

# BioDiesel

## A Role for SAE

SAE Motor Vehicle Council

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# Topics for Discussion

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- What is BioDiesel?
- How much is out there?
- Why the recent interest?
- What are the issues?
- What standards exist?
- What should SAE do?



# What is BioDiesel?

- A path to get renewable energy into diesel fuel
  - Corn → Ethanol → E10, E85
  - Soy → FAME → B2, B5, B20, B100
- Vegetable oils are transformed into Fatty Acid Methyl Esters (FAME) to improved match to diesel fuel
  - Simple conversion using methanol over a catalyst
  - Separate the FAME from the catalyst and glycerine byproduct
- Various oil seeds can be processed to FAME
  - Rape seed/canola.....predominant in Europe
  - Soy.....predominant in NA
  - Sunflower                      - Palm                      - Others.....
- Waste cooking oil and animal fats are potential resources, but bring other issues
- There are other potential paths from renewable energy to diesel supplement
  - The National BioDiesel Board (NBB) says BioDiesel means FAME



# What is BioDiesel?

DOE is involved through NREL

## The oil source matters:

- Fatty acid types vary
- Differences carry into the ester
- Fuel properties are affected

## What is biodiesel?

- Mono-alkyl esters of fatty acids (i.e. methyl or ethyl esters)



100 lb triglyceride soy oil + 10 lb alcohol methanol = 10 lb glycerine (byproduct) + 100 lb Mono-alkyl ester Biodiesel

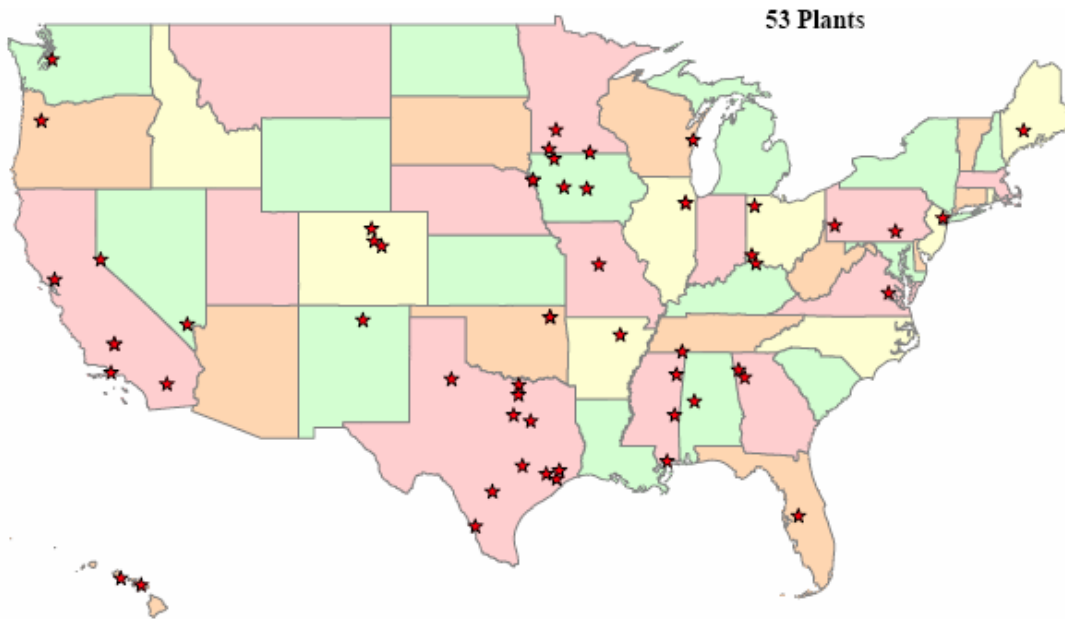
- Must meet the quality requirements of ASTM D6751
- Biodiesel is NOT unrefined vegetable oil or used cooking oil
- Typically used as blend with petrodiesel (up to 20%)
- Current U.S. average rack price \$2.78/gal (versus \$1.94 for No. 2 diesel)

DEER 2005 W Clark, NREL

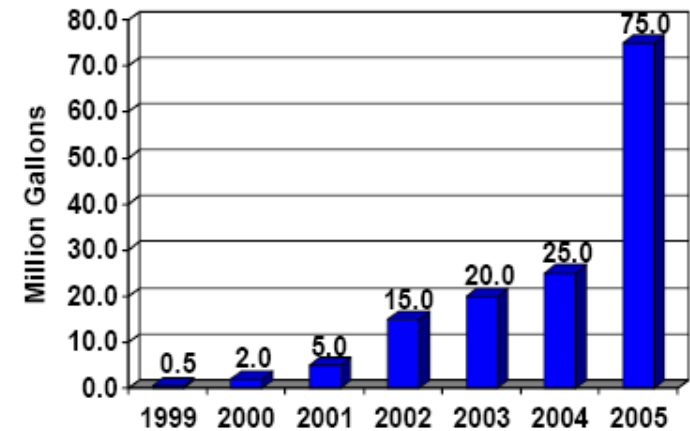
NREL National Renewable Energy Laboratory



# How much BioDiesel is out there?



Estimated US Biodiesel Production



	<u>Plants</u>	<u>FAME, M Gal/yr</u>				<u>Sold</u>	<u>Diesel Fuel</u> <u>M Gal/yr</u>	<u>FAME % of Diesel</u>	
		<u>Total</u>	<u>Soy</u>	<u>Canola</u>	<u>Other</u>			<u>Actual</u>	<u>Potential</u>
<b>2005</b>	53	354	250	0	104	75	64,000	0.1%	0.6%
<b>Construction</b>	40	329	203	13	113				
<b>Planned</b>	24	518	215	50	253				
<b>Total</b>	117	1201	668	63	470				1.9%

NBB <http://www.biodiesel.org/>



# How much BioDiesel is out there?

NREL predicts much larger long term potential if all sources are included

## U.S. Biodiesel Feedstock Supply

- 1.7 billion annual gallon resource
- 3.6 billion annual gallons by 2015
- Long-Term Potential: 10 billion annual gallons by 2030
- US on-road market: 40 billion annual gallons



DEER 2005 W Clark, NREL

Feedstock analysis from NREL/TP-510-34796, June 2004

NREL National Renewable Energy Laboratory



# Why the recent interest?

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- **Blender's Tax Credit.....\$0.01/gal for each 1% FAME**
  - \$1.00 for each gallon of B100
  - Brings the cost of FAME close to diesel fuel
- **Energy Policy Act (EPAAct)**
  - Requires an alternative fuel in 75% of government fleets
  - B20 is the only diesel fuel choice
- **Agriculture interest in a diesel transport fuel market**
- **National interest in energy security and renewable fuels**
- **State of Minnesota mandate for 2% in all diesel fuel**
  - Fall 2005
  - Waived in January due to plugged filters until quality issues corrected



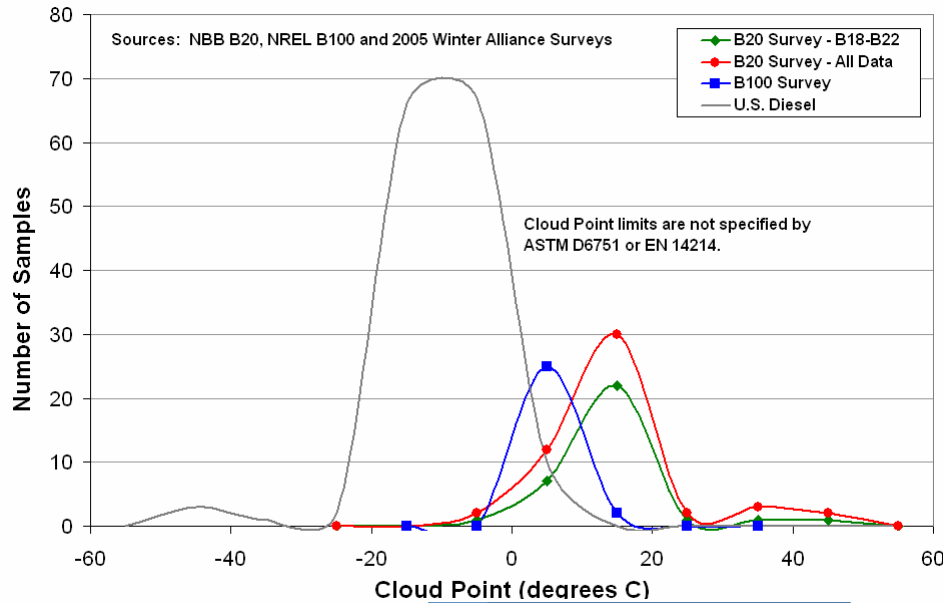
# What are the issues?

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- BioDiesel properties are a mixed story
  - Beneficial cetane, lubricity
  - Troublesome oxidation stability, cloud point, water pickup, corrosion
  - Wide variation in feedstock quality
  - Issues increase as the FAME content in the blend increases
- Reports of success and reports of failure are understandable from fuel properties and event history
- Manufacturers are reluctant to approve more than B5 until standards and quality control are in place.
  - DCX has approved B20 for fleets that accept the military B20 specification
- The market is unwilling to wait, and is experimenting



# The key FAME issues are cold flow and hot oxidation



**Cloud Point**  
Formation of wax leads to poor cold flow and filter plugging

FAME und FIE: Problemfelder & Anforderungen an eine Felderprobung **BOSCH**

### 1.2. Fettsäuren

VE L649 FD: 771 P-Nr.: 002455 Funktionssteller 20 Tkm Feld Schweden

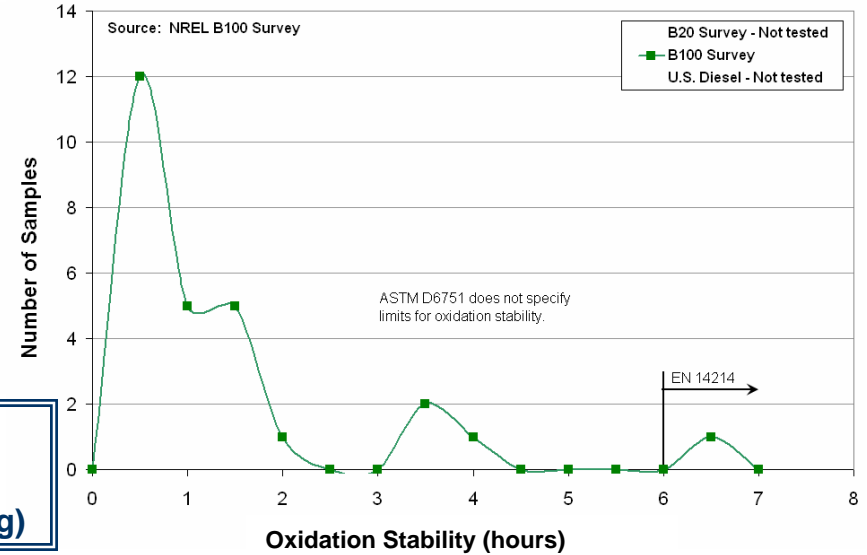
Massive Seifenbildung im Stellwerk der Verteilerpumpe VP37

FAME und FIE: Problemfelder & Anforderungen an eine Felderprobung **BOSCH**

### 1.3. Düsenverkokungen

oben: Düsenverkokungen aus dem RME-Betrieb  
rechts: Düsenverkokungen aus dem Betrieb mit Diesel

An Düsenverkokungen aus dem RME-Betrieb sind Glyceride und Natriumcarbonat ( $\text{Na}_2\text{CO}_3$ ) sicher nachgewiesen.  $\text{Na}_2\text{CO}_3$  entsteht aus Natriumionen und dem  $\text{CO}_2$  aus der Brennraumatmosphäre.



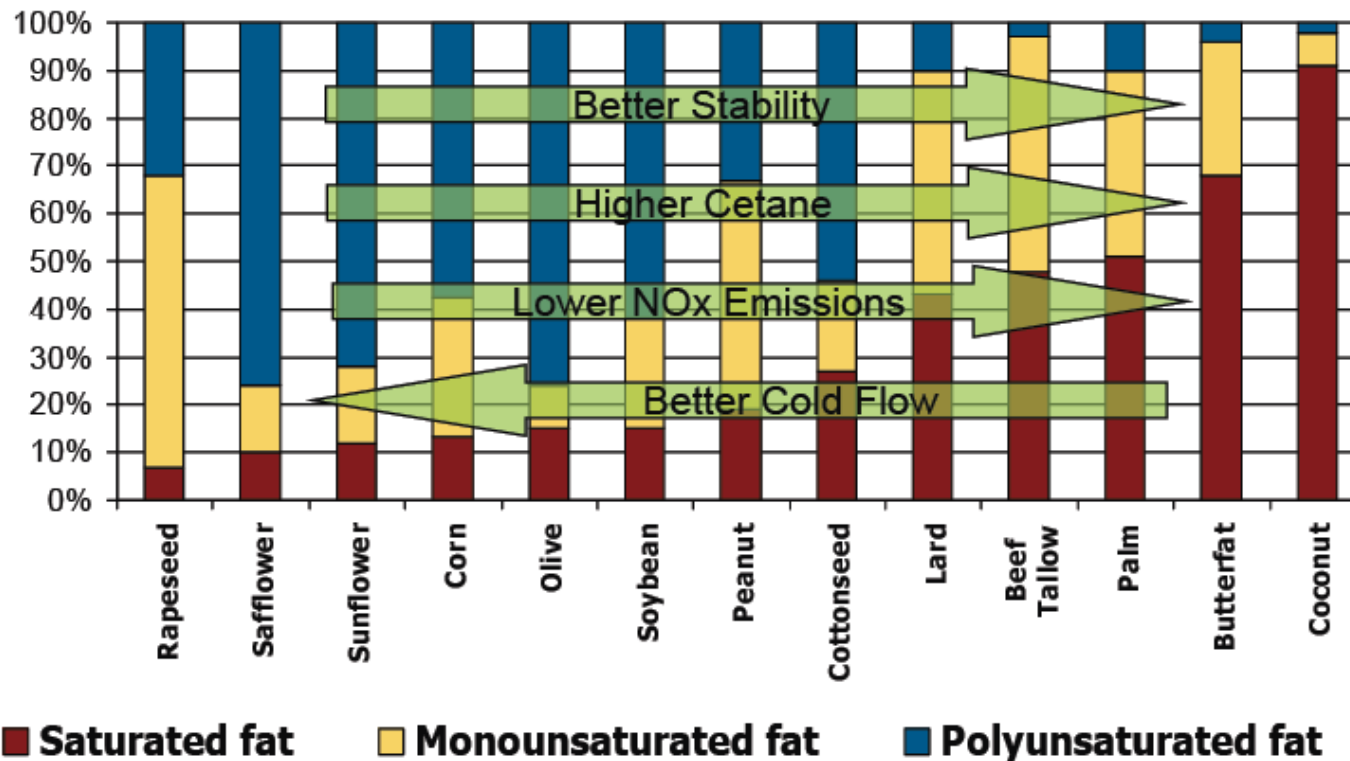
**Oxidation Stability**  
Unstable chemical composition leads to oxidation in storage, forming acids (corrosion) and insolubles (deposits, filter plug)



# Properties are linked to composition



## Composition of Fats and Oils

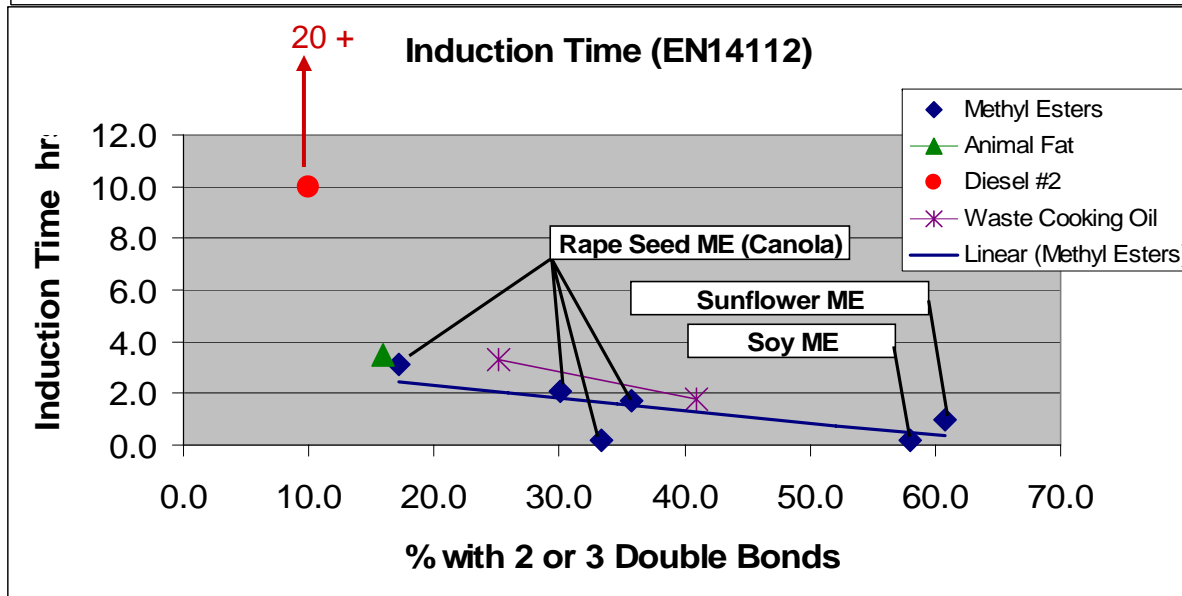
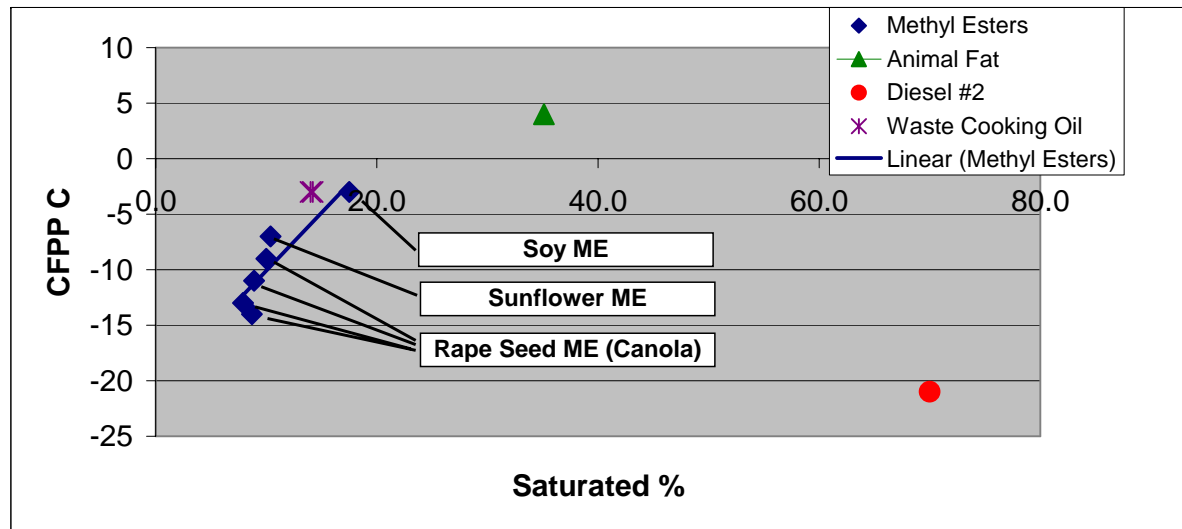


Information from National Renewable Energy Laboratory

Tom Weyenberg, personal communication



# Properties are linked to composition



- Cold flow depends on saturated content

- Oxidation stability depends on amount of unsaturated content

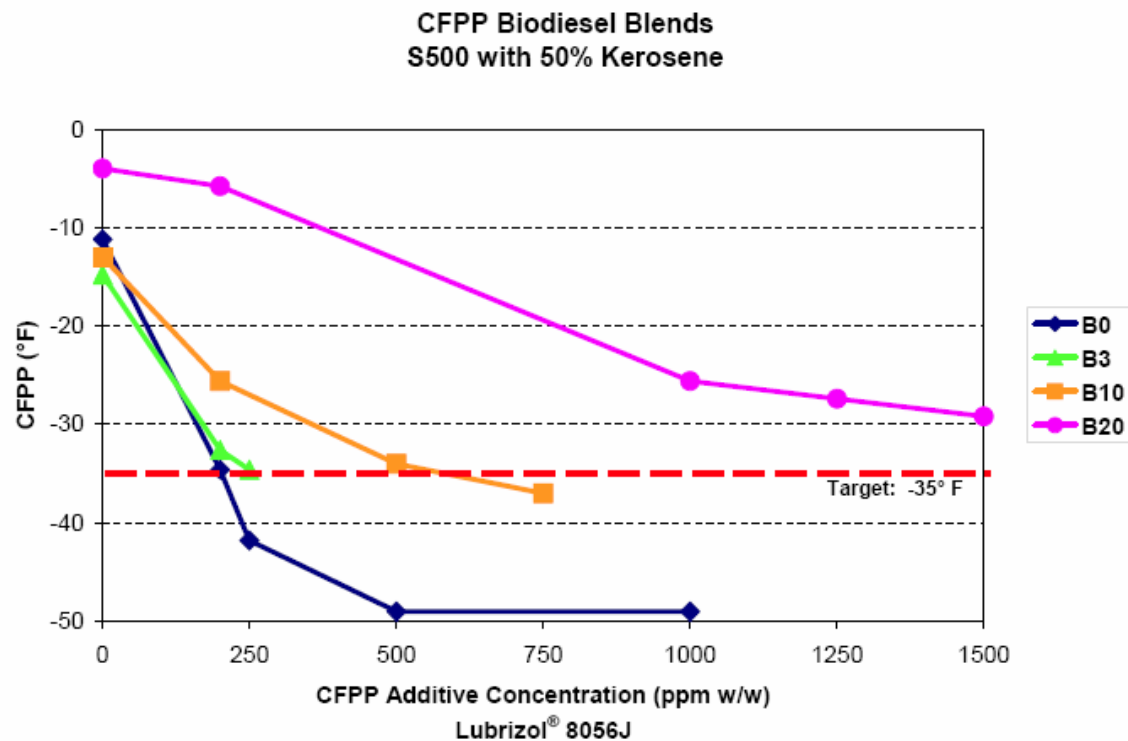
SAE 2004-01-3031 I. Miyata, Toyota



# Cold flow improvement will require:



## Additive Impact on Biodiesel Blend CFPP



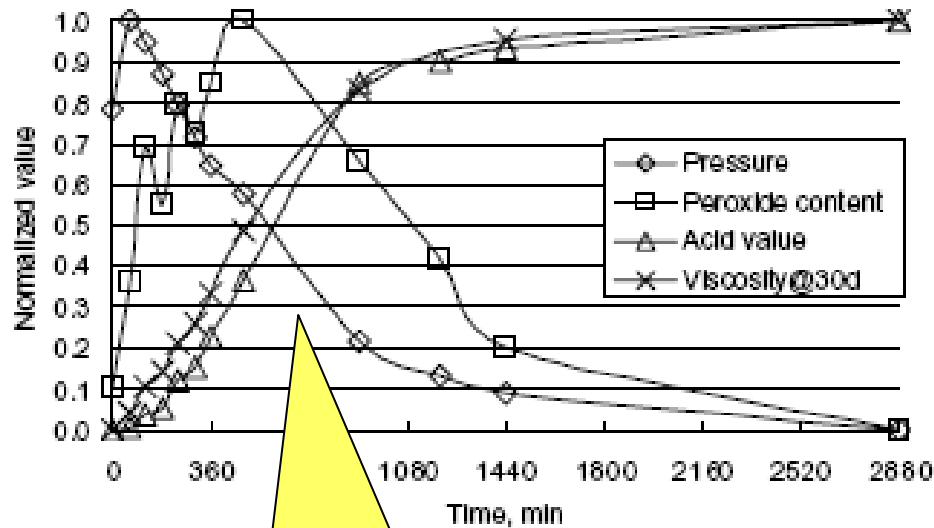
- Quality control of process to remove glycerine
- Selection of the base diesel fuel
- Heated FAME for cold blending
- Flow improving additives

Tom Weyenberg, personal communication



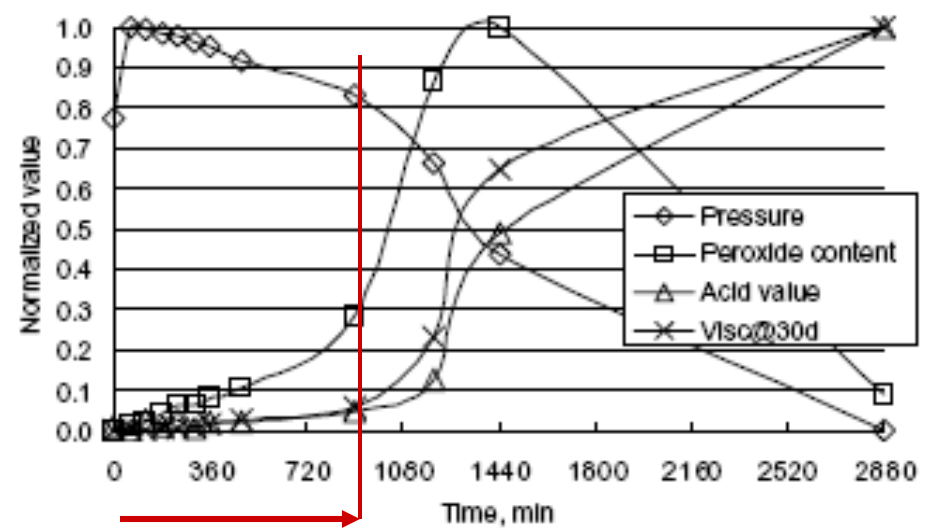
# Oxidation stability improvement will require:

- Additive treatment at the FAME plant
- Controlled heat / sealed storage history
- Limited storage lifetime



### Oxidation test

Oxygen is depleted and peroxides build followed by acids and insolubles



### Inhibitor additives

Oxidation inhibitors extend the induction time before rapid oxidation begins

SAE 2004-01-3031 I. Miyata, Toyota



# What standards exist?

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## Commercial fuel quality

- ASTM D6751 for B100 in NA (SME)
  - Needs oxidation stability and cold flow control
  - Debate continues over best methods
  - Proposals coming for June 2006
- ASTM attempts at a B20 spec have failed to date (oxidation stability)
- EN14214 for B100 in Europe (RME)
  - Uses EN 14112 for oxidation induction period at 6 hrs
  - Proceeding with B2-B5
- Military B20 CID A-A-59693
  - 20% D6751 B100, 80% D975 Diesel fuel
  - Adds Cloud Point, Cold Flow, and max storage life (6 months)

## Engineering development

- The challenge is just being defined
- Manufacturers are meeting within USCAR and EMA to become aligned

**There is a role for SAE**



# What should SAE do?

- SAE Fuel Systems Technical Standards Committee
  - Task Force to start in April 2006
  - Define BioDiesel test fluids for qualifying materials and for component development
  - Incorporate modifications into:
    - J1681 Gasoline, Diesel, and Alcohol-Based Fuel Surrogates for Materials Testing
    - J1748 Methods for Determining Physical Properties of Polymeric Materials Exposed to Gasoline/Methanol Fuel Mixtures

## Recommendation

- Develop an automotive position on the necessity of standards and quality control leading commercial introduction of fuel alternatives
- Drive this point home with state and federal regulators
- Monitor progress and provide direction to standards organizations and implementation programs as needed to assure quality delivery

