Virent BioForm® SAK: Enabling 100% Drop-In SAF

Brice Dally
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Parade of US SAF Commercialization Session
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Virent Forward Looking Statements

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Developing Opportunities for Renewable Markets

- Headquartered in Madison, WI
- Founded in 2002 on APR Hydrogen
- Acquired by Tesoro in 2016 and now a wholly owned subsidiary of Marathon as of 2018
- Commercial focus is on scale-up and first plant deployment
  - Virent, Marathon and Johnson Matthey (JM) working together to explore options for a first plant project to produce biofuels from corn sugars
  - The same platform produces bio-paraxylene, a key raw material for production of bio-polyester
- Also progressing next-generation technologies for further growth opportunities
The Virent Business Platform
Providing a pioneering technology platform to lead the energy evolution

A scalable bio-based catalytic technology to reduce the carbon footprint of everyday fuels and chemicals
A Carbohydrate Conversion Technology

Feedstock is readily available and provides opportunities for growth toward lower carbon sources without limiting access.

Initial Deployments
- CO Reduction >50%
- Potential for Net Zero

Future Deployments
Once Commercially Available

* Above numbers are in million tonne units and derived from the following data sets:
BioForm® SAK is the SAF Cut from BioFormate
Fuel engineered to have low PM emissions – No naphthalenenes

High density, low freeze pt SAK + low density, high freeze pt HEFA

<table>
<thead>
<tr>
<th>Test</th>
<th>Units</th>
<th>D1655 Limit</th>
<th>HEFA</th>
<th>SAK</th>
<th>20% SAK + HEFA</th>
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<tr>
<td>Aromatics</td>
<td>Vol %</td>
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<tr>
<td>Naphthalenes</td>
<td>Vol %</td>
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<tr>
<td>Density</td>
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<tr>
<td>Freeze Point</td>
<td>°C</td>
<td>&lt; -40</td>
<td>&lt; -40</td>
<td>&lt; -77</td>
<td>&lt;&lt; -40</td>
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</tbody>
</table>

30-70% PM reductions using 100% SAF (SAK/HEFA blend)
BioForm® SAK + SPK = 100% Drop-In SAF
Illustrative example with HEFA can extend to FT-SPK, ATJ-SPK, etc.

<table>
<thead>
<tr>
<th></th>
<th>Jet A</th>
<th>HEFA</th>
<th>SAK</th>
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<tbody>
<tr>
<td>1</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>5%</td>
<td>95%</td>
</tr>
<tr>
<td>3</td>
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<td>35%</td>
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<td>4</td>
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<td>95%</td>
</tr>
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<td>7</td>
<td></td>
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<td>80%</td>
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- **Drop In?**
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes

- **Lower PM?**
  - Yes
  - Yes
  - Yes
  - Yes
  - Yes
  - 35-70% reduction

- **100% SAF?**
  - Yes
  - Yes

- **Comments**
  - Enabled by SAK Annex
  - Enabled by HEFA Annex
  - HEFA density limits blending level
  - SAK allows higher HEFA blending
  - Not drop-in
  - Unique 100% drop-in SAF option

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100% Drop-In Makes SAF Adoption Simpler
Eliminates need to change aircraft or fueling infrastructure

Source: OIG analysis of Boeing and FAA data
100% “Drop-In” SAF is a Reality
Demonstrated in the lab, test flights and in commercial applications

Extensive Ground Rig & Engine Tests
Successful Initial Test Flight
World’s 1st 100% SAF Passenger Demo Flight

Final ASTM testing requirements under review with a target for completion and formal ASTM approval in 2022
Pursuing SAK Annex, then 100% Drop-In SAF
Working with industry at ASTM

1. SAK Annex in D7566 = SAK + Conventional Jet Fuel
   Targeting Dec 2022 ballot

2. 100% Drop-In SAF Annex in D7566 = SAK + other SAF
BioForming® is Ready for Commercialization
Demonstrated process to produce renewable fuels and chemicals

Demonstrate & Optimize at Scale
- Fully integrated “Eagle” demo plant currently running with all recycles included
- Currently producing 0.75 bpd of BioFormate® product per day
- Over 30,000 hours of operation on Eagle to date
- Commercial scale catalysts loaded and performing as expected while achieving established targets
- Current focus is optimization

Product Demo & Marketing
- Over 30,000 gallons of BioFormate® produced
- Over 2,000 gallons of SAK produced for 100% SAF
- Over 15 tonnes of BioForm® PX produced
- Renewable gasoline fleet trials and EPA certification demonstrated acceptability for commercial use
- 100% drop-in SAF test flight in 2015 demonstrated equivalent performance & 35-70% lower PM emissions
- 100% drop-in SAF demonstration flight in 2021 validated readiness for commercialization

Working collectively to license the technology

Key Development Partners

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3B Gallons SAF Can Be 100% Drop-In with SAK
Example to meet US SAF grand challenge 2030 target and beyond

3B gal/yr 100% drop-in SAF → 450M gal/yr SAK
1B gal/yr total low CI fuel → Only 4% of US corn sugar or cane, beet, biomass sugars

>2.5B gal
HEFA-SPK
FT-SPK
ATJ-SPK
Others

@ 15% SAK blend rate
assumes SPK = 760 kg/m³

~6 BioForming plants

Future focus on biomass

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Opportunities to Expand Markets
Broadening feedstocks & product offerings, further reducing carbon intensity

Feedstocks
- Ethanol
- Carbohydrates (Sugars)
  - Corn
  - Beet
  - Cane
- Cellulosics (Solvolyis)
  - Ag Waste
  - Woody biomass
  - MSW
  - Switch Grass
  - Miscanthus
  - Other Lignocellulosics

Technology and Processes
- Ethanol to Aromatics
- BioForming®
  - Aqueous Phase Reforming
- Hydrogen

Products and Markets
- Aromatics
  - NetZero BioForm® SAK Jet Fuel
  - BioForm® Gasoline
- Distillates
  - NetZero BioForm® PX
  - BioForm® Benzene
- Hydrogen
  - NetZero BioForm® SK Jet Fuel
  - BioForm® Renewable Diesel
  - Green Hydrogen for Transportation

OPTIMIZATION FOR LOWER CARBON INTENSITY:
- Renewable Natural Gas
- Wind & Solar
- CCUS
- Regenerative Farming
Thank you
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