>
<thead>
<tr>
<th>Current Downstream Products</th>
<th>New and Potential Downstream Product Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDPE</td>
<td>Isocyanates, Pu (1)</td>
</tr>
<tr>
<td>LDPE</td>
<td>PLA</td>
</tr>
<tr>
<td>LLDPE</td>
<td>ABS</td>
</tr>
<tr>
<td>PS</td>
<td>SBR</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>PP</td>
</tr>
<tr>
<td>Ethoxylate</td>
<td>PC</td>
</tr>
<tr>
<td>Ethanolamine</td>
<td>Epoxy Resins</td>
</tr>
<tr>
<td></td>
<td>PMMA</td>
</tr>
<tr>
<td></td>
<td>Nylon 6</td>
</tr>
<tr>
<td></td>
<td>Polyester Fiber</td>
</tr>
<tr>
<td></td>
<td>PET Resin</td>
</tr>
<tr>
<td></td>
<td>New Investments</td>
</tr>
</tbody>
</table>

Potential Product Opportunities (2)

- Foams, Coatings, Elastomers
- Films/Cards, Durables, Beverages, Non-Wovens/Fibers
- Automotives, Electronic and Electrical
- Appliances, Packaging, Construction, Paints
- Automotives, Textiles, Agriculture
- Textiles, Packaging, Furniture,
**Strategic Direction**

**EXCELLENCE**

**EXECUTION**

**CORE UPLIFT PROJECTS**
- Debottle necking
- Operational Excellence
- Marketing Excellence
- Synergy Excellence

**NEW GEOGRAPHIES**
- ASEAN: Pertamina
- CHINA: Sinochem

**NEW PRODUCTS**
- PC, PU, SBR, Nylon 66
- System House
- Compounding

**1-STEP ADJACENCIES**

**EBITDA Uplift**
- 15-30%
- (2012-2017)

**1st Quartile**
- Performance
- ROIC > 14%

**GREEN**
- Oleochemical
- PLA
- Succinic Acid
- PLA/PBS Compound

Leverage collaboration with PTT Group
Capabilities and Organization enablers
Social and environmental sustainability
“Synergy and Collaboration”

- Di-acids products provider
- Linkage to PU Chain
- Linkage to Nylon Chain from Bio-based
- Joint marketing activities and share customer base information
- Execute Strategic IPs

Myriant
World Class Biotechnology R&D Center
Emery Oleochemical

**Rationale of investment**

- **50%** to **50%**
- Investment transaction completed in July 2008
- 50% stake — Investment capital to USD 151 million

**Transaction:**
- Investment transaction completed in July 2008
- 50% stake — Investment capital to USD 151 million

**Objective:**
- To diversify product portfolio with world scale production asset
- To presence in Global Oleochemicals & build market network
- Use Emery’s Technology and R&D capability
- To grow in downstream derivatives

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**Way Forward:**

- **To strengthen Basic Oleochemical and explore specialties oleo chemical**
- **Two main strategies going forward**
  - Oleo Basic Chemical: strengthened cost competitive position
  - Specialties Oleo Chemical: High value added product portfolio via growth projects

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**Strengthened Oleo Basics Business and Grow into Specialties Oleochemical Business**

**Feedstock**
- Vegetables
  - Oil and Fats (Tallow)

**Oleo Basics Platform**
- Raw Glycerin
- Methyl esters
- Refined Glycerin/Triacetin
- Fatty Alcohols
- Specialties Oleochemicals
  - Plastics Additives
  - Ozone Acid (Di-acids)
  - Oilfield Chemical

**Specialties Oleochemical Platform**
- Home & Personal Wellness
  - Green Polymer Additives
    - Eco-Friendly Polyols
  - Agro Green
    - Bio-Lubricants
  - Applications
    - Laundry Detergen
    - Shampoo
    - Toilex Paste
    - PIPES
    - Foam Sheets
    - Toys
    - Flooring
    - Herbicides
    - Insecticides
    - Biodegradables
    - LE DRILLING FLUIDS
    - Biolubes

**New specialties Products**
- Sulfactants
- Thickeners
- Ethoxylates
- Sodium Lauryl Sulfate (SLS)
- New Bio- Polyols and Recycled Polyols
Natureworks
Expanding PLA Sales and Application

Rationale of Investment

Transaction:
- Investment transaction completed on May 31, 2012
- 50% stake – Investment capital to USD 150 million

Objective:
- To build second plant potentially in Asia
- Capture Mega trend i.e. environment and resource scarcity.
- To produce PLA from diversified feedstock

Way Forward:
- To expand PLA sales and application
- To grow sales volume by approximately 10-15% p.a. in the next 3 years
  - Focus growth on oil field service application
- To be bio plastic hub in Southeast Asia
- R&D for new application
- To build second plant in Southeast Asia
  - In the process of front end engineering
  - Jacobs Engineering has been awarded the engineering design contract.
  - Location to be finalized by 10/15

Varieties of New Products Application

Sales Volume Growth at 16% p.a. in the past 5 Years

Unit: KTA

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales Volume</th>
<th>U-Rate (RHS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009A</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>2010A</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>2011A</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>2012A</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>2013A</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>2014E</td>
<td>98</td>
<td></td>
</tr>
</tbody>
</table>

Note: U-Rate based on effective capacity for the year.
Capacity: 2009 at 125 KTA, 2012 at 140 KTA, 2013 at 150 KTA.
Vencorex Business Directions

**Business Restructuring**

**Rationale of Investment**

**Transaction:**
- Investment transaction completed on May 31, 2012
- 51% stake – Investment capital to €121 million

**Objective:**
- To step into HVS (PU Chain) by using the technology and knowhow (TDI & HDI) from Vencorex
- To maintain existing business and expand business in Asia
- To forward integration into downstream

**Business Directions**

1. Expand and enhance HDI Business
2. Continue R&D for TDI and HDI Process Improvement
3. Vencorex’s France operations base will become HDI Monomer Hub and Center of High Technology Product Development
4. Conversion of TDI to HDI Monomer in France while sustaining strong TDI customer base in Europe
5. Seek for Business Partner of Isocyanates & PU to expand the Business in Asia

**Restructuring of Vencorex**

- TDI Reactor 1.25 KTA
- New HDI Reactor 70 KTA By 2016
- HDI Monomer
- HDI Derivatives 24 KTA
- HDI Derivatives 11 KTA
- New HDI Derivatives 12 KTA
- New HDI Derivatives 11 KTA
- New HDI Derivatives 12 KTA

- **Restructuring Provision** at 51% of 1,142 M. Baht
- **HDI Derivatives in Thailand**
  - Investment: EUR 40 million
  - Expected IRR: > 15%
- **Integrated PU Complex in Asia**

**HDI Major Applications**

- High value coating
- Building & construction
- Leather finishing
- Plastic & wood coatings
- Transportation, aerospace, ACE

**TDI Major Applications**

- Flexible Foam
- CASE
- Paint
- Coatings, adhesives, Elastomers

**Manufacturing Sites**

- Pont-de-Claix
- Freeport, Texas
- Rayong

**ASIA**

**Integrating PU Complex**
JV with Pertamina Updates
“Indo Thai Trading”

**JV Marketing & Trading Holding Structure**

- PTT Global Chemical: 49%
- Pertamina: 51%
- Indo Thai Trading: 100%

**Supply Chain in Indonesia**

**Unit: KTA**

<table>
<thead>
<tr>
<th>Year</th>
<th>MEG</th>
<th>PP</th>
<th>PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>48</td>
<td>37</td>
<td>31</td>
</tr>
<tr>
<td>2015</td>
<td>195</td>
<td>150</td>
<td>45</td>
</tr>
<tr>
<td>2016</td>
<td>255</td>
<td>200</td>
<td>45</td>
</tr>
<tr>
<td>2017</td>
<td>325</td>
<td>250</td>
<td>45</td>
</tr>
<tr>
<td>2018</td>
<td>415</td>
<td>250</td>
<td>45</td>
</tr>
</tbody>
</table>

**Product Source**

- HDPE, LDPE, LLDPE, MEG

**ITT Office Grand Opening in Jakarta**

**ITT Organization**

- President Director
- Senior Vice President
- Senior Vice President Director
- Sales Director
- Marketing Director
- Corporate Functions Head
- Finance & Accounting
- Corporate Support
- Technical Service
- Marketing Strategy
- Supply Chain Management

- Nominated by Pertamina
- Nominated by PTTGC
- Pertamina, PTTGC or local new hire
Myriant’s Target Products

Selection Criteria

1. Large volume potential (from DOE Report)
2. C3 or greater to avoid competition with shale gas economics
3. Oxygen containing molecules to make full use of sugar feedstock
4. Focus on drop-in products such as bioBDO rather than new molecules/polymers such as PLA

<table>
<thead>
<tr>
<th>DOE Top Bio-Based Building Block Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,4 diacids: succinic, fumaric and malic acids</td>
</tr>
<tr>
<td>2,5 furan dicarboxylic acid</td>
</tr>
<tr>
<td>3 hydroxy propionic acid (for acrylic acid)</td>
</tr>
<tr>
<td>Aspartic acid</td>
</tr>
<tr>
<td>Glucaric acid</td>
</tr>
<tr>
<td>Glutamic acid</td>
</tr>
<tr>
<td>Itaconic acid</td>
</tr>
<tr>
<td>Levulinic acid</td>
</tr>
<tr>
<td>3-hydroxybutyrolactone</td>
</tr>
<tr>
<td>Glycerol</td>
</tr>
<tr>
<td>Sorbitol</td>
</tr>
<tr>
<td>Xylitol/arabinitol</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Large Volume Chemical Intermediates (C, H, O)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alcohols</strong></td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td><strong>C3</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>C4</strong></td>
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<tr>
<td></td>
</tr>
<tr>
<td><strong>C5</strong></td>
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</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>C6</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>C7-8</strong></td>
</tr>
</tbody>
</table>

Commercial Products: D(-) Lactic Acid

- *E.coli*-based
  - One strain licensed exclusively and globally to Purac
  - Commercial production started in Spain in 2008

Myriantr’s Lactic Acid Technology has been in Commercial Operation since 2008, with continued development. Myriantr’s technology is commercially ready on conventional sugars today, with a clear path toward utilizing cellulosic sugars when commercially available.
Commercial Products: Succinic Acid
1st Bio-Succinic Acid Facility in U.S.

Recent Updates

• Commercial Start-Up: Q2 2013
• Demonstrated >70% Production Capacity: Q2 2014
• Successfully completed 72 hour performance test required by the USDA LG Program
• Shipping on-spec bio-succinic acid product around the world
Bio Succinic Acid product quality testing

<table>
<thead>
<tr>
<th>Customer Application</th>
<th>Customer feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymers</td>
<td>Approved</td>
</tr>
<tr>
<td>Coatings</td>
<td>Approved</td>
</tr>
<tr>
<td>Plasticizers</td>
<td>Approved</td>
</tr>
<tr>
<td>Urethanes</td>
<td>Approved</td>
</tr>
<tr>
<td>Solvents</td>
<td>Approved</td>
</tr>
</tbody>
</table>

Sampled over 190 customers with superior product quality

- LOWER CARBON FOOTPRINT
- NO GREEN PRICE PREMIUM
- NON-FOOD BASED
- HIGHER PERFORMANCE
Commercial Products: Succinic Acid
Myriant’s Competitiveness

Myriant has the lowest cost manufacturing process

Source: ChemSystems PERP report May 2012.
Commercial Products: Succinic Acid
Close partnership with ThyssenKrupp - Uhde

ThyssenKrupp-Uhde guarantees scale-up and final product quality
Commercial Products: Succinic Acid
Myriant and Davy Integration Project

Myriant Generation 1 Process: Bio SAC is qualified as feedstock to Davy Process

Myriant Generation 1 Process
Sugar → CO₂ → Fermentation → Salt separation → Polishing → Evaporation / crystallization → SAC

Current Davy Process
Reaction + MeOH → Dimethyl Succinic Acid

Integration
Sugar → CO₂ → Fermentation → Salt separation → SAC

Legend:
- Succinic Acid process
- Butanediol process
- Eliminated process

Phases 2 and 3 will further reduce operating cost and capital
Commercial Products: Succinic Acid
Myriant’s Bio BDO Competitiveness

Figure 5.8 BDO Process Comparison
(United States, Third Quarter 2012, Dollars per Ton)

All product development activities will be subjected to a rigorous Stage Gate process.

(X = Program cancelled due to low return-on-capital potential)
Developmental Products: Acrylic Acid

Lactic Acid

Bio-Acrylic Acid

-\( \text{H}_2\text{O} \) (Dehydration)

Bio-Acrylate Ester

Bio-Acrylic Acid + ROH (Esterification)

Lactate Ester

Lactic Acid -\( \text{H}_2\text{O} \) (Dehydration)

Bio-Acrylic Acid

ROH + Lactic Acid (Esterification)
Developmental Products: Acrylic Acid
Commercial Activities

Current Status of Our R&D Work

<table>
<thead>
<tr>
<th></th>
<th>Targets</th>
<th>Status</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion</td>
<td>&gt; 90%</td>
<td>&gt;90</td>
<td>Achieved</td>
</tr>
<tr>
<td>Selectivity</td>
<td>&gt; 90%</td>
<td>82 – 83%</td>
<td>Good progress: target within reach</td>
</tr>
<tr>
<td>(with only one byproduct &gt;10%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalyst Life</td>
<td>Regeneration within 2-3 months</td>
<td>Ongoing</td>
<td>Good progress: target achievable</td>
</tr>
</tbody>
</table>

Once 90% selectivity is reached at laboratory scale, the project will move to pilot plant phase in 2015, which could be at PTTGC facilities.

- **Sept. 7, 2011**
  - An international full patent application filed on lactic to acrylic process.
    (Catalytic Dehydration of Lactic Acid and Lactic Acid Esters; International Application No.: PCT/US2011/050707)

- **March 7, 2012**
  - 2nd provisional patent application filed.
    (Preparation of α, β-Unsaturated Carboxylic Acids and Esters Thereof; U.S. Patent Application No. 61/608,053)

- **March 6, 2013**
• **Penn State to end of 2014**

  – Further optimization of reaction parameters, key characteristics of catalyst preparation.
  – Longer reaction runs with intermittent regeneration to test the catalyst stability.
  – Run in-process lactic acid samples from Leuna pilot plant as feed for dehydration reaction.

• **2015: Pilot Scale**

  – Scale up to larger reactor with integrated crude acrylic acid recovery
  – Gather thermodynamic data for reactor design
  – Sample generation for potential customers
  – Basic engineering data
Developmental Products: Muconic Acid

- On DOE Top-12 List
- On Myriant grid
- Platform chemical – Very large volume
- Not exposed to Shale gas economics
- Bio route competitive with petro route (TBD?)
- Engineered strain to make a non-native compound
- Stable, integrated strain developed using a minimal medium – necessary for economic targets
- Continuing development to commercial targets (reached ~50% of targets)
Developmental Products: Muconic Acid Applications

High Value
(Provisional Patent filed)

- HomoPolymers
- Polyesters & Polyamides
- Co-Polymers
- High-Value Derivatives

High Value Products:
Higher revenue specialty niche product

High Volume

- Adipic Acid
  Nylon 6,6 Monomer
- HMDA
  Nylon 6,6 & 6,12 Monomers
- Caprolactam
  Nylon 6 Monomer
- HDO
  Polyester & Polyurethane

High Volume Products:
Scale-Up & Expansion to commodity quantities

High Value Products:
Higher revenue specialty niche product
Conclusions

Formula for Success in Asia

• Strategic Partner
• Market Presence
• Technology
• People
• Funding
• Long-term Strategy