



Superior performance, naturally.



Cargill
Industrial Oils & Lubricants

Green Industrial Products for The Environment

Presentation to the Great Lakes Regional Pollution
Prevention Roundtable Conference

Brent Aufdembrink
Cargill Industrial Oils and Lubricants

March 6, 2003

Cargill Industrial Oils and Lubricants Vision Statement

Cargill Industrial Oils and Lubricants is the leading global supplier of fats and oils and environmentally advantaged products to targeted industrial markets

Drivers For Market Development



Cargill Industrial Oils and Lubricants is able to add an environmental dimension to the traditional cost/ performance trade off

Biodegradable Lubricant and Industrial Products

- Why Use Biodegradable, Renewable Products?
- Definition of Biodegradability
 - Types of Biodegradability
 - Means of Testing – Standards
- Types of Products
 - Biodegradable Content
 - Standards of Performance
 - Competitive Issues/Products
 - Uses
- How can the Great Lakes Regional Pollution Prevention Roundtable accelerate the use of bioproducts?
- Cargill Products

Why Use Biodegradable, Renewable Products?

- Reduced Environmental Impact in case of spills
 - Rapidly biodegradable
 - Less toxicity to living organisms
- Safer
 - Higher flash and fire points than most mineral based fluids
 - Less toxic to organisms and humans
 - Food grade in many cases
- Reduced dependence on foreign oil
- Enhance economy in Farm States using renewable resources

Biodegradable Product Concerns

- Traditional product performance concerns;
 - For example oxidation, low temperature, antiwear, antifoam, etc. in Lubricants
- Will the product biodegrade, to what extent and how fast?
- What is the toxicity of the product?

Biodegradable Lubricant and Industrial Products

- Passenger Car Motor Oils
- Two Cycle Engine Oils
- Hydraulic Fluids
 - Tractor Hydraulic Fluids
 - Food Grade Lubricants
 - Antiwear Hydraulic Fluids
 - Gear Oils
- Transformer Oils
- Solvents – FAME

Vegetable Base Oils

Advantages

- Excellent boundary lubrication
- Lower viscosity with low volatility
- Good Viscosity index
- Biodegradable, nontoxic and environmentally friendly

Traditional Limitations

- Poor oxidative stability
- Poor low temperature properties
- Lack of viscosity range
- Limited additive technology

How is “Biodegradable” Defined?

Two general classifications (extent of)

Primary Biodegradation

Measures the loss of a product by alteration of the chemical structure resulting in loss or change of chemical nature of the product, but not the degree of degradation, i.e., partial or complete to CO₂ and water.

CEC L-33-A-93 is a test for primary biodegradation.

Ultimate Biodegradation (Mineralization)

Percentage of the substance that undergoes complete degradation to CO₂ and water, i.e., how long it takes to achieve a specific percentage of degradation.

ASTM D-5864 and EPA 560/6-82-003 are tests for ultimate biodegradation.

How is “Biodegradable” Defined?

Rate of biodegradation

Readily Biodegradable

Exhibits greater than a certain fixed percentage in a standard test. Most common are OECD301B-D, CEC L-33-A-93

Inherently Biodegradable

Degrade > 20% however have no defined test duration and are allowed to proceed as long as needed to achieve 20%.

Biodegradability Testing

Two Major Tests

- CEC L-33-A-93
 - Primary Biodegradation
 - IR method
 - Loss of -CH₂- absorbance in IR of extracted material
- OECD 301 B (modified Sturm)
 - Ready Biodegradability
 - Measures the Ultimate Fate of a Lubricant
 - Lubricant breaks down to give CO₂, H₂O, and inorganic salts.
 - Test lasts 28 days
 - 10 day window when lubricant must biodegrade >60% (Readily Biodegradable)
- Specifications will usually call for a higher amount of biodegradation if the CEC test is used than if the OECD 301 B test is used

Comparison of Rapid Primary Biodegradability

- Vegetable oil 95-100%
- Synthetic Esters
 - 2Ethylhexylcocoate 95%
 - TMPTriOleate 86%
- Mineral Oil 23-63%

CEC 33-L-93A

Willig, Chemosphere 43, 2001, 89.

Toxicity Testing

- **Acute Aquatic Ecotoxicity is determined by testing on plant(algae), vertebrate (fish)and invertebrate (daphnia).**
 - **Many types of plants, fish and invertebrates**
 - **Dependent on nature(location) of material being tested**
- **Acute Soil Ecotoxicity is determined by testing on invertebrate (earthworms) and plant (lettuce).**
- **Many additive companies do not have aquatic toxicity data for additives**
- **Aquatic toxicity concerns rule out some additives**
 - **Some Food Grade Lubricant additives are too toxic for aquatic life yet are safe for humans!**
- **Difficult, costly testing**
 - **Reproducibility**
 - **Standardization**
 - **Statistical evaluation important**

ASTM D-6046 Hydraulic fluids:

Toxicity results are used to classify the fluid

TABLE 3 Acute Ecotoxicity Classification

Ecotoxicity in Soil Designation	Ecotoxicity in Water Designation	Loading Rate, wppm LL50, IL50, or EL50
Ts1	Tw1	greater than 1000
Ts2	Tw2	1000-100
Ts3	Tw3	100-10
Ts4	Tw4	<10

Hydraulic Fluids

- Hydraulic Fluids Exist Based on Biodegradable/Renewable Base Oils
 - Different “levels” of Performance
 - Veg Oil
 - Polyol Esters
- Biodegradable Content is high – up to 90+%
- Additive Packages and technology are limited
- Approval warranted by completing pump testing by existing Standards
 - Vickers (35VQ) and Denison HF0 are two major tests
 - Very few biodegradable fluids have obtained approvals
- Used in environmentally sensitive areas
 - Wetlands
 - Forestry
 - Waterways
- Compete against
 - Conventional Mineral Oil Hydraulic Fluids
 - PAO based Hydraulic Fluids
 - White Oil Based Hydraulic Fluids
- Issues – Cost and performance vs mineral oil based hydraulic fluids

Bio-renewable Passenger Car Motor Oils (PCMO)

- Very challenging application for renewable based materials
- Renewable content of 20-30% possible
- Additive technology important
 - Overcome oxidative instability
- API/ILSAC certifications allow marketing as any other motor oil
 - Labeled with “star” on container
 - No veg based oil has yet achieved this certification
 - Product containing AP-560 has passed all tests
- Competes vs. conventional motor oils
- Reduces dependence on foreign oils

- More expensive than conventional motor oils

- How do we sell this to GLRPPR state vehicle fleets?
 - Cars and light trucks

Two Stroke Motor Oils

- Significant reductions in emissions of outboard motors being required.
- Engine modifications being implemented
 - Direct Fuel Injection 2 cycle
 - 4 Stroke
- Approvals
 - National Marine Manufacturing Association
 - JASO
- DFI engines require improved lubricity and deposit control over conventional 2 cycle oils.
- New renewable based containing formulas being tested
- Improved detergency relative to test formulations
- Potentially important for motors on waterways

- Issues
 - Hotter engines due to less air cooling of design
 - Deposit control important
 - Cost relative to conventional 2 cycle oils

Transformer Oils

- Conventional Mineral Oils in Transformer Oils can pose threat to environment if spilled
- Vegetable Oils with additives make excellent replacement (98% veg oil)
- Completely PCB, Dioxin, Furan free
- High flash and fire point relative to conventional mineral oil transformer fluids
 - Safer in applications near buildings and schools
- Dielectric properties are sufficient
- Improved lifetime over mineral oils shown in studies
 - To be proven in real life
- Emerging Technology
 - ASTM Specifications being defined
 - Fire Resistance verified by Factory Mutual and Underwriters Laboratory Approvals
- Main Issues
 - Relatively high cost of fluid
 - Potential longer life, retrofill, smaller transformers may accelerate adoption
 - Technology needs to be demonstrated in commercial applications
- How can the GLRPPR accelerate use of biodegradable transformer oils?

Solvents – Fatty Acid Methyl Esters

- Methyl Esters of vegetable oil
- Solvent properties for clean –up of grease, oil
- Low volatility
- Relatively high flash point compared to mineral oils
- Good solvency for oils and greases
- Low odor

- No standardized performance specification – try and see if applicable to each proposed use.

- Issues – cost relative to mineral spirits and other solvents

- Where are areas of interest for solvents in State of Illinois governments?

How Can “Biobased” Acceptance be Accelerated?

Farm Bill

The Farm Security & Rural Investment Act of 2002 (“Farm Bill”) establishes a new program for the purchase of biobased products by federal agencies.

Federal Agencies must give preference in purchasing to biobased materials if they:

- 1) Meets performance requirements
- 2) Not excessively expensive (provide value)
- 3) Available

- 12 Categories of Biobased Products

- Adsorbent
- Adhesives
- Alternative Fuels
- Bioplastics/polymers
- Solvents and Cleaners
- Construction materials, composites, plastic lumber
- Inks
- Landscaping materials
- Lubricants and functional fluids
- Paints and Coatings
- Personal Consumer Items
- Inks
- Tree free paper and alternative fibers

Definition of biobased and listing of products being developed at Iowa State University.

- Biobased content and Lifecycle impact analysis to be required.
- Industry to determine performance standards

How Can “Biobased” Acceptance be Accelerated?

- Many Regulations dictate/decide/influence permissibility or desirability of use
 - Dependent on applications and definitions
- Regulations covering disposal of used oils
 - Used Oil disposal covered under RCRA (Title 40 CFR Part 279)
 - Veg oil is “not” used oil
- Spills –
 - Classified as Hazardous or non-hazardous
 - Land or Waterbased Spill
 - EPA or Coast Guard Authority
 - All spills are treated equally
 - Regulations to date do not differentiate small vs. large spill
 - Can small spills be considered less hazardous with their own cleanup protocol?
 - Individual state regulations?
- Studies show reduced persistence and impact of veg oils on soils and crops in subsequent years relative to mineral oil.
 - Haigh, S. Science of the Total Environment 168(1995), 71.
- Recognition of this fact by EPA in regulation of spills
 - Relative economic benefit – cost effective to require \$30,000 for spill of 20 gallons of transformer oil??

Three main lubricant product lines



Formulated Hydraulic Fluids

Agri-SperseTM Water Dispersable Lubricants

Cargill Industrial Oils Oleochemical Products - For the Lubrication Industry

Products

- **Synthetic Esters**
 - **Interester Chemistry**
 - **Polyol Vegates**
- **TMP-TO Ester replacements**
- **Polyol Esters**
- **Fatty Acid Methyl Ester**
- **Free Fatty Acid**
 - **Tallow**
 - **Stearic**
 - **Soybean**
 - **Coconut**
- **Vegetable Base Oils**
- **Fats & Greases**

Biodegradable, Renewable Industrial Products

- Low Environmental Impact
 - Reduced Persistence in the environment
 - Rapidly Biodegradable
- Increased usage of renewable components – crop based
- Performance Meeting Industry Needs
 - Technology reducing price and performance gaps
- Low Toxicity
- Government Use Necessary to Drive Initial Demand
- Total Cost of Use Needs Increased Awareness
 - Government Promote Use
 - Implementing Environmental Policies