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Improving the Lubricity of Gas Oils by Biodiesel Additivation

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Abstract

This paper presents our investigations concerning the lubricity characteristics of the gas oils. Three gas oils produces by different processes (atmospheric distillation-DA, hydrofining-HF and catalytic cracking-CC) were used as raw materials for our research. The physical-chemical characteristics of gas oils (viscosity, density, STAS distillation, refractive index, composition and lubricity) were determinate before and after additivation with bioDiesel. The aims of our investigations were to establish relationships between the chemical composition of the Diesel fuels and friction and the improvement of the lubricity characteristics of gas oil by bioDiesel additivation.

Keywords: *lubricity, bioDiesel, additives*

Introduction

Over the last years several attempts have been made to minimize the amount of toxical and harmful exhaust gases from Diesel powered vehicles. Therefore, the amount of sulphur and aromatics in Diesel fuels has been reduced, usually by hydrotrating the fuels. As a consequence, a very important feature of Diesel fuels (respectively-the lubricity) was affected, by decreasing.
The aims of this study were to establish relationships between the chemical composition of the Diesel fuels and friction and the possibility of increasing of Diesel fuels lubricity by additivation with by applying environmental friendly blending compounds and additive-packages high performance level [1, 2].
In this study, the friction of the Diesel fuels and Diesel fuels additivated with bioDiesel-were studied on High-frequency Reciprocating Rig (HFRR) equipment. The HFRR is a microprocessor-controlled reciprocal friction and wear test system which enables rapid, repeatable assessment of the performance of fuels and lubricants. This equipment is particularly suitable for wear-testing relatively poor lubricants and has the big advantage of using small quantities of lubricants [3].

Experimental study

In order to study the lubricity of diesel fuels three gas oils, obtained in different processing processes (atmospheric distillation-DA, hydrofining-HF and catalytic cracking-CC), were

selected. The physical-chemical characteristics of the Diesel oils, measured with Irox Diesel equipment, are presented in table 1.

Table 1. Gas oils physical-chemical characteristics

Characteristics	Gas oil		
	from DA	**from HF**	**from CC**
Kinematics Viscosity at 40°C, cSt	2.31	2.52	2.03
Density at 20°C, g/cm^3	0.8320	0.8378	0.9396
Polyaromatics, wt%	5.4	4.3	47
Aromatics, wt%	30.8	29.2	0
Cetanic index	50.5	50.2	13.7
Sulphur content, ppm	6175	104	1062
Lubricity, (HFRR test), μm	423	454	282

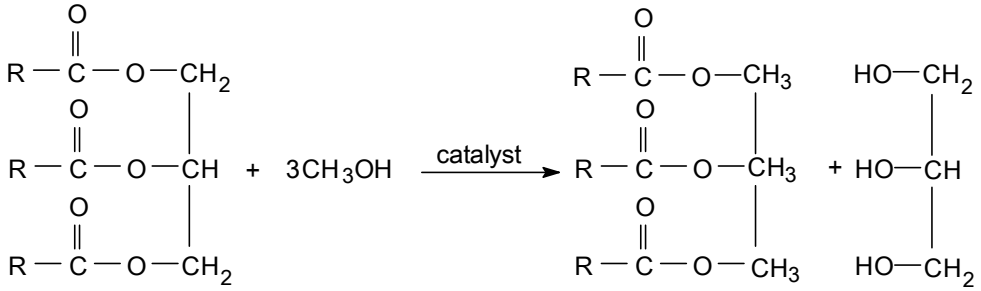
Additive preparation

The increasing qualitative requirements of the modern Diesel fuels can be satisfied by applying environmental friendly blending compounds as methylic-ester.
The aim of our experimental work was to produce an additive based on rapeseed oil methyl ester. Many literature studies [1, 2] prove that the process is more environmental friendly, allows a very easy separation between the phases and energy economic respect to the widely used thermal synthesis method for the production of polyisobutylene (PIB)-succinimide type additives.
Vegetable oils as rapeseed, sunflower or soybean are triglycerides of the fatty acids and have different compositions depending on the raw material composition, as presented in table 2.

Table 2. The chemical composition of vegetable oils

Fatty acids	Symbol	Rapeseed oil, wt %	Sunflower oil, wt %	Soybean oil, wt %
Lauric acid	12:0	-	-	4.5
Miristic acid	14:0	-	-	4.5
Palmitic oil	16:0	3.5	5.5	11.0
Stearic acid	18:0	1.0	5.2	2.5
Oleic acid	18:1	64.6	24.3	21.1
Linoleic acid	18:2	22.4	64.5	50.4
Linolenic acid	18:3	8.5	-	6.0

The additive based on methyl ester was prepared by catalytic transesterification of the triglycerides contained in rapeseed oil with methanol.



triglyceride methanol bioDiesel glycerin

After preparation, the bioDiesel was characterized from viscosity, density, lubricity and refraction index points of view (table 3).

Table 3. Physical-chemical characteristics of rapeseed oil and methyl ester

Characteristics	Rapeseed oil	Methyl ester
Kinematics Viscosity at 40°C, cSt	35.399	4.67
Density, d_4^{20}	0.9164	0.8752
Lubricity, (HFRR test), μm	140	226
Refraction index	1.4756	1.4562

Lubricity tests

The next step in our investigations was the lubricity tests. The effect of bioDiesel- metylic ester type-in Diesel oils was studied using a ball-disk tester. The friction of the steel ball against steel disk was studied at a frequency of 50 Hz, 1000 um stroke, 200g load and 60 °C (according to ISO 12156-1).

Because gas oil obtained from catalytic cracking has poor combustion features, for the lubricity tests only Diesel oils obtained from atmospheric distillation and hydrofining-HF were selected for advanced investigations.

Therefore, two ml of gas oil mixed with different weight percents of bioDiesel (1 wt%, 2 wt%, 4 wt%, 8 wt% and 15 wt%) were fed to the contact area. The results of our investigations are presented in Table 4.

Results

The lubricity tests proved modifications of the scar diameter by applying additivation of the Diesel oils with different percent of bioDiesel. Additivation of Diesel oil (produced from atmospheric distillation process) with bioDiesel-methylic-ester type, seems to be beneficial in direction of decreasing of the scar diameter by increasing of the weight percent of the additive added in the mixture. Unexpected were the results obtained by additivation of the Diesel oil (produced from hydrofing process) with bioDiesel in direction of increasing of the scar diameter by increasing of the weight percent of the additive. Probably, this effect is the result of the attempts that have been made to minimize the amount of sulphur in Diesel fuels by hydrotreating.

Table 4. The influence of the bioDiesel over the scar diameter

	Scar diameter, μm				
	+ 1 wt% bioDiesel	**+ 2 wt% bioDiesel**	**+ 4 wt% bioDiesel**	**+ 8 wt% bioDiesel**	**+ 15 wt% bioDiesel**
Diesel oil from DA	480	370	325	274	270
Diesel oil from HF	240	258	358	389	406

The physical-chemical characteristics of the gas oil from HF mixed with 4wt% bioDiesel were investigated by IROX Diesel equipment. The results of these investigations are presented in table 5.

Table 5. The physical-chemical characteristics of the gas oil from HF mixed with 4wt% bioDiesel

Characteristics	Gas oil from HF+4wt% bioDiesel
Density at 20°C, g/cm^3	0.8399
Polyaromatics, wt%	2.9
Aromatics, wt%	24.2
Cetanic index	127.9
Sulphur content, ppm	104
Lubricity, (HFRR test), μm	358

Conclusions

In order to establish relationships between the chemical composition of the Diesel fuels produced in different processing processes and lubricity, the composition of the gas oils were analyzed by IROX Diesel equipment.
The modification of Diesel fuels lubricity was done by additivation with by applying environmental friendly blending compounds, therefore an additive based on methyl ester was prepared by catalytic transesterification of the triglycerides contained in rapeseed oil with methanol.
The lubricity of the Diesel oils produced by atmospheric distillation was improved by additivation with bioDiesel, while the effect of the same additive over the lubricity of the Diesel oils produced by hydrofining is contradictory in direction of increasing of the scar diameter by increasing of the weight percent of the additive.

References

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Îmbunătățirea lubricității motorinelor prin aditivare cu bioDiesel

Rezumat

Studiul experimental prezintă investigaţiile noastre privind caracteristicile lubrifiante ale combustibililor bioDiesel. În acest scop au fost utilizate trei motorine obţinute din procese diferite (distilare atmosferică, hidrofinare şi cracare catalitică). S-au determinat caracteristicile fizico-chimice (vâscozitate, densitate, indicele de refracţie, distilare STAS, compoziţie şi lubricitate) ale motorinelor înainte şi după aditivarea cu bioDiesel. Scopul studiului experimental a fost determinarea relaţiilor dintre compoziţia chimică şi lubricitate precum şi găsirea posibilităţilor de îmbunătăţire a caracteristicilor de lubrifiere prin aditivare cu biocombustibili.