

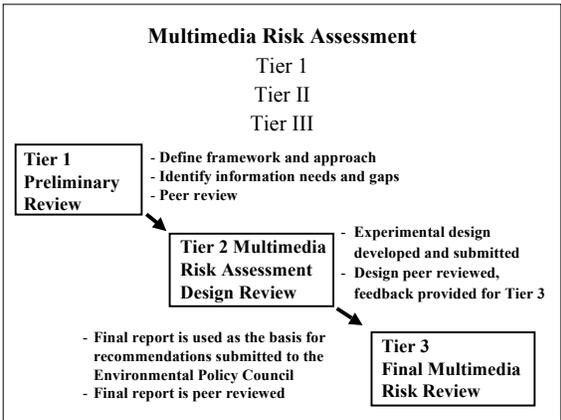
**Tier II Results for Multimedia
Risk Assessment of Biodiesel:
Relative Mobility,
Biodegradation, and Aquatic
Toxicity**

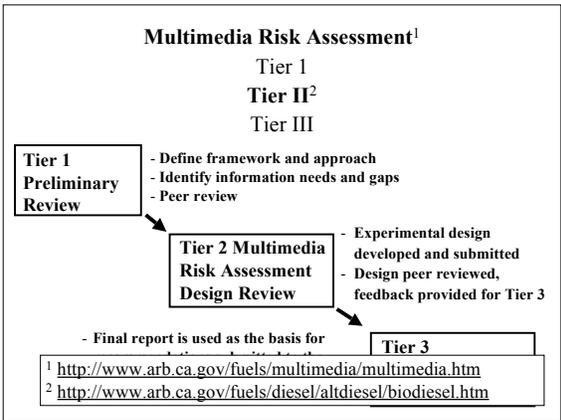
**8 December 2010 MMRA
Workshop**

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**Multimedia Risk Assessment¹
Tier II²
Experiments Performed**

- **Mobility**
 - Side-by-side infiltration in 2D “ant farm” flow cells
- **Biodegradation Tests**
 - Microcosm respirometry in soil slurry, 29 day
- **Aquatic Toxicity**
 - Suite of freshwater/estuarine toxicity tests

¹ <http://www.arb.ca.gov/fuels/multimedia/multimedia.htm>
² <http://www.arb.ca.gov/fuels/diesel/aldiesel/biodiesel.htm>

Mobility

Fuel Blends

Type	Feedstock	Totals	Additization			
			#	None Quantity	#	Bioextend Quantity
B100	Animal-fat	6	3	50 mL/test	3	50 mL/test
B100	Soy	3			3	50 mL/test
B20	Animal-fat	3			3	50 mL/test
B20	Soy	3			3	50 mL/test
ULSD	petroleum	15	15	50 mL/test		

Note: Experiments involve include side by side comparison between ULSD and Biodiesel within the same sandbox for consistency of sand compaction.

Mobility

- Image analysis of biodiesel vertical infiltration in Sandbox
- 30x20x2cm, #20 (coarse) sand, water table
- Soy- and Animalfat-based 100% and 20% blends, 1 additive

- **Sandbox preparation**
 - Wet-pluviated sand
 - Drain to water table
 - simultaneous 50mL ULSD#2 and biodiesel side-by-side, both dyed



- **Data collected**
 - infiltration rate in vadose zone
 - redistribution
 - lens form & surface area, on water table

Mobility

Soy B20a CARB ULSD#2

**Sample Results
Final Lenses**

- Soy B20 least different

Mobility

AF B100a CARB ULSD#2

**Sample Results
Final Lenses**

- Animalfat B100 strongest effect
 - similar travel times
 - Less lateral dispersion
 - thicker, deeper lens
 - more residual, less sfc area

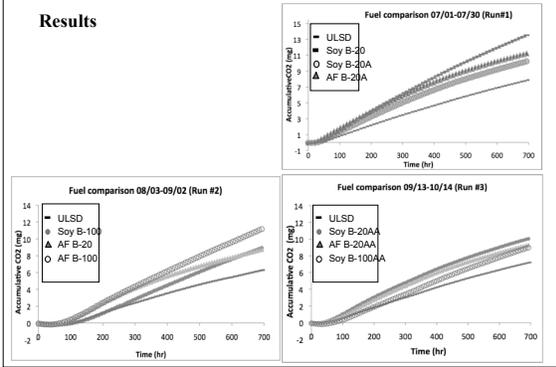
Mobility

Summary

- Minor differences in travel times
- AF B100a only shows Moderate differences
 - thicker lens formation
 - more residual

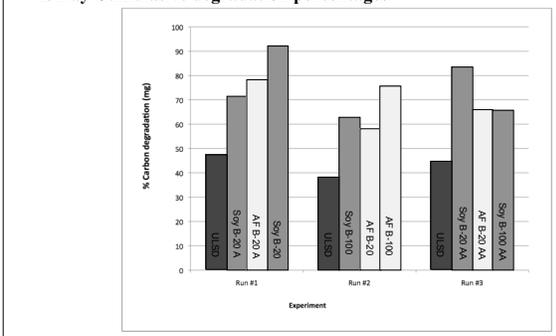
Biodegradation Tests

Results



Biodegradation Tests

29Day Cumulative degradation percentages



Biodegradation Tests

Summary

- All fuel blends more readily degradable than ref. fuel
- Soy-based blends somewhat more degradable than Animalfat-based blends
- 20% biodiesel blends somewhat more degradable than 100% biodiesel
- Additives effect are minor

Aquatic Chronic Toxicity Tests



- 6 fuel blends
- 3 freshwater and 3 estuarine organisms
- 6 dilutions plus a control per species/fuel
- Using published USEPA chronic toxicity testing protocols
- “100% solutions” produced using the “slow stir” method, defining equilibrium solubility conditions
- All tests met protocol QA/QC requirements

Aquatic Chronic Toxicity Tests

Details

- 6 Blends in addition to reference fuel (ULSD)
- Animalfat biodiesel (100% 20%, 20% w/additive)
 - Soy biodiesel (100% 20% 20% w/additive)
- 100% solubility solution by slow stir method
- solutions 100%, 50%, 25%, 10%, 5%, and 1%, w/stock
 - # 2 samples/test archived frozen for later analysis
 - # Replicates for particular combinations.
- Interpolate among dilutions to determine EC₂₅
- “Toxicity” as $TU = 100/EC_{25}$
 - # TU < 1 no effects
 - # TU = 1 effects seen only at 100% solution
 - # TU = 100 effects seen at 1% solution

Aquatic Chronic Toxicity Tests

Fuel Blends

Fuel Type ^a	Code
100% Ultra-Low Sulfur Diesel	ULSD
100% Soy Biodiesel	Soy B-100
20% Soy Biodiesel + 80% ULSD (w/w)	Soy B-20
20% Soy + 80% ULSD (w/w) amended with additive ^b	Soy B-20A
100% Animal Fat Biodiesel	AF B-100
20% Animal Fat Biodiesel + 80% ULSD (w/w)	AF B-20
20% Animal Fat + 80% ULSD (w/w) amended with additive	AF B-20A

Aquatic Chronic Toxicity Tests

Test Species

Category	Test Species	Test Type	Test Endpoints	Replicates	Temp.
Freshwater	Green algae (<i>S. coarctatum</i>)	96-hour static	Cell growth	10,000 cells/rep 4 reps/conc	25 ± 1 °C
	Water flea (<i>C. dubius</i>)	7-day daily renewal	Survival Reproduction	3 fish/rep 30 reps/conc	25 ± 1 °C
	Fathead minnow (<i>P. promelas</i>)	7-day daily renewal	Survival Growth	10 fish/rep 4 reps/conc	25 ± 1 °C
Estuarine/ Marine	Red abalone (<i>H. rufescens</i>)	48-hour static	Normal shell development	5 reps/conc 2000 embryos/rep	15 ± 1 °C
	Mysid shrimp (<i>M. bahia</i>)	7-day daily renewal	Survival Growth Fecundity	5 fish/rep 8 reps/conc	25 ± 1 °C
	Topsmelt (<i>A. affinis</i>)	7-day daily renewal	Survival Growth	5 fish/rep 5 reps/conc	20 ± 1 °C

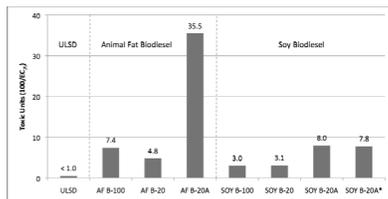
Aquatic Chronic Toxicity Tests

Results

- ULSD - low but detectable toxicity on mysid growth (1.0 TU) and *Ceriodaphnia* reproduction (1.8 TUc) only.
- No unaditized Animalfat or Soy Biodiesel blends produced detectable toxicity to the mysid, topsmelt or fathead minnow.
- Animal Fat and Soy B-100 and B-20 mixtures caused toxicity to algae cell growth, abalone shell development, and *Ceriodaphnia* survival and/or growth.
- Except for algae, the aditized Biodiesel B-20 test materials were substantially more toxic than the corresponding unaditized material.

Aquatic Chronic Toxicity Tests

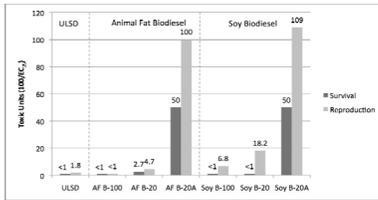
Examples



Red Abalone (*Haliotis Rufescens*) shell development

Aquatic Chronic Toxicity Tests

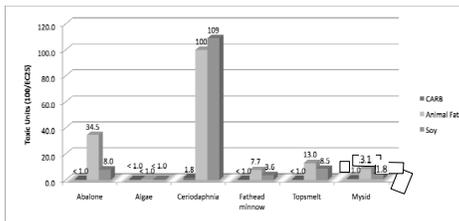
Examples



Water flea (*Ceriodaphnia dubia*) survival and reproduction

Aquatic Chronic Toxicity Tests

Summary Toxicity with additive



Toxicity apparent in all 6 species per growth endpoint

Aquatic Chronic Toxicity Tests

Summary

- Biodiesel blends are significantly more toxic than CARB ULSD#2
 - algae cell growth
 - abalone shell development
 - *Ceriodaphnia* survival and growth
- Biodiesel 20% blends with antioxidant additive were substantially more toxic than the corresponding unadditized blend
 - abalone shell development
 - *Ceriodaphnia* survival and growth

Tier II for Biodiesel Blends Tested

Summary

- Mobility
 - AFB100a shows thicker lens, more residual
 - due to higher viscosity, IFT

- Biodegradation
 - All biodiesel blends more readily degradable than ULSD
 - Soy-based blends, or 20%s, somewhat more degradable
 - Additives effect are minor

- Aquatic Toxicity
 - Biodiesel blends are more toxic than ULSD#2
 - Biodiesel 20% blends with antioxidant additive are more toxic than the corresponding unadditized blend

Tier II for Biodiesel Blends Tested

Summary

- Mobility
 - AFB100a only shows smaller lens, more residual

- Biodegradation
 - All biodiesel blends more readily degradable than ULSD
 - Soy-based blends, or 20%s, somewhat more degradable
 - Additives effect are minor

- Aquatic Toxicity
 - **Biodiesel blends are more toxic than ULSD#2**
 - Biodiesel 20% blends with antioxidant additive are more toxic than the corresponding unadditized blend
