Multimedia Risk Assessment of Biodiesel: Relative Mobility, Biodegradation, and Aquatic Toxicity

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Multimedia Risk Assessment

Tier 1
Tier II
Tier III

Tier 1
Preliminary Review
- Define framework and approach
- Identify information needs and gaps
- Peer review

Tier 2 Multimedia
Risk Assessment
Design Review
- Experimental design developed and submitted
- Design peer reviewed, feedback provided for Tier 3

Tier 3
Final Multimedia
Risk Review
- Final report is used as the basis for recommendations submitted to the Environmental Policy Council
- Final report is peer reviewed
Multimedia Risk Assessment

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Tier II
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- Final report is used as the basis for

1 [http://www.arb.ca.gov/fuels/multimedia/multimedia.htm](http://www.arb.ca.gov/fuels/multimedia/multimedia.htm)
2 [http://www.arb.ca.gov/fuels/diesel/altdiesel/biodiesel.htm](http://www.arb.ca.gov/fuels/diesel/altdiesel/biodiesel.htm)
Multimedia Risk Assessment\textsuperscript{1}

Tier II\textsuperscript{2}

Results to Date

- 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

\textsuperscript{1} \url{http://www.arb.ca.gov/fuels/multimedia/multimedia.htm}
\textsuperscript{2} \url{http://www.arb.ca.gov/fuels/diesel/altdiesel/biodiesel.htm}
Mobility

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

“Ant-farm” preparation
  - Wet-pluviated sand
  - Drain to water table
  - simultaneous 40mL CARB#2 and biodiesel side-by-side, both red

Data collected
  - plume motion in vadose zone
  - lens form & surface area, on water table
Sample Results
Final Lenses

• Soy B20 least different
Mobility

Sample Results
Final Lenses

• Animalfat B100
  strongest effect
  - similar traveltimes
  - Less lateral dispersion
  - Smaller, deeper lens
  - more residual, less sfc area
Mobility

Summary

- Minor differences in
  - traveltimes

- AFB100a only shows
  Moderate differences
  - smaller lens formation
  - more residuals
Biodegradation Tests

- 29-day Respirometry using soil slurry inoculum
  - Soy- and Animalfat-based 100% and 20% blends, 2 additives
- Microcosm preparation
  - 250 mL flask that consists of 200 ml mineral medium
  - 2 g soil (Yolo silt loam) as bacterial inoculums
  - 5uL of test substrate
- For each fuel type:
  - triplicate batch
  - one sterilize control (1% sodium azide) - showed no CO2.
Biodegradation Tests

Example Results

Fuel comparison 07/01-07/30 (Run #1)

Fuel comparison 08/03-09/02 (Run #2)

Fuel comparison 09/13-10/14 (Run #3)
Biodegradation Tests

29Day Cumulative degradation percentages

![Bar chart showing cumulative degradation percentages for different samples over three runs.](chart.png)
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 EC$_{25}$
- “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

### Details

<table>
<thead>
<tr>
<th>Category</th>
<th>Species</th>
<th>Duration</th>
<th>Endpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshwater</td>
<td>Green algae <em>(Selenastrum capricornutum)</em></td>
<td>48-hour</td>
<td>Cell Number</td>
</tr>
<tr>
<td></td>
<td>Water flea <em>(Ceriodaphnia dubia)</em></td>
<td>7-Day</td>
<td>Survival and Reproduction</td>
</tr>
<tr>
<td></td>
<td>Fathead Minnow <em>(Pimephales promelas)</em></td>
<td>7-Day</td>
<td>Survival and Growth</td>
</tr>
<tr>
<td>Estuarine/Marine</td>
<td>Abalone <em>(Haliotis rufescens)</em></td>
<td>48-Hour</td>
<td>Shell Development</td>
</tr>
<tr>
<td></td>
<td>Mysid shrimp <em>(Mysidopsis bahia)</em></td>
<td>7-Day</td>
<td>Survival and Growth</td>
</tr>
<tr>
<td></td>
<td>Topsmelt <em>(Atherinops affinis)</em></td>
<td>7-Day</td>
<td>Survival and Growth</td>
</tr>
</tbody>
</table>
Aquatic Chronic Toxicity Tests

Results

• ULSD - low but detectable toxicity on mysid growth (1.0 TU) and Ceriodaphnia reproduction (1.8 TUc) only.

• No unadditized 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 additized Biodiesel B-20 test materials were substantially more toxic than the corresponding unadditized material.
Aquatic Chronic Toxicity Tests

Examples

Red Abalone (*Haliotis Rufecens*) 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 Overall

• 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

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