Virent: Replacing crude oil as a feedstock for fuels and chemicals

Brian Blank
Virent INC.
October 16th, 2013
Ending Dependence on Crude Oil

Virent Technology can Replace > 90% of the Barrel

The US consumes over 18 million barrels of oil per day; 49% is imported from foreign countries.
Organizational Capabilities
<table>
<thead>
<tr>
<th>Hydrocarbons</th>
<th>Gasoline/Aromatic Chemicals</th>
<th>Jet Fuel</th>
<th>Diesel</th>
<th>Bio-Crude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virent</td>
<td>Solazyme</td>
<td>Amyris</td>
<td>Solazyme</td>
<td>Sapphire Cellana</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td>Dynamic Fuels</td>
<td>Solazyme</td>
<td>Amyris LS-9</td>
<td>Syntrolem Choren Sundrop Fuels Rentech</td>
<td>Envergent (UOP/Ensyn) Kior</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butanol</td>
<td>Butamax</td>
<td>Gevo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol</td>
<td>Ethanol</td>
<td>Algenol</td>
<td>DuPont BP Abengoa Mascoma Iogen ZeaChem Qteros Coskata Lanzatech INEOS Bio</td>
<td>Range Fuels Enerkem</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algae</td>
<td>Enzyamatic / Fermentation</td>
<td>Gasification/FT</td>
<td>Pyrolysis</td>
<td>Catalytic</td>
</tr>
<tr>
<td>Biological</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Biological</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Virent’s BioForming® Technology

Leading catalytic route to renewable hydrocarbon fuels and chemicals.

Fast and Robust
- Inorganic Catalysts
- Moderate Conditions
- Industry Proven Scalability

Energy Efficient
- Exothermic
- Low Energy Separation
- Low Carbon Footprint

Premium Drop-in Products
- Tunable Platform
- Infrastructure Compatible
- Fuels and Chemicals

Feedstock Flexible
- Conventional Sugars
- Non-Food Sugars

Virent’s “Eagle” Demonstration Plant- Madison, WI

30 Issued/Allowed Patents
152 Pending Patent Applications

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Virent’s Capabilities

• Lab Capability (research)
  • >20 continuous and integrated lab plants
  • 0.5-200cc catalyst
  • 24/7 operation
  • Flexible design

• Demonstration Capability:
  • 10,000 gpy gasoline; 5,000 gpy distillate
  • “More commercial”
  • Product volumes
    • Fleet testing
    • Fuel Registration

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Virent at a Glance
The global leader in catalytic biorefinery research, development, and commercialization

>80 Employees

Financial

> $77 MM in Equity Funding, > $75 MM in Gov & Industry

Partners & Investors

Cargill

HONDA

The Coca-Cola Company

Infrastructure
The BioForming® Process

Converting Multiple Feedstocks to High Value Hydrocarbons

Familiar to Petrochemical Industry
- Similar Reactor Processing Practices
- Proven Catalytic Scale-Up Engineering
- Industry Experience Operating at Scale

High Quality Drop-in Products
- Premium Hydrocarbon Mixtures
- Tunable to Produce Desired Blends
- Adaptable to Provide Chemicals
- Compatible with Logistics Infrastructure

Cellulosic
Sugars
Starches

Aqueous Phase Reforming/Hydrodeoxygenation

Chemical Intermediates

Conventional Chemical Processing

Chemicals
Fuel Gas
Hydrogen
Reformate
Gasoline
Jet
Diesel

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Virent Gasoline and Chemicals projects

Shell Collaboration
• Gasoline process development & scale-up
• Collaboration completed 06/2013

NABC (US department of energy)
• Biomass derived motor fuels
• Techno economics of biofuels
• Project Close-out 11/2013

Coca-Cola Joint Development
• Customer acceptance of bio-renewables
• Long-term “Path to parity” with crude
Virent’s BioFormate® Product

- Due to the high energy density of aromatics reformate materials, these materials are blended into high performance gasoline to increase octane.

<table>
<thead>
<tr>
<th></th>
<th>Petroleum Reformate (Vol%)</th>
<th>Virent BioReformate Product (Vol%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paraffins</td>
<td>22.5</td>
<td>20.6</td>
</tr>
<tr>
<td>Naphthenes</td>
<td>0.7</td>
<td>3.9</td>
</tr>
<tr>
<td>Aromatics</td>
<td>60.8</td>
<td>64.4</td>
</tr>
<tr>
<td>Overall Totals</td>
<td>84.0</td>
<td>88.9</td>
</tr>
<tr>
<td>Typical RON</td>
<td>~95 - 105</td>
<td>105</td>
</tr>
</tbody>
</table>
Virent’s Product in Scuderia Ferrari Race Fuel

Virent has provided fuel to Ferrari/Shell for the past 3 seasons
Virent’s BioFormate® A renewable source of aromatics

**Reformate:**

- Primary source of the world’s aromatics (Benzene, Toluene, and Xylenes) which are vital building blocks for modern polymer fibers.
- Downward trending production due to shale gas and gasoline market dynamics leading to increase cost.
- Aromatics processing infrastructure would be compatible with Virent reformate for the production of PET and other polyesters.

*Figure: sources for aromatics.*
Virent Enables 100% RR-PET

- 100% Recyclable
- 100% Renewable

Adapted from Coca-Cola website graphic
http://www.thecoca-colacompany.com/citizenship/plantbottle_basics

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Chemicals Strategic Investors & Partners

Develop, deploy and commercialize at scale a renewable “petrochemical” platform that can utilize existing infrastructure

- Major shareholder
- Participating in feedstock development and commercial deployment

- Platform Research & Development
- Technology provider
- Feedstock R&D
- Catalyst development
- Operations

In Progress

- Development Partner
- In existing petrochem supply chain
- Scale-Up partner
- Market channels

- Demand and supply chain “pull-through”
- Strategic alignment on alternative feedstocks
- Support validation of final product
**Major Distillate Projects**

**Shell Collaboration**
- Distillate fuel production and process development
- Collaboration completed 06/2013

**FAA Award**
- Jet fuel production and qualification
- $1.5 MM Grant
- Project closeout 05/2013

**DOE Award**
- Cellulosic sugars to jet fuel
- $13.4 MM Grant
Virent’s Renewable Distillate

- Broad distribution of boiling points
  - Preferred over single components
- Tunable composition
  - Flexibility to maximize desired fuel
Polynuclear aromatics (2+ ring aromatics) increase particulate emissions.
Virent’s Renewable Jet Composition

Boiling Point

Polarity

Jet A

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### Jet Specification Evaluation
Wright Patterson AFB

<table>
<thead>
<tr>
<th>Specification Test</th>
<th>MIL-DTL-83133G Spec Requirement</th>
<th>JP-8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat of Combustion (measured), MJ/Kg</td>
<td>≥42.8</td>
<td>43.3</td>
</tr>
<tr>
<td>Flash point, °C</td>
<td>≥38</td>
<td>51</td>
</tr>
<tr>
<td>Freeze Point, °C</td>
<td>≤-47</td>
<td>-50</td>
</tr>
<tr>
<td>Density @ 15°C, kg/L</td>
<td>0.775 - 0.840</td>
<td>0.804</td>
</tr>
</tbody>
</table>

#### Physical and Chemical Properties

**Heat of Combustion** (measured), MJ/Kg

- **Virent 2013**
- **Excellent freeze point and density due to unique Virent jet composition**

**Flash point, °C**

- **High thermal stability ensures low levels of impurities**

**Freeze Point, °C**

**Density @ 15°C, kg/L**

### Distillation

<table>
<thead>
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<th>MIL-DTL-83133G Spec Requirement</th>
<th>JP-8</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% recovered (T₁₀), °C</td>
<td>≤205</td>
<td>182</td>
</tr>
<tr>
<td>EP, °C</td>
<td>≤300</td>
<td>265</td>
</tr>
<tr>
<td>T₉₀-T₁₀, °C</td>
<td>≥22</td>
<td>62</td>
</tr>
</tbody>
</table>

### Thermal Stability

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>260°C</td>
<td>325°C</td>
</tr>
<tr>
<td>Tube Deposit Rating</td>
<td>&lt;3</td>
<td>1</td>
</tr>
<tr>
<td>Change in Pressure, mm Hg</td>
<td>≤25</td>
<td>2</td>
</tr>
</tbody>
</table>

Virent 2013
Thank you.

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Madison, Wi