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BIODEGRADABLE HYDRAULIC LUBRICANTS BASED ON MODIFIED VEGETABLE OILS

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The aim of this research study is to obtain biodegradable hydraulic oils characterised by improved oxidant resistance. The formulation of this type of lubricant is based on vegetable oils modified by selective hidrogenation process or using mixtures of vegetable oils with more stable base oil. That allows to obtaininig more appropriate chemical structures in order to realise the required oxidation resistance of hidraulic lubricants.

The study evaluates the laboratory testing results of modified vegetable oils lubricating characteristics and hydraulic oils obtained from base oil mixture and suitable additives.

1.INTRODUCTION

Vegetable oil-based lubricants are emerging as an environmentally preferable alternative to established petroleum oil products. Vegetable-based oils have a good biodegradability and pose a greatly reduced threat to human health and the environment. Corn, sun flower, canola, soy, and other vegetable oils are being used to produce a wide range of lubricants, many which meet Original Equipment Manufacturer's (OEM) performance and warranty requirements [1].

The lubricants including a large and various types of oils as engine oils, hydraulic oils, compressor oils, turbine oils, slide way oils, transmission oils, greases, metal working fluids, preservative fluids and so on. After engine oils, the hydraulic oils are the most utilized type of lubricant. Different types of vegetable-based biodegradable hydraulic fluid for use in heavy equipment is moving toward commercialization [2].

There are a great number of mechanical systems with hydraulic components. Hydraulic systems use fluid (hydraulic oil) to transfer energy to move parts in such systems. In an automobile, for example, a particular kind of hydraulic fluid (brake fluid) transfers pressure on the brake pedal to the brake shoes, and stops the car.

2. CHARACTERISTICS OF HYDRAULIC OILS

First and foremost amongst the other characteristics required is enhanced adequate fluid viscosity and anti-wear properties.

Other characteristics of importance include the following:

- oxidation resistance – important with a growing tendency for bulk oil temperatures to increase in many hydraulic systems;
- thermal stability – to resist degradation and attack of metals at high temperatures;
- corrosion resistance – to avoid harmful attack on the variety metals used in hydraulic systems;
- water separation – to avoid problems of emulsification with small quantities of water entering the system trough condensation;
- air-realease and antifoam properties – to avoid cavitation effects and increased compressibility.

The specific range values of these characteristics is regulate by standards as DIN 51524, NFE 48603, DENISON HF-O, CINCINNATI MILACRON .

3. COMPARISON BETWEEN VEGETABLE OILS AND OTHER BASE OILS

Nowadays, the lubricants market is divided like this:

- Mineral oils (92-94%)
- Synthetic oils (5-6%)
- Vegetable oils (1.5-2%)

The data about such type of oils, concerning the lubricating properties, environmental impact and extent, emphasize the following aspects:

Tabel no.1 Lubricants comparison

Oil type	Lubricating properties	Biodegradability	Renewability	Extent	Price
Mineral	good	low	low	very good	good
Vegetable	acceptable	very good	very good	low	acceptable
synthetic	very good	partial	-	low	high

Evaluating these results it can notice the indication “very good” for mineral type as regards the extent, for vegetable type concerning biodegradability and renewability and for synthetic referring to quality.

The vegetable oils have a promising potential to be used for lubricants manufacture, considering nowadays regulations concerning biodegradability, renewability and toxicity.

But, the environmental impact and human safety represent only a part of the imposed requirements of lubricant oils. For specific applications of the lubricants we have to consider a lot of aspects referring to the work conditions.

To satisfy this requirements, the feed stock for lubricating oils fabrication, respectively lube base oils and additives, have to accomplish some important characteristics as :

- viscosity corresponding to the designed working parameters;
- high viscosity index;
- low pour point;
- high flash point;
- high oxidation resistance
- high biodegradability grade;
- other (corrosion resistance, wear protection, extreme pressure resistance, foaming tendency, demulsibility etc)

Refering to these properties, the table 2 shows the average values of the characteristics, for three representative base oil types: vegetable oils, mineral oil and synthetic oil.

Tabel no.2 Tested characteristics.

Characteristics	Veg.oil Sunflower	Mineral oil ISO-VG 32	Syn.oil PAO 6	Test method
Kinematics Viscosity at 40°C, cSt at 100°C, cSt	 31,85 7,62	 29,50 4,93	 31.16 5.78	 ISO 3104
Viscosity Index	222	92	129	ASTM 2270
Pour Point °C	- 9	- 12	- 40	ISO 3016
Flash Point, °C	260	210	210	ISO 2592
Oxid. stability RBOT, min.	10	60	100	ASTM 2272
Acidity, mg KOH/g	6	0,005	0.03	ASTM 974
Biodegradability, %	> 90	< 50	> 70	CEC L-33-A-934

As it can notice, the vegetable oils have remarcable viscosity index, flash point and biodegradability but poor acidity, pour point and completely unsatisfactory oxidation resistance.

The mineral oils have a good viscosity index, flash point, pour point, acidity and oxidation resistance but a low biodegradability capacity.

The synthetic oils as poly-alpha-olephin, have a very good viscosity index and pour point, good flash point, acidity and oxidation resistance and an acceptable biodegradability capacity; the only problem is the expensive price.

Refering to vegetable oils, the application of this type of base oil at lubricants manufacture is conditionated by oxidation resistance improuving .

Considerring that, what could be the solution ?

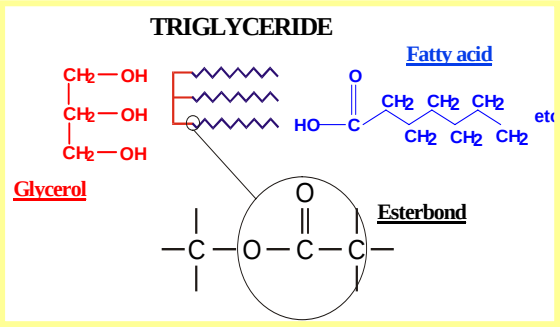
- to modify the chemical structure;
- to add appropriate additives;
- to mix vegetable oils with more suitable types of base oils;

4. LABORATORY TESTS

The first step of research study was to modify the chemical structure of the vegetable oils.

It is known that vegetable oils are natural esters - triglyceride type (Fig,1).

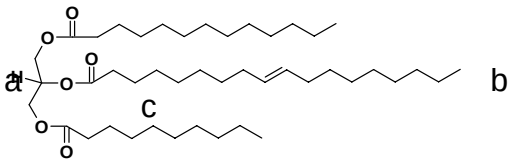
Fig.1 Vegetable oils chemical structure



Theirs chemical structure have three labile structure element (fig.2) [3]:

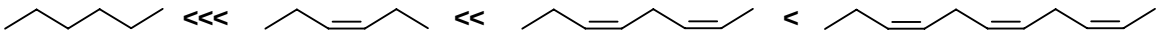
- Hydrogen Atoms in the β-Position (a)
- Unsaturated double bonds (b)
- Sterically low hindered Ester groups (c)

Fig.2 Specific structure element



Also, relative reactivity of stearic-, oleic-, linoleic and linolenic- acids towards oxidative degradation is diferrent (fig.3):

Fig.3 Relative reactivity



rel = 1 **rel = 100** **rel = 1200** **rel = 2500**

Considering these facts, the idea of the research study was to hidrogenate the acids unsaturated bonds in order to stabilize the vegetable oils.

It was perform a series of hidrogenation process, on diferrent conditions concerning hydrogen ratio, temperature, presure and cathalyst composition, but the results wasn't suitable: it isn't obtain more stable vegetable oils structures. It must to try more selective catalyst composition, to find appropriate methods for catalyst particles separation and establish most suitable process parameters.

So, the next step was to mix the vegetable oils with appropriate base oils and performant additives.

The study was developed taking in account the fallowing base oil: synthetic oil – PAO 8 and vegetable oil –Sunflower .

The main characteristics of these components, tested in the ICERP laboratory, are presented in the table no.3.

Table no.3 Base oils characteristics

Characteristics	PAO 8	Sun flower	Test method
Viscosity at 40 ^{0}C, cSt	46.88	32.6	ISO 3104
Viscosity at 100 ^{0}C, cSt	7.78	7.64	ISO 3104
IV	135	216	ASTM 2270
Pour point, ^{0}C	< -40	- 9	ISO 3016
TAN, mg KOH/g	< 0,03	2.0	ASTM 974
RBOT, minutes	90	5	ASTM 2272

The additives used for the mixtures was:

- antioxidants additives
  AO: dialckyl-dithiophosphate type;
- depressant additives:
  Dep: poly-alpha olephin

The compositon of the mixture is detailed in table no.4

Table no.4 Compositions of the mixtures

Components	Mix.1	Mix.2	Mix.3	Mix.4
AO, %	-	0.6	-	0.6
Dep, %	-	0.5	-	0.5
PAO8, %	20	20	70	70
Sunflower, %	80	78.9	30	28.9

The mixture Mix.1 and Mix.3, don't contain additives, only base oils in different dosage.

Mixtures Mix.2 and Mix.4 have antioxidant additive and depressant additive included in the base oils mixtures.

In table no.5 are presented the results obtain from the mixture between Sunflower oil, PAO8 and additives AO (dialckyl-dithio-phosphate antioxidant) and Dep (poly-alpha olephin depressant).

Table no.5 Testing results of the mixtures.

Characteristics	Mix.1	Mix.2	Mix.3	Mix.4
Viscosity at 40 ^{0}C, cSt	30.67	31.01	39.3	39.37
Viscosity at 100 ^{0}C, cSt	7.19	7.3	7.5	7.52
IV	211	212	161	162
Pour point, ^{0}C	- 24	- 36	- 36	< - 42
Copper corrosion	1b	1b	1b	1b
RBOT, minutes	0	30	0	115

Evaluating these testing results could be observ that:

- specific characteristic values for mixtures Mix.1 and Mix.3 are almost an average of the specific values of each base oil used for blending, except oxidation resistance who has 0 value;
- specific characterisitcs values for Mix.2 and Mix.4 show the influence done by the additives: the pour point has a lower values and the oxidant resistance has a higher values, than the reference mixtures (Mix.1 and Mix.3);
- comparing Mix.1 with Mix.3 and Mix.2 with Mix.4, we can observ that a higher dosage of PAO 8 (Mix.3 and Mix.4) has a better influence concerning the performance of the mixture.

5. CONCLUSIONS

The vegetable oils could be an approchable solution for manufacturing of hydraulic lubricants and an alterrnative for the mineral base oil.

The mixtures between vegetable oils, poli-alpha olephin and suitable additives offer adequate characteristics.

Most convenient mixtures (with smaller dosage of PAO), could be obtain by using the most efficient additives.

The hidrogenation of vegetable oils for increasing the chemical stability could be a solution, but it have to find more appropriate conditions for the technological process.

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