XVIII IMEKO WORLD CONGRESS
Metrology for a Sustainable Development
September, 17 – 22, 2006, Rio de Janeiro, Brazil

CHARACTERIZATION AND EFFECT OF USING BLENDS OF DIESEL AND SOYBEAN BIODIESEL AS FUEL IN A STATIONARY ENGINE

Roberto G. Pereira[1*], *Carlos E. Fellows*[2], *Cesar D. Oliveira*[3], *Jorge L. Oliveira*[1], *Paulo Cesar P. Oliveira*[1], *Oscar E. P. Tulcán*[1,4]

[1]Universidade Federal Fluminense, Departamento de Engenharia Mecânica, Programa de Pós-Graduação em Engenharia Mecânica, Rua Passo da Pátria 156, CEP 24210-240, Niterói-RJ, Brazil, temrobe@vm.uff.br
[2]Universidade Federal Fluminense, Instituto de Física, Av. Gen. Milton Tavares de Souza, s/n, Niterói, 24210-340, Brazil, fellows@if.uff.br
[3]Universidade Federal Fluminense, Departamento de Química Orgânica, Campus do Valonguinho, CEP 24210-150, Niterói-RJ, Brazil, gqocdol@vm.uff.br
[4]Universidad Nacional de Colombia-Bogotá, Carrera 30, nº 45-03, Facultad de Inginiería, Bogotá, Colombia, oepiambat@unal.edu.co
[*]Member of Brazilian Society of Metrology

Abstract: The present work describes an experimental investigation concerning the electric energy generation using blends of diesel and soybean biodiesel. The soybean biodiesel was produced by a transesterification process of the soybean oil using methanol in the presence of a catalyst (KOH). The properties (density, flash point, viscosiy, pour point, cetane index, conradson carbon residue and distillation) of the diesel and soybean biodiesel were determined. The exhaust emissions (CO, CO_2, C_xH_y, O_2, NO, NO_x and SO_2) were, also, studied. The results show that the use of diesel-soybean biodiesel as fuel blends in stationary engine is an alternative for the sustainable development.

Keywords: biodiesel, electric power, environmental measurements.

1. INTRODUCTION

The world, in the last years, has been confronted with an energy crises due to the reduction of petroleum sources associated with the increase of environmental problems.

The use of alternative fuels has been studied. Among some possibilities, stand out the fuels produced from biomass and residues that can be used for the operating of engines. These alternative fuels can be mixed to the diesel, for instance, reducing the demand of the diesel and minimizing the emission of gases of the greenhouse effect.

In that way, the central objective of this research is to study the use of blends of diesel and soybean biodiesel for the electric energy generation. For the accomplishment of this study a stationary engine was used for the electric energy generation. The gas emissions were, also, analyzed.

1.1. Biodiesel

Biodiesel is an alternative fuel to the diesel substitution.

The biodiesel is obtained from renewable sources, such as vegetable oils or animal fats, through a transesterification process.

To use vegetable oil in a diesel cycle engine without need of adaptations in the motor, it is necessary to submit this oil to a denominated chemical reaction of transesterification with the main objective of lowering the oil viscosity to value close to the conventional diesel one.

Among the advantages alleged for the use of the biodiesel are: it presents good lubricity and it has less sulfur than diesel.

On the other hand, the literature makes mention to some technical problems related to its use, such as the increase of NO_x emission when compared with diesel, that should be examined with more caution.

Brazil presents an enormous potential for the biodiesel production. It possesses a great amount of productive lands and a big variety of oleaginous for the production of vegetable oils.

The soybean constitutes an important component in the effort of biodiesel production, once it already has a very big offer of the oil, corresponding to more than 90% of the oil production in Brazil.

The importance of biodiesel has been pointed out in recent works [1-6]

2. MATERIAL AND METHODS

2.1. Soybean biodiesel and diesel obtaining and characterization

The soybean biodiesel was prepared by a transesterification process, at Federal Fluminense University, using methanol in the presence of a catalyst (KOH).

The diesel was obtained in commercial gas station at Rio de Janeiro.

Physical and chemical analyses were accomplished in the soybean biodiesel and diesel, being used the following methods: ASTM D 4052 (Density); ASTM D 93 (Flash

Point); ASTM D 445 (Viscosiy); ASTM D 97 (Pour Point); ASTM D 86 (Distillation); ASTM D 4737 (Cetane Index), ASTM D 189 (Conradson Carbon Residue).

2.2. Blends of diesel and soybean biodiesel

The soybean biodiesel was mixed with diesel, for the accomplishment of tests with motor, in the following proportion in volume: 20%, 50% and 100%. These percentages were chosen tends in view the future tendency in Brazil of to allow mixing in diesel, amounts of biodiesel for commercialization.

The following nomenclature was used: B20: 20%vol. of soybean biodiesel and 80%vol. of diesel; B50: 50%vol. of soybean biodiesel and 50%vol. of diesel and B100: 100%vol. of soybean biodiesel

2.3. Stationary engine

The diesel-soybean biodiesel blends were tested in a stationary engine whose characteristics are listed in Table 1.

Table 1. Stationary engine specifications

PARAMETERS	SPECIFICATIONS
Make	BD-2500
Speed	3600 rpm
Fuel	Diesel
Type	Four-stroke, direct injection
Number of cylinders	One
Cooling system	Air
Displacement volume	0.211 L
Maximum output	2.0 kW
Nominal power	1.8 kW
Fuel capacity	2.5 L
Weight	47 kg

2.4. Electric energy generation

It was used in the tests a load panel with the stationary engine. Every fuel was tested by 2.5 hours with 85% of the full load.

The electric properties (voltage, power and frequency) were measured and stored through a digital equipment, manufactured by CCK, model CCK 4300. The communication with this meter was made through Converter RS 485 supplied also by CCK.

2.5. Exhaust emissions

The engine emissions gas analyses were done in a GreenLine 8000 instrument using non-dispersive infrared (NDIR) analyzer for measurements of CO_2 and C_xH_y and electrochemical sensors for measurements of O_2, CO, NO, NO_x and SO_2.

3. RESULTS AND DISCUSSION

3.1. Soybean biodiesel and diesel characterization

The Table 2 shows the results for the physical and chemical properties of soybean biodiesel and diesel. Each value represents a mean of at least 5 tests.

According to Table 2, the soybean biodiesel presented properties similar to the diesel one.

Table 2. Properties of soybean biodiesel and diesel

PROPERTIES	Soybean biodiesel	Diesel
Density at 15ºC (kg/L)	0.8830	0.8450
Viscosity at 40ºC (mm^2/s)	4.5	3.0
Distillation – 10% recovered (ºC)	340	240
Distillation – 50% recovered (ºC)	345	285
Distillation – 90% recovered (ºC)	354	360
Cetane Index	59.2	54.3
Flash Point (ºC)	150	85
Pour Point (ºC)	-11	-10
Conradson Carbon Residue (wt %)	0.18	0.17

The soybean biodiesel also presented properties similar to other fuels reported in the literature [1-5].

3.2. Electric energy generation

Table 3 shows the properties (medium values of five measurements) obtained in the electric energy generation tests, using diesel and alternative fuels (diesel and soybean biodiesel blends).

Table 3. Medium values obtained in the electric energy generation tests

PARAMETERS	Diesel	B20	B50	B100
Power (W)	1584	1543	1572	1593
Voltage (V)	102.4	100.9	101.7	102.6
Frequency (Hz)	58.8	58.2	58.7	58.9
Speed (rpm)	3490	3490	3500	3500
Fuel consumption (L/h)	0.864	0.828	0.864	0.900

In agreement with the Table 3, it can be said that for all the mixtures the electric power generation happened without problems. With the mixture B20, was obtained the smallest consumption of fuel.

During the operation of the stationary engine with the alternative fuels there were not any type of breakdown occurrence or abnormal operation of the motor.

3.3. Exhaust emissions

The results (medium values of five measurements) of the emissions of gases are shown in Table 4. The emissions of CO_2 are larger in the mixtures diesel-soybean biodiesel indicating a more complete combustion in these cases. The emissions of CO, C_xH_y and SO_2 decrease in the case of the mixtures diesel-soybean biodiesel. In relation to the

temperatures of the exhaust gases and the emissions of NO and NO_x, these are similar to or less than those of diesel.

The reduction of CO, C_xH_y and SO_2 emissions with diesel-biodiesel mixtures are also reported in the literature [2-6].

Table 4. Medium values of exhaust emissions

PARAMETERS	Diesel	B20	B50	B100
O_2 (%)	19.1	19.1	19.2	19.3
CO_2 (%)	1.38	1.45	1.39	1.68
CO (ppm)	174	144	102	156
SO_2 (ppm)	5.7	3	2	2.7
NO (ppm)	446	410	438	407
NO_x (ppm)	460	420	452	419
C_xH_y (ppm)	103	102	102	70
Exhaust gas temperature (ºC)	141.4	129.5	129	135
Test room temperature (ºC)	32.4	34.4	39.1	27.8

4. CONCLUSIONS

The results of the tests show the viability of using mixtures diesel- soybean biodiesel in a stationary engine for the electric power generation, being an alternative for the sustainable development.

ACKNOWLEDGMENTS

The authors are grateful to the National Research Council of Brazil - CNPq for the financial support received.

REFERENCES

[1] M. Lapuerta, O. Armas, R. Ballesteros, J. Fernández, "Diesel Emissions from Biofuels Derived from Spanish Potential Vegetable Oils" Fuel, Vol. 84, pp. 773-780, 2005.

[2] C. Carraretto, A. Macor, A. Mirandola, A. Stoppato, S. Tonon, "Biodiesel as Alternative Fuel: Experimental Analysis and Energetic Evaluations" Energy, Vol. 29, pp. 2195-2211, 2004.

[3] B K. Barnwal, M P. Sharma, "Prospects of Biodiesel Production from Vegetable Oils in India" Renewable & Sustainable Energy Reviews, Vol. 9, pp. 363-378, 2005.

[4] S. Kalligeros, F. Zannikos, S. Stournas, E. Lois, G. Anastopoulos, Ch. Teas, F. Sakellaropoulos,. "An Investigation of Using Biodiesel/Marine Diesel Blends on the Performance of a Stationary Diesel Engine" Biomass and Bioenergy, Vol. 24, pp. 141-149, 2003.

[5] S. Puhan, N. Vedaraman, B. V. B. Ram, G. Sankarnarayanan, K. Jeychandran, "Mahua Oil (Madhuca Indica Seed Oil) Methyl Ester as Biodiesel-Preparation and Emission Characterstics" Biomass and Bioenergy, Vol. 28, pp. 87-93, 2005.

[6] N. Usta, "An Experimental Study on Performance and Exhaust Emissions of a Diesel Engine Fuelled with Tobacco Seed Oil Methyl Ester" Energy Conversion & Management Vol. 46, pp. 2373-2386, 2005.