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RESEARCHES REGARDING THE BIODIESEL USE IN DIESEL ENGINES

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Abstract: *In this paper we present we present the influence of bio-diesel on diesel engine performance taking into account the physical-chemical properties of this type of fuel. For this we study the main properties that we determined for three different types of bio-diesel and compare them with classic petrodiesel. We notice that biodiesel can be an alternative to diesel but with the condition that biodiesel need to respect the actual standard EN 14214.*

Keywords: *biodiesel, diesel engine, viscosity, density, flash point.*

1. Introduction

Biodiesel is composed of long-chain fatty acids with an alcohol attached, often derived from vegetable oils. It is produced through the reaction of a vegetable oil with methyl alcohol or ethyl alcohol in the presence of a catalyst. Animal fats are another potential source. Commonly used catalysts are potassium hydroxide (KOH) or sodium hydroxide (NaOH). The chemical process is called transesterification which produces biodiesel and glycerin. Biodiesel can be used in the pure form, or blended in any amount wuth diesel fuel for use in compression ingnition engines.

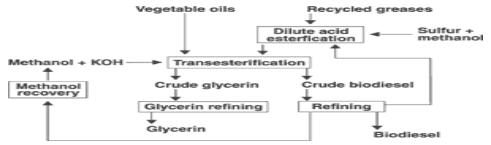

Fig. 1. *Basic transesterification technology*

The transesterification process of converting vegetable oils to biodiesel is shown in Figure 2**.** The "R" groups are the fatty acids, which are usually 12 to 22 carbons in length. The large vegetable oil molecule is reduced to about 1/3 its original size, lowering the viscosity making it similar to diesel fuel.

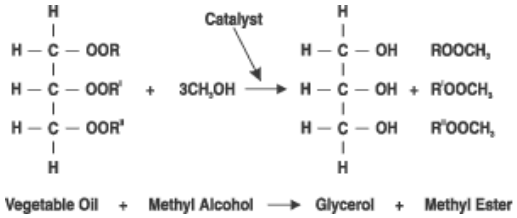

Fig. 2. *Transesterification of vegetable oil*

2. Comparative analysis of physical, chemical and thermodynamically properties of biodiesel

For the formation of the main tasks and aspects of experimental and mathematical modeling research it is necessary to evaluate the difference of physical, chemical and thermodynamically properties of biodiesel from mineral diesel fuel and its influence for technical-economical and ecological parameters of an indicating process.

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Biodiesel can be defined as liquid fuel, produced from biological feedstocks: vegetable oil, animal fat, used fried oil for the application in a diesel engine. Biodiesel and its blends with diesel fuel usually are marked with B letter and figure which means the percent part of biodiesel in the blend, for example: B100 – pure biodiesel, B30 – blend with 30 % of biodiesel.

The feedstock of biodiesel consists of triglyceride molecules, which structure consists of three fatty acids with long chains of carbon – from 8 to 22, connected to glycerol. Chemical and physical properties of biodiesel mostly depend on fatty acids of feedstock.

Short abbreviators for biodiesels are created depending on the feedstock of biodiesel and the type of alcohol used in the production process, for example: rapeseed methyl ester – RME, rapeseed ethyl ester – REE, soybean methyl ester – SME, tallow methyl ester TME etc.

In this paper we use three different types of biodiesel in comparative with classic petrodiesel. The comparative analysis of physical, chemical and thermodynamically properties of biodiesels are presented below.

2.1. Elemental composition of fuel.

Fuel for internal combustion engines consists of 3 basic chemical elements: carbon – C, hydrogen – H_2 and oxygen – O_2.

For the elemental analysis we use the apparatus COSTECH ECS 4010 – CHNS-O of Department of Equipment and Nuclear Classic and Thermomechanics in the Polytechnics of Bucharest. The value of each element is measured through his corresponding area on the diagram.

The results of these analyses are presented in Figure 3 to Figure 6.

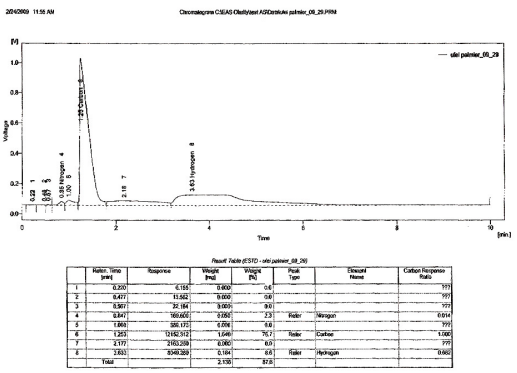

Fig. 3. *Diagram of chromatographic analyses for palm oil*

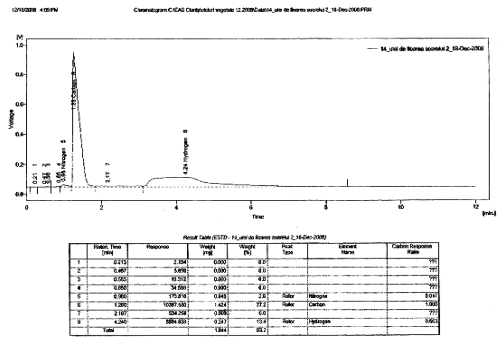

Fig. 4. *Diagram of chromatographic analyses for biodiesel of sunflower oil*

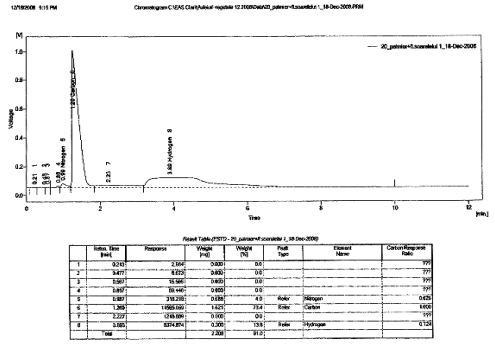

Fig. 5. *Diagram of chromatographic analyses for biodiesel of palm and sunflower oil*

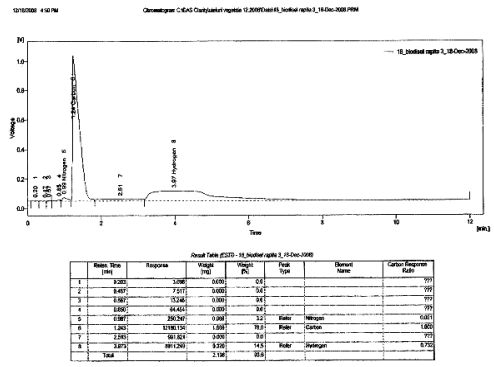

Fig. 6. *Diagram of chromatographic analyses for biodiesel of rapeseed*

Elemental composition of biofuels Table 1
comparative with petrodiesel

Fuels	O_2 [%]	H_2 [%]	C [%]	N [%]	S [%]
Euro L Diesel	0,1	12,9	86,6	0,1	0,3
Palm oil	12,4	8,6	76,7	2,3	-
Biodiesel of rapeseed	6,3	14,5	76	3,2	-
Biodiesel of sunflower	6,8	13,4	77,2	2,6	-
Biodiesel of palm and sunflower	9	13,6	73,4	4	-

- the part of oxygen in biodiesel is from 6,3 up to 12,4 % compared to up to 0,1 % in diesel fuel, because of that a combustion process is organized with higher value of excess air ratio; the increase of oxygen in the fuel improves a combustion process reduces the emission of non-combusted products (CO, CH, soot), but at the same time increases the emission of nitric oxides NOx, which is one of the most toxic of emission gases;
- the increase of oxygen part in biodiesels is related to the reduction of quantities of C and H_2:
- biodiesel consists of C – 73,4÷77,2 % and H2 –13,4÷14,5 % and these portions are lower compared to mineral diesel fuel where C – 85÷87 %, H_2 – 12,5÷14,7 %; this factor causes the lower calorific value of biodiesel because oxygen is ballast in fuel and C and H are sources of energy;
- the quantity of nitrogen shows the quality of biodiesel, because the presence of nitrogen shows a not-completed process of cleaning biodiesel after production.

2.2. Biodiesel density

Fuel density for the diesel fuel is determined at 15˚C. The density of biodiesel at 15 ˚C is 0,86–0,90 g/cm^3 and it is 2–7 % higher value compared to diesel fuel (0,82–0,85 g/cm^3).

This factor positively influences the saving characteristics of the load of a diesel engine on the same level for the transference of diesel fleets for work on biodiesel without additional regulation of units of a fuel supplying system.

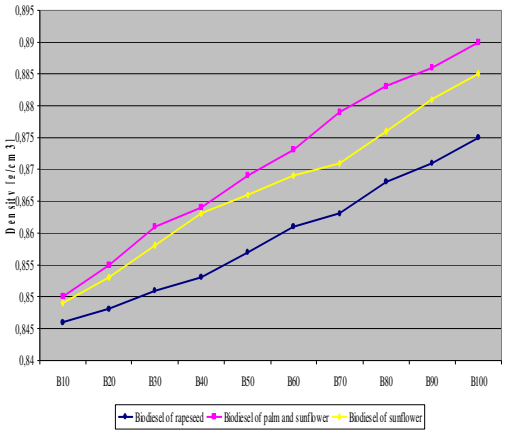

Fig. 7. *Density of different blends of biodiesel*

2.3. Viscosity of biodiesel

Fuel viscosity is regulated by the standards at 40 ˚C. Viscosity dependence on temperature is a very important characteristic of each fuel, because transport means are exploited in a wide range of climatic conditions. Viscosity of fuel influences the injection of fuel, the quality of filtering and fuel supply through tubes. Viscosity decreases with the decrease of temperature; it influences the decrease of the quality of fuel injection, what in turn increases the emission of non-combusted products and decreases the quality of lubrication conditions of diesel parts. The viscosity of vegetable oils is significantly higher than of mineral diesel fuel and it is the main reason why they are not directly applied in diesel engines as fuel and the aim of transesterification is to lower the viscosity of vegetable oils.

Cinematic viscosity of biodiesel at 40 ˚C is 4,0– 6,2 mm^2/s and it is twice higher than diesel fuel viscosity 2,4–2,6 mm^2/s.

The viscosity of biodiesel depends on feedstock, the viscosity of rapeseed oil and biodiesel is higher than of soybean oil and soybean biodiesel. Higher viscosity of biodiesel decreases the leakages of fuel in a plunger pair and in turn it changes the parameters of a fuel supply process: injected quantity of fuel, real advanced angle of fuel injection what directly influences an indicating process and harmful emission of exhaust gases.

The viscosity was determined with viscometer Ubbelohde with suspended level. We notice that all the three types of biodiesel Figure 8 have a viscosity almost double than petrodiesel and the viscosity increases with the concentration of the biodiesel in the blend.

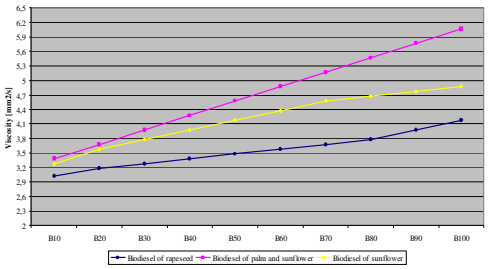

Fig. 8. *Viscosity of different blends of biodiesel*

2.4. Flash Point

The highest value of Flash Point belongs to biodiesels of vegetable oils because they don't have light fractions.

Transesterification significantly lowers the value of Flash Point. Flash Point of biodiesels is higher than of diesel fuel.

The value of Flash Point is limited by standard EN 14214 and it is > 120 ˚C so we can conclude that the safety of biodiesel is ensured.

For the measurement we use a Pensky Martens with closed cup at laboratory of Thermodynamics and Thermal machines of Faculty of Mechanics of Craiova. For petrodiesel we use a Euro L Diesel from station LUKOIL Craiova.

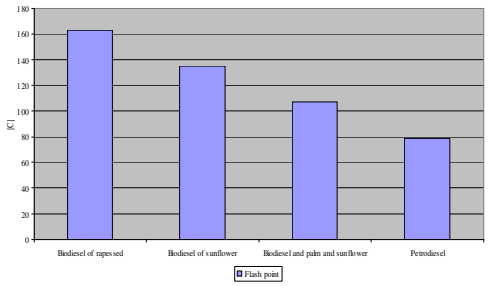

Fig. 9. *Flash point of biodiesel and petrodiesel*

2.5. Freeze point

In order to evaluate the biofuels capacity to function in low temperature we have determined the freeze point of biodiesel and compared him with classic petrodiesel.

Biodiesel have worse properties than diesel due his chemical property.

Freeze point of fuels Table 2

Fuels	^{0}C
Euro L Diesel	-26
Biodiesel of rapessed	-9
Biodiesel of sunflower and palm oil	-1
Biodiesel of sunflower	-6

3. Discussion

Performed analytical research into physical, chemical and thermodynamically properties of biodiesels blends allows concluding the following influence of these properties on the working process, technical-economical parameters and the formation of the harmful emission of exhaust gases:

- higher density and viscosity of biodiesel accelerate the injection of biodiesel which exhibits the increase of a real advanced angle of fuel injection (in the case of fixed angle of fuel injection), the duration of fuel injection decreases and dynamics of fuel torch increases (increase of speed and penetration) in the camera of combustion what in turn increases the time for fuel-air mixture formation;
- lower quantity of aromatic hydrocarbons in biodiesel blends with diesel fuel improves the characteristics of flammability what causes the decrease of duration of an induction period of combustion and the increase of a phase of beginning visible combustion;
- because of higher enthalpy of vaporization of biodiesel a shorter period of induction decreases the portion of fuel-air mixture of a cycle prepared for the combustion; these factors compensate the increase of dynamics of an induction period (kinetic phase of combustion) related to the increase of phase of beginning of combustion; on a certain level noticed tendencies are characterized for modern diesels boosted by the medium effective pressure;
- early beginning of combustion increases the amount of heat extracted until the maximum pressure max P of a cycle is reached what influences the increase of emission of nitric oxides NOx;
- lower content of sulphur in the composition of biodiesel blends decreases the emission of sulphur oxides because it directly depends on sulphur content in the fuel;
- a positive factor which ensures the absolute level of soot formation and influences a combustion process is the presence of oxygen ~ 6 ÷ 9 % in the composition of biodiesel; it also increases the excess of air and improves the combustion to the complete products, accelerate the main phase of fuel combustion what in turn improves fuel economy;
- the next negative factor of biodiesel application is the aggressiveness of biodiesel to synthetic materials;
- biodiesels have properties with worse characteristics at low temperatures.

We notice that biodiesel can represent an alternative to classic petrodiesel but with certain precautions:

- due to the increase level in oxygen it is possible an oxidation of the fuel so is necessary if we want to store biodiesel for a long period of time to use an antioxidant additive.
- due to the problems of the biodiesel in low temperatures it is necessary sometime to heat the pipes of alimentation of fuel of the vehicles.

4. Conclusions

The tests for the physical chemical properties show the capacity of biodiesel fuels to compete with classic petrodiesel.

Despite the high value in viscosity, density, flash point the methyl esters of fatty acids have almost the same behavior in diesel engine.

It had been analyzed three types of biodiesel comparative with petrodiesel.

Biodiesel shows certain problems in countries with have a cold climate due to the small freeze point of these types of fuels.

In conclusion the biodiesel analyzed can become a solution to the actual crises of petroleum with the condition that are respected the qualitative prescription regarding his quality in concordance with biodiesel standards.

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