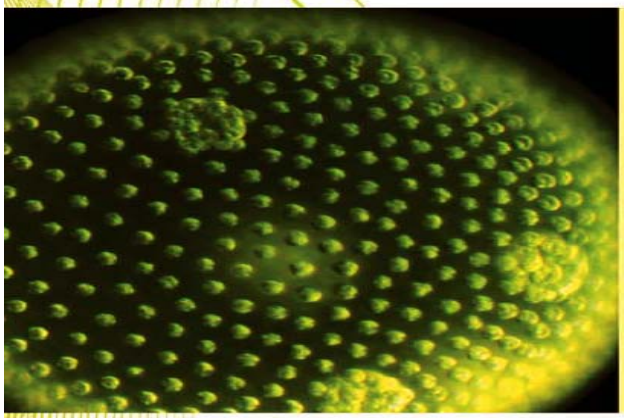
Evaluation of Bio-Derived Synthetic Paraffinic Kerosenes (Bio-SPK)



Billy Glover and Jennifer Holmgren

June 2009

Sustainable Aviation Biofuels

- Produce real “drop-in” fuels instead of fuel additives
- Leverage existing refining/transportation infrastructure
- Focus on path toward advanced generation feedstocks
- Improve aviation environmental performance

Oxygenated Biofuels

Ethanol

Biodiesel

Hydrocarbon Biofuels

Diesel

Jet

Gasoline

“Other” Oils: Camelina, Jatropha

First Generation

Natural oils (vegetables, greases)

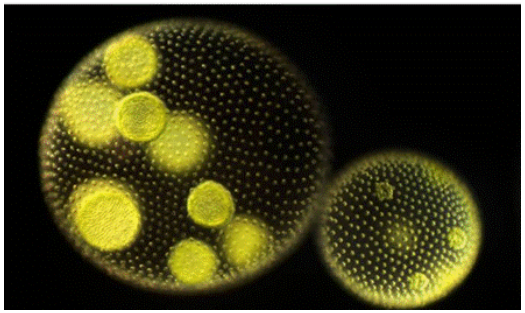
Advanced Generation

Lignocellulosic biomass, algal oils

Viable Bio-SPK feedstock alternatives

Algae

Ready in 8 to 10 years



Challenges

- **Technological innovation needed for processing**

Jatropha

Ready in 2 to 4 years

Challenges

- **Limited to warm climates only**
- **Mechanical harvesting isn't mature**

Halophytes

Ready in 2 to 4 years

Challenges

- **Proven at pilot scale**
- **Improve agronomy for cost reduction**

Camelina

Ready Now

Challenges

- **Limited total potential owing to yield**
- **Somewhat tied to grain market swings**

Viability is based on timing, technology and local resources

Sustainable Biofuels Research and Technology Program

- Evaluation focused on bio-derived Synthetic Paraffinic Kerosene (Bio-SPK) for aviation use
- Conducted comprehensive laboratory, engine and flight test program
- Broad industry involvement and support
- Executive summary of industry findings available today

Key fuel property comparisons: Neat

Property		Jet A/Jet A-1	ANZ Jatropha	CAL Jatropha/Algae	JAL Jatropha/Algae/Camelina
Freeze Point °C	Max	-40 Jet A -47 Jet A-1	-57.0	-54.5	-63.5
Thermal Stability JFTOT (2.5 hrs. at control temperature) Temperature °C	Min	260	340	340	300
Viscosity -20°C, mm^2/s	Max	8.0	3.663	3.510	3.353
Contaminants Existent gum, mg/100mL	Max	7	<1	<1	<1
Metals ppm	Max	0.1 per metal	<0.1	<0.1	<0.1
Net Heat of Combustion MJ/kg	Min	42.8	44.3	44.2	44.2

Table 2-3: Properties summary of neat Bio-SPKs against existing jet fuel specifications

Key fuel property comparisons: Blends

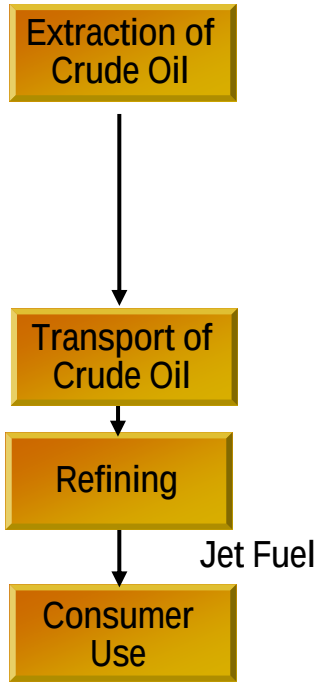
Property		Jet A/Jet A-1	ANZ Jatropha	CAL Jatropha/Algae	JAL Jatropha/Algae/Camelina
Freeze Point °C	Max	-40 Jet A -47 Jet A-1	-62.5	-61.0	-55.5
Thermal Stability JFTOT (2.5 hours @control temperature) Temperature °C	Min	260	300	300	300
Viscosity -20°C mm^2/s	Max	8.0	3.606	3.817	4.305
Contaminants Existent gum, mg/100mL	Max	7	1.0	<1	<1
Net Heat of Combustion MJ/kg	Min	42.8	43.6	43.7	43.5

Table 2-5: Properties summary for Bio-SPK jet fuel blends

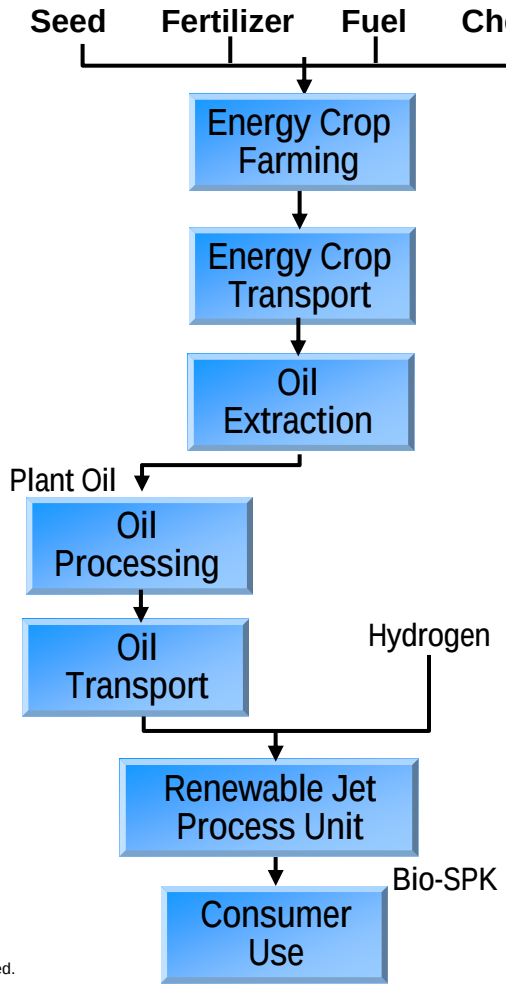
All Bio-SPK blends met or exceeded aviation jet fuel requirements

Life Cycle Assessment

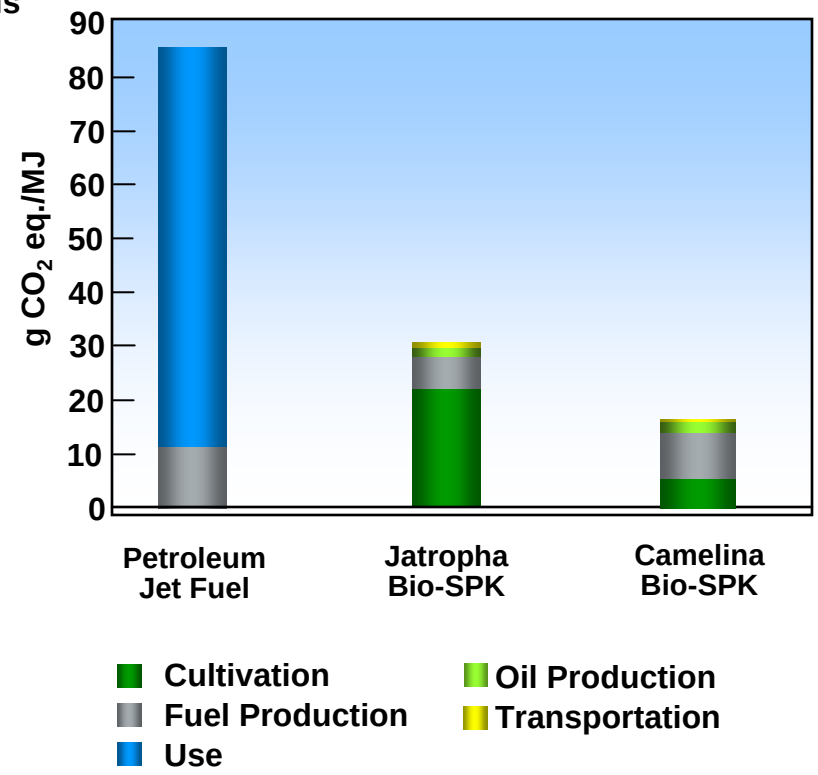
Petroleum-Based Fuels



Bio-SPK from Energy Crops



Well-to-Wheels Green House Gas Emissions



The knowledge base of advanced generation biofuels for aviation is growing

AIR NEW ZEALAND

“Scientific testing has found that up to 1.4 tonnes of fuel can be saved on a twelve-hour long haul flight powered by a 50/50 blend of second generation jatropha sustainable biofuel and traditional Jet A1.”

Continental Airlines

"The technical knowledge we gain today will contribute to a wider understanding of the future for transportation fuels."

BOEING

“The processing technology exists today and based on results we’ve seen, it’s highly encouraging that this fuel not only meets, but exceeds key criteria for the next generation of jet fuel. That tells us we’re on the right path.”

Honeywell

“In a series of tests in both propulsion engines and commercial APUs, Honeywell saw no degradation in engine performance or fuel consumption…the engines performed just as they would with traditional aviation fuels.”

Next steps on sustainable biofuels

- Preparing a comprehensive report for submittal to ASTM International fuel approval process
- Anticipating ASTM approval in 2010 in support of industry goal to accelerate availability and use
- Working across the industry on regional biofuel commercialization projects
- Continuing lifecycle analysis to verify sustainability of feedstocks and methods

Questions