Natural Oils – The Next Generation of Diesel Engine Lubricants?

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OUTLINE

- **Introduction**
- **Current Technology**
  - **CI-4**
  - **Environmentally Acceptable/Friendly Fluid**
- **Renewable Technology and Resources**
- **Experimental Progress**
- **Needs**

INTRODUCTION

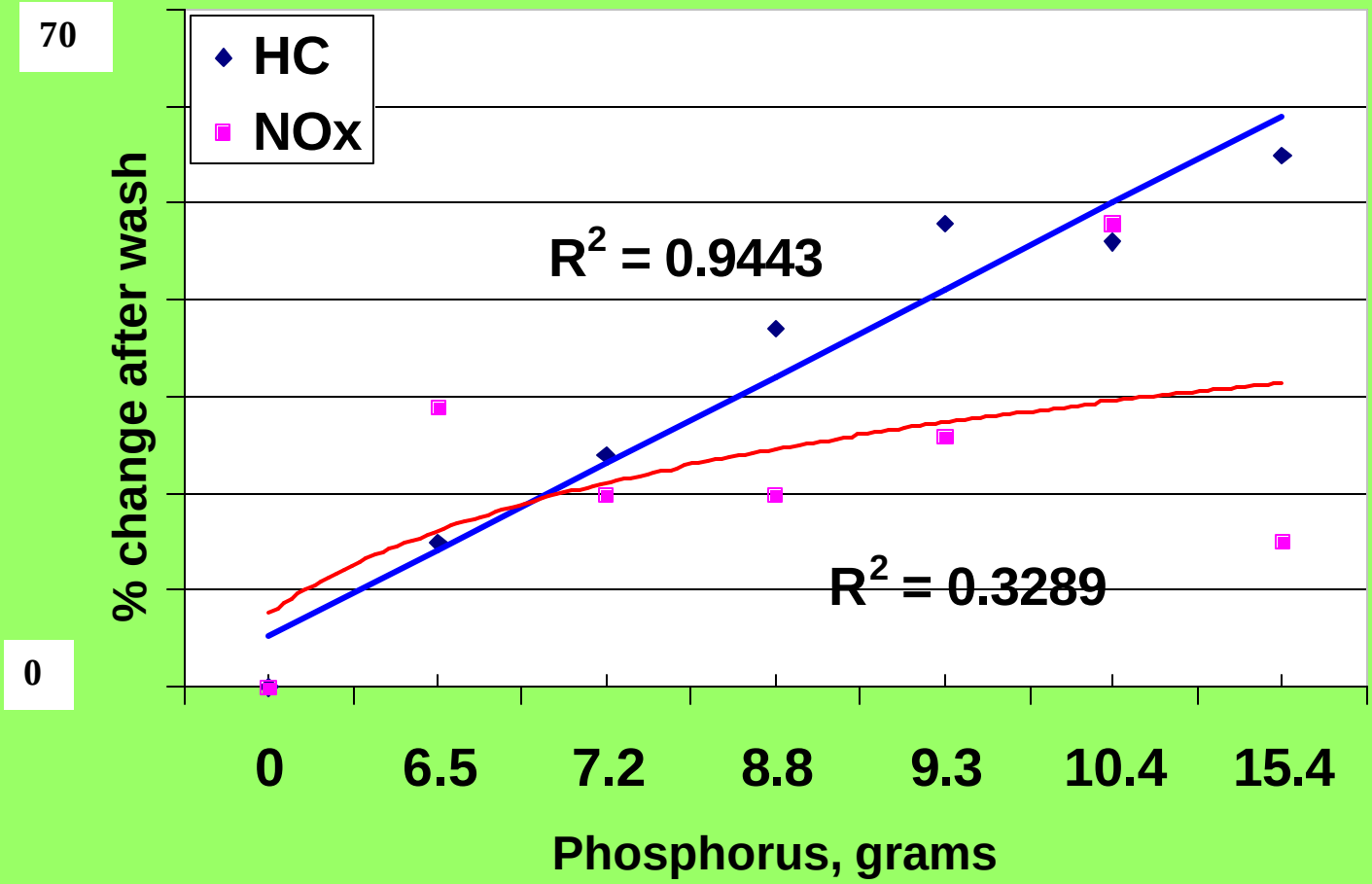
Future Diesel Engine Emission Regulations –

- **Ultra-low Sulfur Fuels**
- **Aftertreatment Systems**
- **Catalyst Compatible Engine Oil**

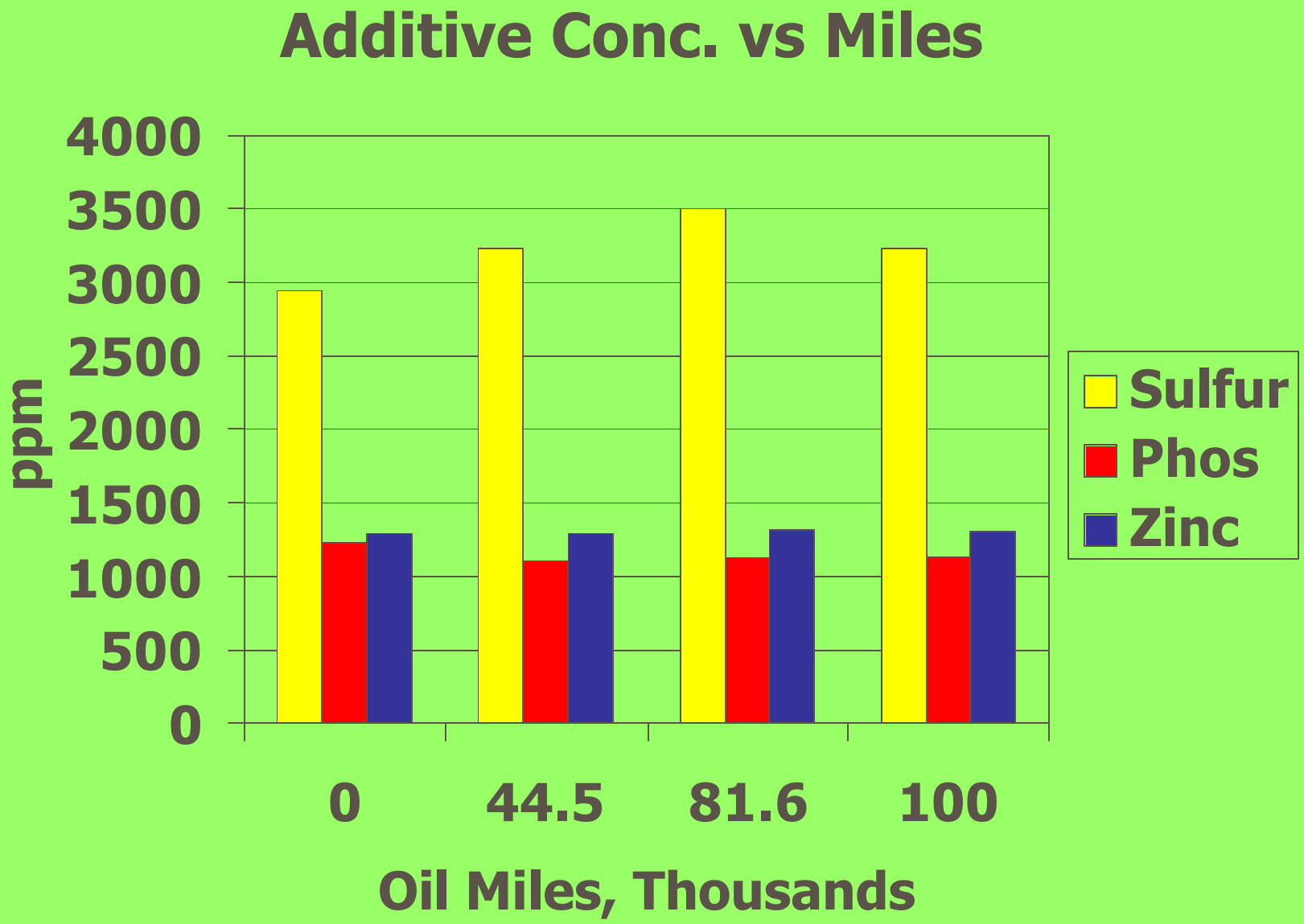
Aftertreatment Poisoning

- **Efficiency and Life**
- **Metals**
- **Sulfur, Phosphorus**

Effect of Phosphorus on Hc and NOx Emissions – Change after Catalyst Oxalic Acid Wash



From "Future Engine Oil Trends", Filter Technology Workshop, Stefan Korcek, Ford, (May 2001)



(EDI Oil analyses –Samples from same truck)

Introduction (continued)

- **“Evolution” versus “Revolution”**
  - **CI-4 : Evolution**
  - **PC-10 : A Quantum Jump**

Evolution of Diesel Engine Oils

API Designation	YEAR	No. of TESTS TO QUALIFY OIL	Purpose or Reason for Change
CD	PRIOR 1988	2	Deposits/Corrosion
CE	1988	5	Oil Consumption
CF-4	1990	5	Fuel Efficiency/PM
CG-4	1995	8	PM & S Reduction
CH-4	1999	12	NOx Red'n High Soot Extended ODI
CI-4	2002	15	Cooled EGR
(PC-10)	2007	?	Aftertreatment

CURRENT TECHNOLOGY

API CI-4

Designed to meet needs in 2002

- **Increased soot and corrosion related wear**
- **Changes in viscosity due to increased soot**
- **Oxidative thickening due to higher temperatures**
- **Oil consumption control**
- **Foaming, seals, viscosity loss due to shear**

API CI-4 ENGINE TESTS and PURPOSE

ENGINE TEST	PURPOSE	Comments
Caterpillar 1R	Piston Deposits, Oil Consumption	Two – piece Piston
Caterpillar 1K or 1N	Piston Deposits, Oil Consumption	Aluminum Piston
Mack T-10	Ring, liner, bearing wear, oil consumption	Cooled EGR
Mack T-8E	Viscosity Increase Due to 4.8% Soot	ASTM D5967
Cummins M11-EGR	Ring & Valve Train, Wear, Sludge & Filter Plugging	Cooled EGR
International 7.3L EOAT	Aeration	HEUI Injectors
GM 6.5 liter	Roller-Follower Wear	ASTM D5966
Sequence IIIF	Oil Oxidation	ASTM Seq. IIIF

API CI-4 Bench Tests and Performance Criteria.

TEST	PURPOSE	COMMENT
BOSCH INJECTOR	HIGH TEMPERATURE – HIGH SHEAR	
BOSCH INJECTOR	SHEAR STABILITY	ASTM D6278
MINI ROTARY VISCOMETER TP-1	LOW TEMPERATURE PUMPABILITY, SOOTED OILS	ASTM D4684
NOACK	OIL VOLATILITY	ASTM D5800
CUMMINS BENCH TEST	CORROSION	ASTM D6594
FOAMING TEST	FOAMING	ASTM D892
ELASTOMER COMPATABILITY REF. OIL TEST	ELASTOMER COMPATABILITY	ASTM D471

A related issue is whether renewable, natural oils can be used as the primary base fluid for future diesel engine oils.

Environmentally Friendly Base Oils

Biodegradable, Low Toxicity

And

A Renewable, Natural Product

Advantages & Disadvantages

Advantages:

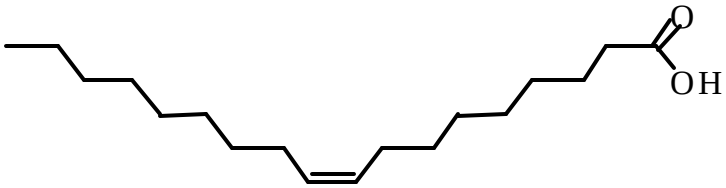
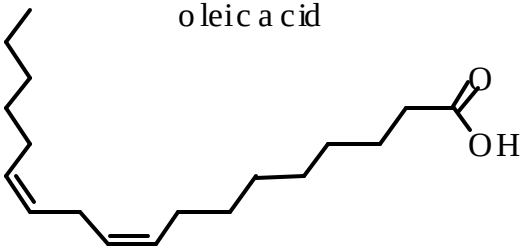
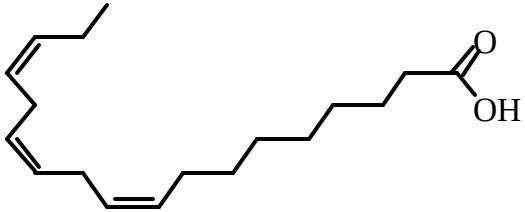
- Very High VI
- Biodegradable
- Non-toxic
- Renewable
- Domestically Produced

Disadvantages:

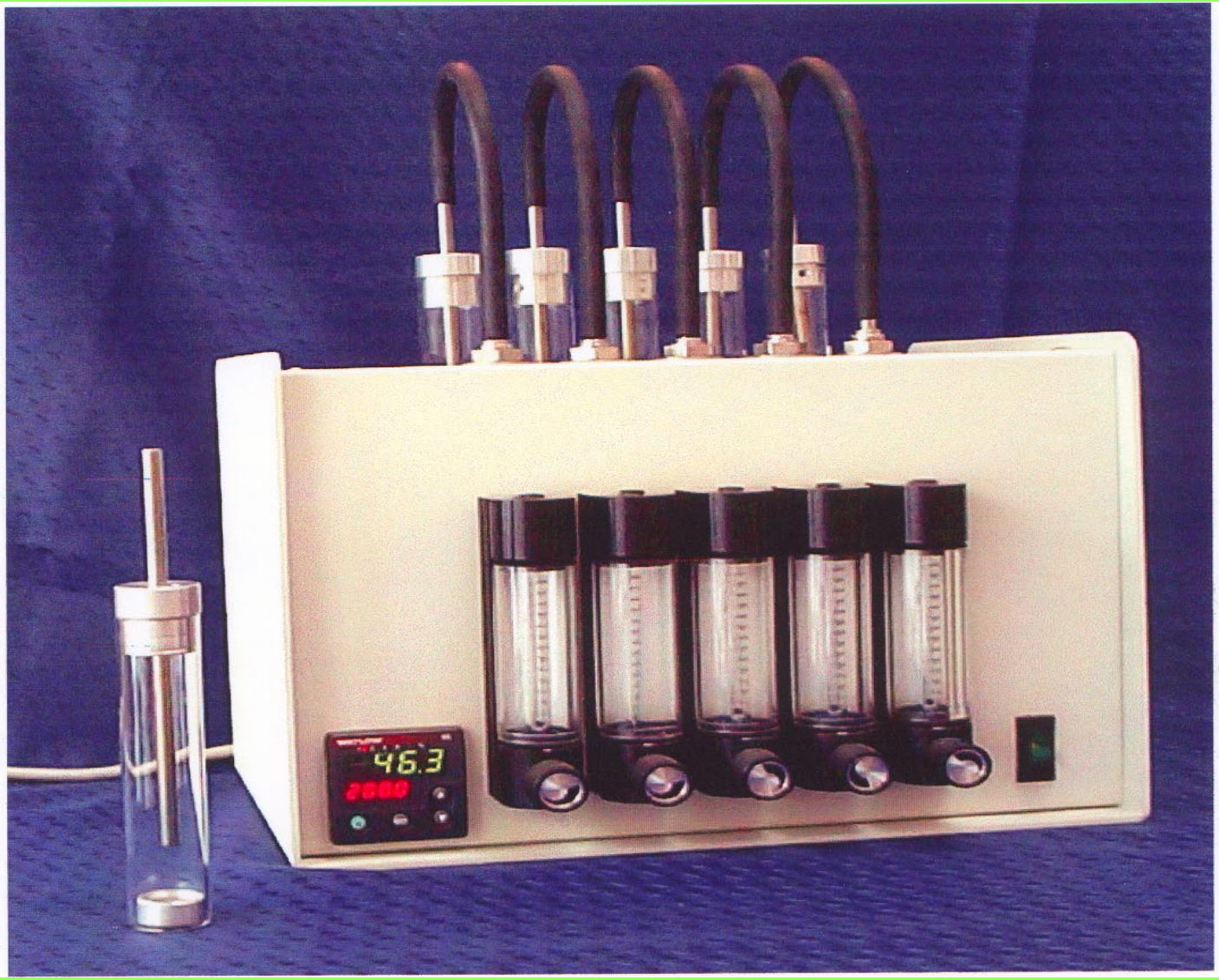
- Oxidation Stability
- Low Temperature Properties
- Hydrolytic Stability
- Availability
- Unproven Performance
- Cost

OXIDATION STABILITY

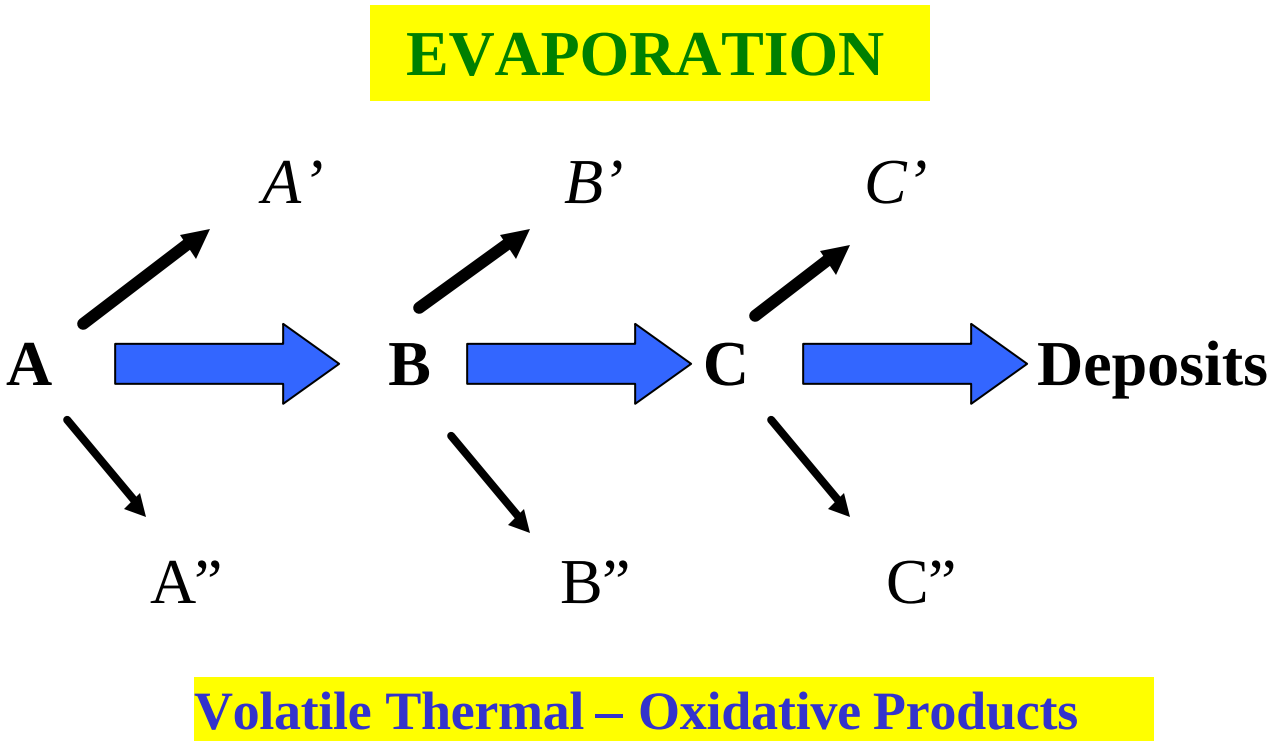
Structures and Properties of Some Unsaturated Fatty Acids

MP, C	# of Carbons	
4	18	 oleic acid
-5	18	 linoleic acid
-11	18	 linolenic acid

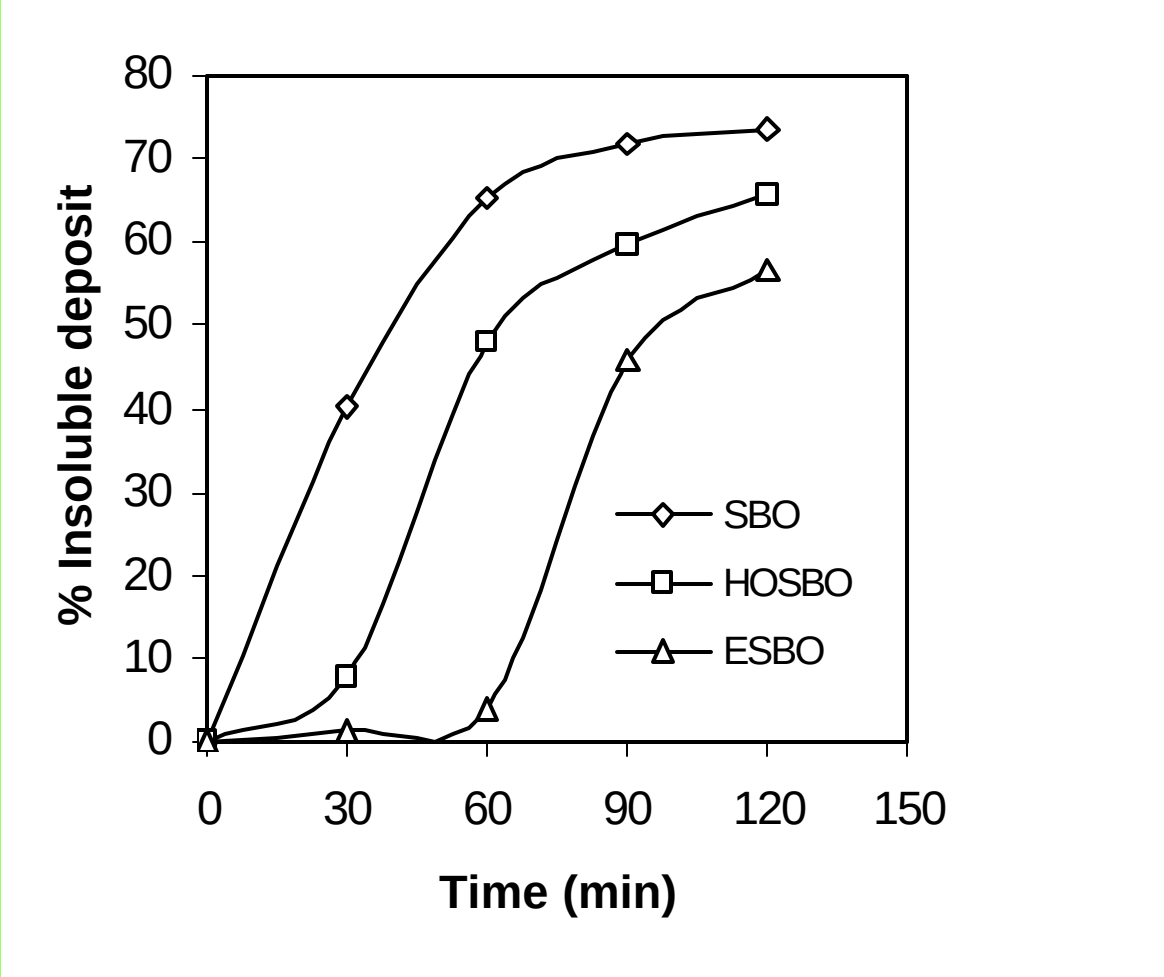
PSMO Oxidation Test



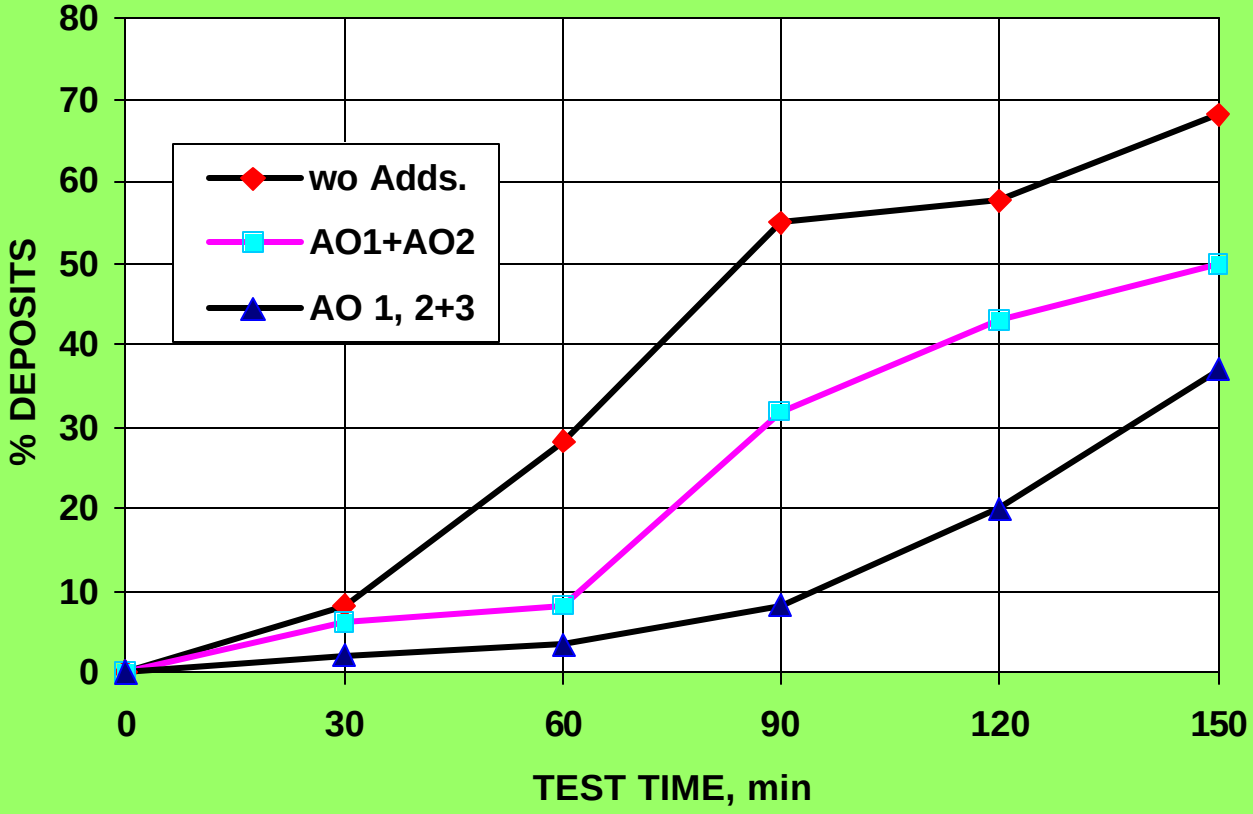
PSMO Deposit Formation Model



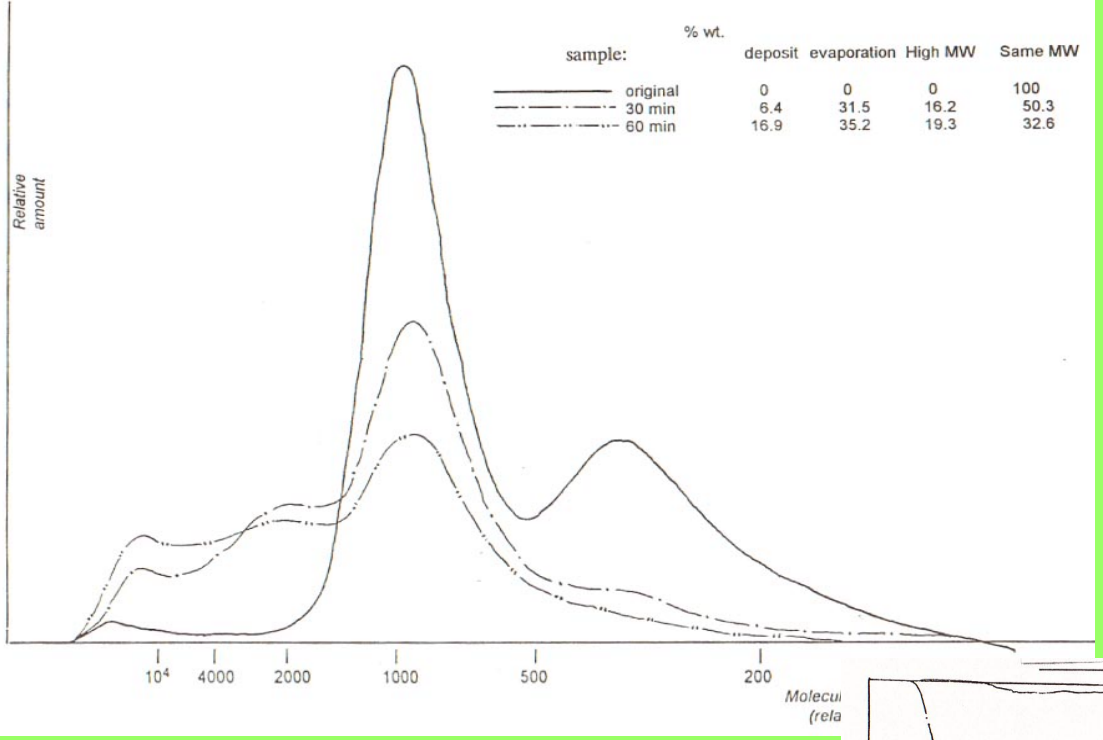
Oxidation Stability - Chemical Modification



Oxidation Stability - Additives

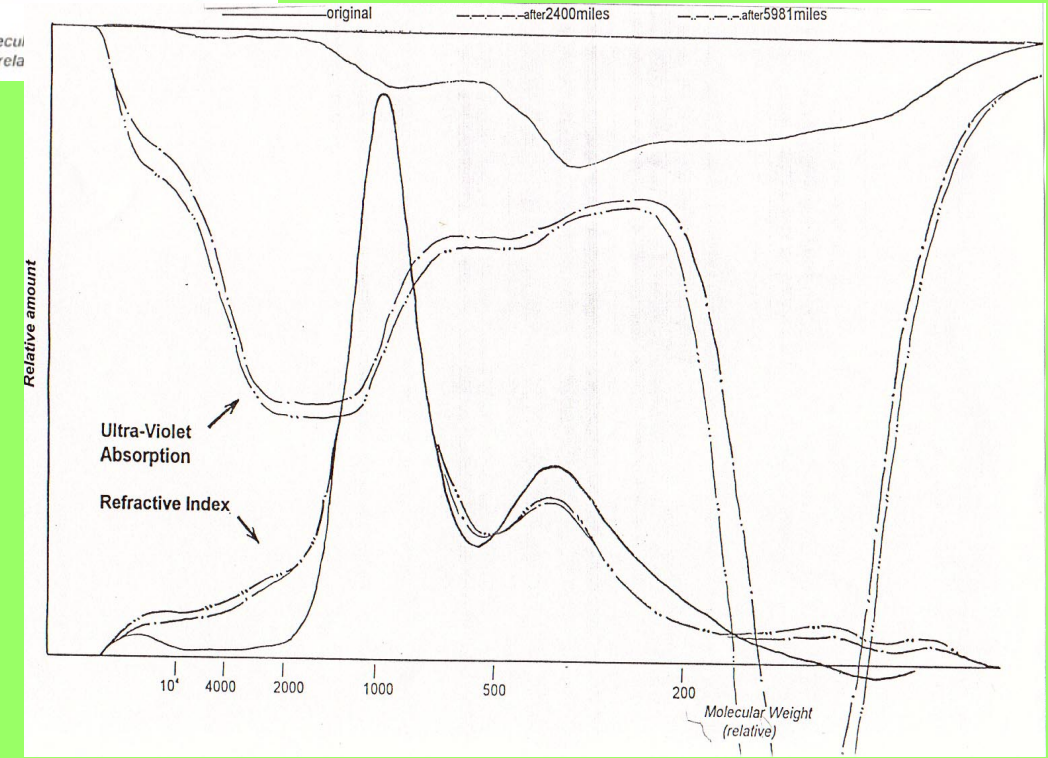


GPC - Analyses of Oxidized Oils

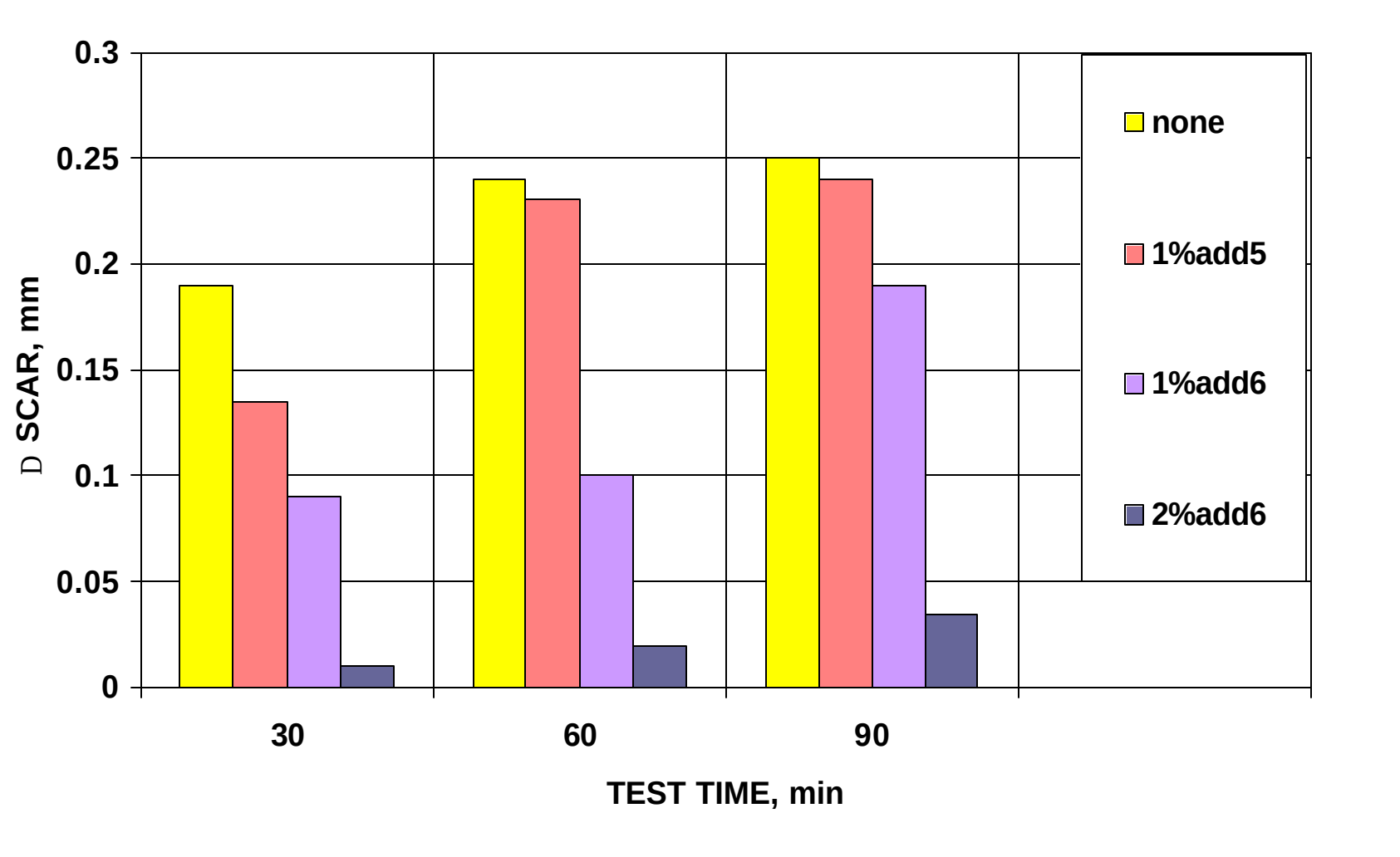


Laboratory

Vehicle – Used Oils



Wear – Soybean Oil



Fuel vs Available Vegetable Oil, Millions of Gallons per Year.

Requirement For	TOTAL DIESEL FUEL (1995)	TOTAL VEGETABLE OIL (1985)	19% OIL YIELD	AMOUNT REQUIRED for B20	AMOUNT 2% Veg Oil in Oxidized Fuel as Additive
U.S.	35,000	4616	877	7,000	840
World	187,000	12,475	2,370	37,400	3,740
Sources: www.bp.com,www.chevron.com, K. Wain PSU MS Thesis					

Questions

1. Level of ZDTP ?
2. Wear and Durability?
3. Adequate Friction?
4. Natural Resource Oils - Performance?
5. Adequate Resources?
6. Standardization – Specifications
7. PC-10

Answers

1. Emission & Catalyst data and analysis.

2 & 3. New Additive Technology.

4. Oxid’n & Hydrolytic Stability, Low Temp.
5. Higher Productivity
6. Team Effort
7. CI-4 Team Repeat

Needs – Recommendations:

- **Quantitative data on aftertreatment poisoning,**
- **Standardization – specifications for renewable oils,**
- **Total refinery concept – Optimize product quality,**
- **Continued research – Genetic & Chemical Modification and Additive Technolgy**
- **Evaluation of new products for PC-10 (performance and cost).**

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