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Original Research Article

Investigation of Fuel Properties of Canola Oil Biodiesel, Bioethanol and Diesel Fuel Mixture

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ABSTRACT

In this study, canola oil was converted into Canola Oil Methyl Esters (Canola Biodiesel) by transesterification method and biodiesel production was carried out. Biodiesel fuel obtained from canola oil was mixed with diesel fuel with 5% and 10% bioethanol addition and by inversion with volumetric proportions, and then fuels in the form of D_{100}, B_{100}, $E_5B_5D_{90}$, $E_{10}B_{10}D_{80}$, $E_{10}B_5D_{85}$ and $E_5B_{10}D_{85}$ were obtained.
Fuel properties of the obtained mixtures and diesel fuel, density, water content, kinematic viscosity, pH value, flash point, color specification, calorific value, clouding, pour and freezing point tests, CFPP (Cold Filter Plugging Point) test and copper rod corrosion tests were performed.
According to the test results, it was concluded that biodiesel produced from canola oil could be used as 100% in diesel engines blending with bioethanol and without any modification on the engine; and it was an alternative fuel to diesel fuel.
Keywords: Canola, bioethanol, biodiesel.

1. Introduction

Today, around 20% of the energy consumed worldwide is derived from renewable sources. Although the dependence on fossil fuels is currently high, the rates of renewable energy usage are increasing gradually over the years [1].
However, despite all attempts, renewable energy sources are still facing high obstacles in the energy markets. There are many reasons for this. The most notable one is that renewable energy sources are regarded as economically weak compared to fossil fuels. This depends more on traditional price configuration. Because, in this price configuration, there are no social and environmental costs, provision and usage costs. Moreover, there are many institutional and financial obstacles in establishing even a small size renewable resource [2].
There are important supports for alternative fuel researches around the world. In many developed countries, especially in European Union countries, serious studies are carried out on this subject and positive results are put into practice. The alternative fuel that can be used in

diesel engines must have economic, renewable, environmental friendly and easily available advantages. Biodiesel is considered as an alternative fuel type for diesel engines with features that meet these requirements [3].

Biodiesel is defined as fatty acid methyl esters according to current standards. In parallel with the developments and the targets in the world of biofuels, it is envisaged that fatty acid ethyl esters will become increasingly important and flexible fuel vehicle applications will also be used in practice [4, 5].

Although there are various methods of biodiesel production, the most widely used method today is transesterification. In the transesterification method; biodiesel is an environmentally friendly and renewable liquid biofuel which is released with a short chain alcohol (usually methanol or ethanol) by means of a catalyst and as a result of transesterification reaction of the oils or animal oils obtained from oilseed plant such as rapeseed (canola), sunflower, and soybean [6].

Although fuel alcohol is a definition including methyl alcohol and ethyl alcohol, it is commonly used for ethyl alcohol (ethanol - bioethanol) derived from biomass sources [7].

Bioethanol is simply a colorless, clear, flammable, oxygenated hydrocarbon. Bioethanol is a fuel that can be obtained from various sources. Cereals, seeds, sugar products and other starch sources can be easily fermented to produce bioethanol. The use of bioethanol as fuel in the world is mostly in the form of low mixing ratios [8].

Today, the biofuel industry has become one of the most important business areas. Bioethanol and biodiesel, one of the first generation biofuels among the biofuels classified as four generations according to the type of production, raw material selection and technologies, are in intensive practice and bioethanol is the leading biofuel in the world [4, 9].

2. Materials and Methods

Canola oil used in this study was obtained from the market. The biodiesel of this oil was produced in the laboratory of the Department of Energy Systems Engineering at Necmettin Erbakan University Faculty of Engineering and Architecture. Transesterification method was used as the production method, NaOH was used as the catalyst and methyl alcohol as alcohol. Diesel fuel was supplied from BP Petrol Company.

Biodiesel fuel obtained from canola oil was mixed with diesel fuel with 5% and 10% bioethanol addition and by inversion with volumetric proportions, and then fuels in the form of D_{100}, B_{100}, $E_5B_5D_{90}$, $E_{10}B_{10}D_{80}$, $E_{10}B_5D_{85}$ and $E_5B_{10}D_{85}$ were obtained. Fuel properties of the obtained mixtures and diesel fuel, water content, color specification, calorific value, flash point, copper rod corrosion tests, CFPP tests were performed at Biodiesel Laboratory of the Department of Agricultural Machinery and Technologies Engineering at Selçuk University, Faculty of Agriculture; kinematic viscosity, density, pH, clouding, pour and freezing point tests were performed at the Department of Energy Systems Engineering at Necmettin Erbakan University Faculty of Engineering and Architecture. Test fuels were defined in Table 1.

Test results were defined in Table 2. It is seen that the values in the table comply with TS EN 590 for diesel and TS EN 14214 for biodiesel. Properties of test devices were defined in Table 3.

Table 1. Names of the test fuels [10]

Fuels	Diesel	Bioethanol	Canola Oil Biodiesel
D_{100}	100	0	0
B_{100}	0	0	100
$E_5B_5D_{90}$	90	5	5
$E_{10}B_{10}D_{80}$	80	10	10
$E_{10}B_5D_{85}$	85	10	5
$E_5B_{10}D_{85}$	85	5	10

Table 2. Analyses results [10]

Characteristic Properties	Units	Canola oil	B_{100}	D_{100}	$E_5B_5D_{90}$	$E_{10}B_{10}D_{80}$	$E_{10}B_5D_{85}$	$E_5B_{10}D_{85}$	Bioethanol	Limiting Values	
										Diesel	Biodiesel
Density (15⁰C)	g/cm³	0,915	0,883	0,834	0,835	0,834	0,833	0,837	0,791	0,82-0,84	0,86-0,90
Water Content	ppm	212,53	492,51	34,52	292,71	490,87	583,04	247,65	372,6	200	500
Kinematic Viscosity (40⁰C)	mm²/s	31,388	4,453	3,071	2,647	2,492	2,444	2,644	1,269	2- 4,5	3,5-5
Kinematic Viscosity (100⁰C)	mm²/s	4,5127	2,044	1,417	1,125	1,211	1,051	1,125	0,697	---------	------
PH	--------	4,8	4,9	4,01	5	5,03	5,02	5,01	6,12	——	——
Flash Point	⁰C	150	125	61	--------	--------	-------	-------	-------	55	120
Color	ASTM	0,8	1,0	1,3	1,3	1,3	1,3	1,3	0,5	——	——
Calorific Value	Cal/gr	-------- --	9585	10319	10876	10120	10752	10272	7068	——	——
Cloud Point	⁰C	-9,8	-5,9	-8,4	-6,9	-7,3	-7,2	-7,1	——	——	——
Pour Point	⁰C	-13,6	-9,1	-15,1	-9,2	-10,1	-9,9	-9,8	——	——	——
Freezing Point	⁰C	-17,4	-12,1	-20	-14,4	-15,2	-15	-14,7	——	——	——
CFPP	⁰C	--------	-7	-17	-18	-17	-17	-18	<-20	- 20	-15
Copper Strip Corrosion	--------	1a	1a	1a	1a	1a	1a	1a	1a	No:1	No:1

Table 3. Properties of test devices

Name of the Device	Trademark	Measurement Accuracy	Measuring Range
Density Measuring Device	Kem Kyoto / DA-130N	±0,0001	0 – 40 ⁰C
Water Content Measurement Device	Kem Kyoto Electronic MKC-501	±0,01	5 – 35 ⁰C
Kinematic Viscosity Measuring Device	Koehler / K23377	±0,01	25 – 150 ⁰C
pH Meter	Hanna Intruments / HI8314	±0,01	0 – 14 pH
Flash Point Determination Device	Koehler / K16270	±0,01	0 – 370 ⁰C
Automatic Color Measuring Device	Lovibont / PFX195	---------	0,5 – 8 units
Calorimeter Device	Ika	± 0,0001	0 - 40000 joule
Chronometer	Taksun	± 0,1	------------
Cloud, Pour and Freezing Point Tester	Koehler / K46000	±0,01	(- 69) - 0 ⁰C
Cold Filter Plugging Point Measurement Device	Tanaka / AFP-102	±0,01	(- 60) – 0 ⁰C
Copper rod corrosion tester	Koehler / K25330	±0,01	0 – 190 ⁰C

3. Results and Discussion

3.1. Density values of the fuels

Figure 1 shows the density values of the fuels. When the test values were examined, it was seen that the density of canola oil was high, B_{100} and D_{100} fuels remained within the standards and the mixture fuels gave results close to D_{100} fuel. Density values were measured according to EN 61326-1 standard.

3.2. Water content values of the fuels

Figure 2 shows water content values of the fuels. When the test values were examined, it was seen that the water contents of the B_{100} and D_{100} fuels remained within the standards, while the canola oil and mixtures gave results close to the B_{100} fuel. Water content values were measured according to EN 61326-1 standard.

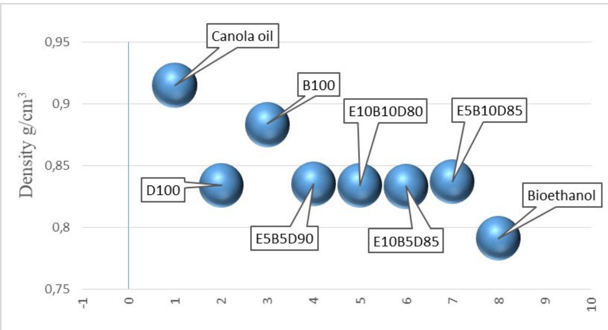

Figure 1. Density values of the fuels

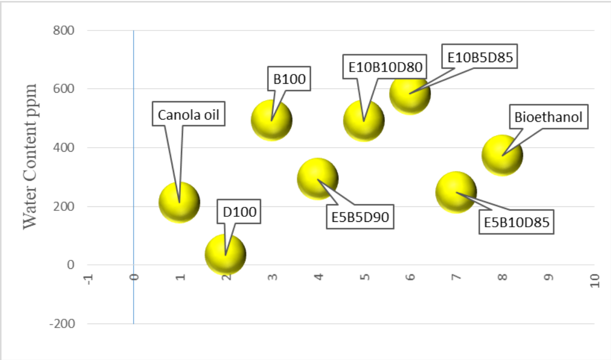

Figure 2. Water content values of the fuels

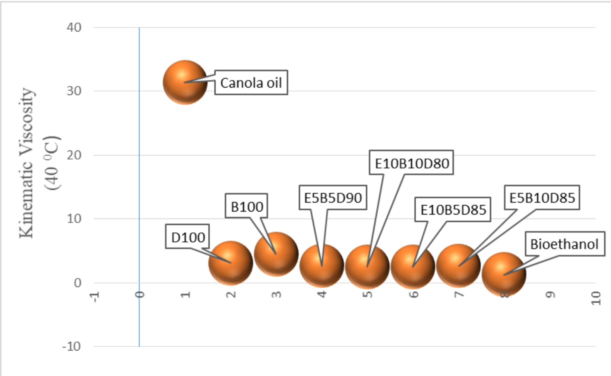

Figure 3. Kinematic viscosity values of fuels at 40°C

3.3. Kinematic viscosity values of fuels at 40°C

Figure 3 shows kinematic viscosity values of fuels at 40°C. When the test values were examined, it was seen that canola oil had a high kinematic viscosity value at 40 ^{0}C and B_{100} and D_{100} fuels remained within the standards. The lowest viscosity value at 40 ^{0}C is in $E_{10}B_5D_{85}$ fuels. Kinematic viscosity values at 40 degrees Celsius were measured according to ASTM D 445 standard.

3.4. Kinematic viscosity values of fuels at 100^{0}C

Figure 4 shows kinematic viscosity values of fuels at 100°C. When the test values were examined, it was seen that the canola oil had a high kinematic viscosity value at 100 ^{0}C and the B_{100} and D_{100} fuels remained within the standards. The lowest viscosity value at 100 ^{0}C was in *$E_{10}B_5D_{85}$ fuels*. Kinematic viscosity values at 100 degrees Celsius were measured according to ASTM D 445 standard.

3.5. pH values of the fuels

Figure 5 shows pH values of the fuels. When the pH test values were examined, the results were equivalent to each other in all fuels.

3.6. Flash point values of the fuels

Figure 6 shows flash point values of the fuels. When the test values were examined, it was seen that the flash point values of the fuels were in compliance with the standards. Flash point values were measured according to ASTM D 93 standard.

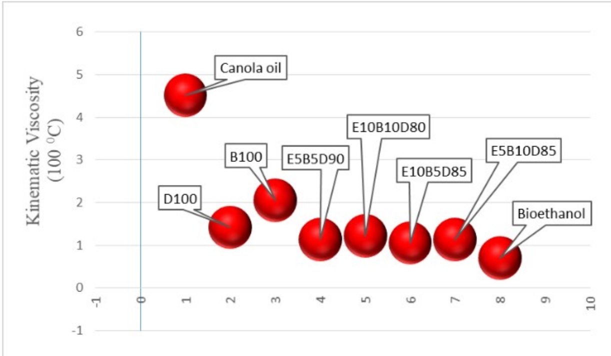

Figure 4. Kinematic viscosity values of fuels at 100^{0}C

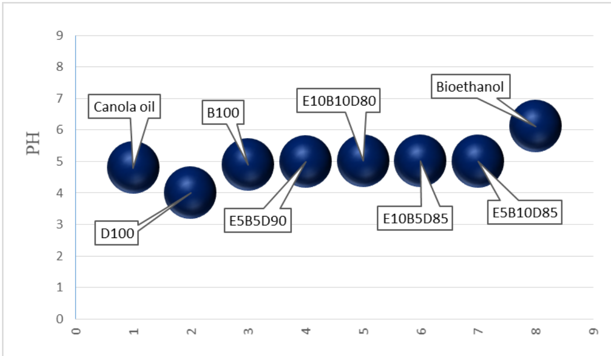

Figure 5. pH values of the fuels

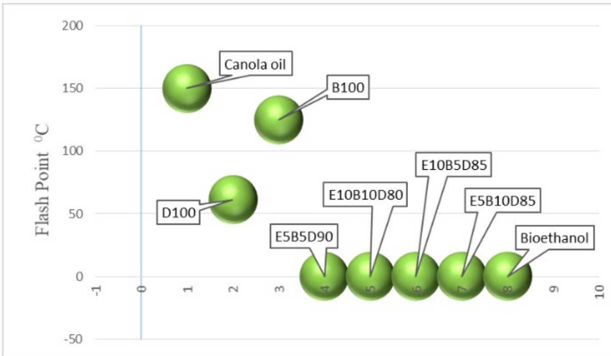

Figure 6. Flash point values of the fuels

3.7. Color specification values of the fuels

Figure 7 shows color specification values of the fuels. When the test values of color specification were examined, it was concluded that Canola oil and B_{100} fuel were lighter than other fuels. Color specification values were measured according to ASTM, CIE, Pt-Co/ Hazen / APHA color scales.

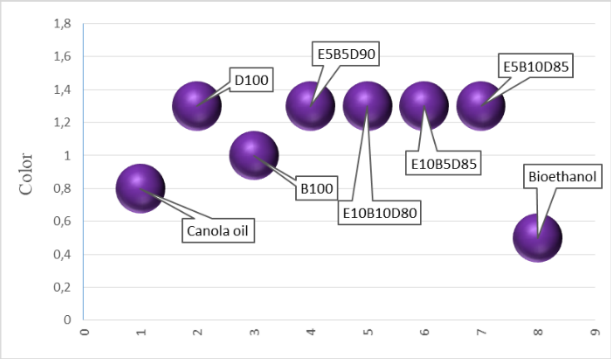

Figure 7. Color specification values of the fuels

3.8. Calorific values of the fuels

Figure 8 shows calorific values of the fuels. When the test values were examined, it was seen that the calorific value of B_{100} fuel was close to D_{100} fuel; and the highest calorific value was in $E_5B_5D_{90}$ fuel among fuel mixtures. Calorific values were measured according to EN 50082 standard.

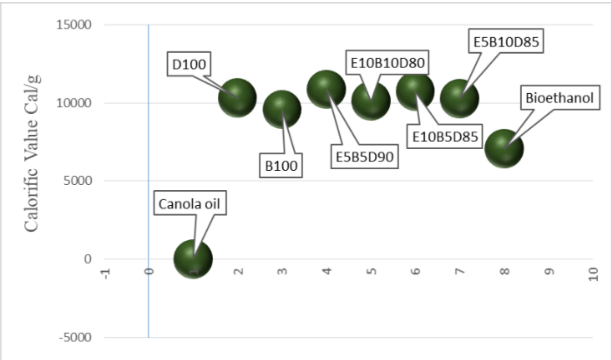

Figure 8. Calorific values of the fuels

3.9. Cloud point values of the fuels

Figure 9 shows cloud point values of the fuels. When the test values were investigated, it was observed that D_{100} fuel gave better results than the other fuels. Cloud point values were measured according to ASTM D97 standard.

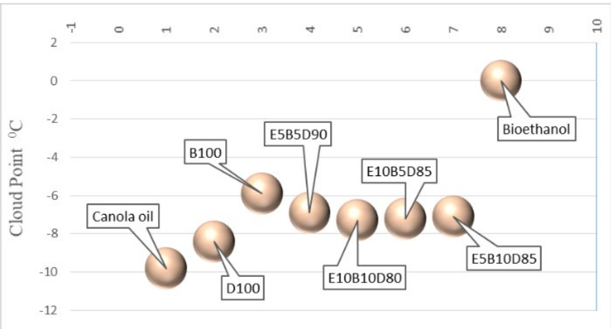

Figure 9. Cloud point values of the fuels

3.10. Pour point values of the fuels

Figure 10 shows the pour point values of the fuels. When the test values were investigated, it was observed that D_{100} fuel gave better results than the other fuels. Pour point values were measured according to ASTM D97 standard.

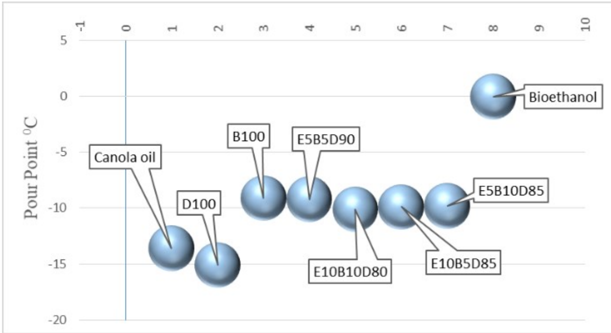

Figure 10. Pour point values of the fuels

3.11. Freezing point values of the fuels

Figure 11 shows freezing point values of the fuels. When the test values were investigated, it was observed that D_{100} fuel gave better results than the other fuels. Freezing point values were measured according to ASTM D97 standard.

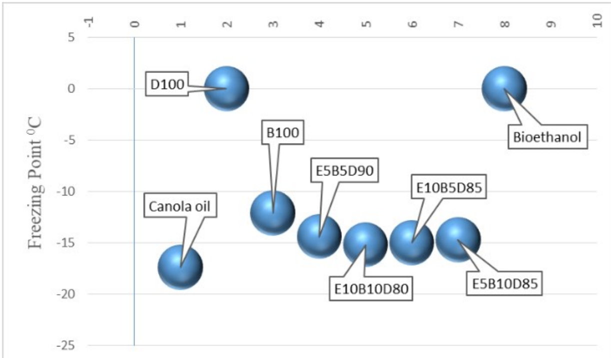

Figure 11. Freezing point values of the fuels

3.12. Cold filter plugging point values of the fuels

Figure 12 shows cold filter plugging point values of the fuels. When the test values were examined, it was seen that the fuels had similar results. Cold filter plugging point values were measured according to ASTM D 6371 standard.

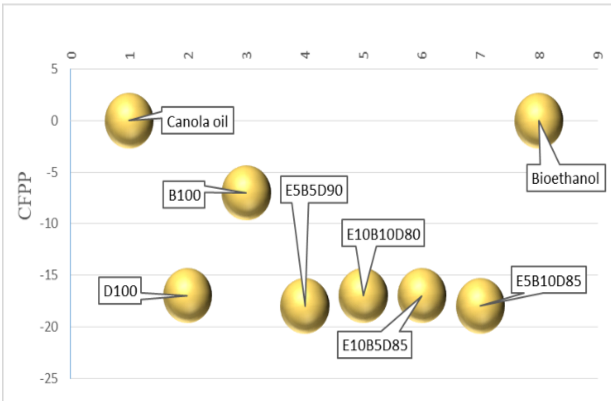

Figure 12. Cold filter plugging point values of the fuels

3.13. Copper rod corrosion values of the fuels

When the copper rod corrosion test values of the fuels were examined, 1a values were obtained in all fuels and they were not shown in graphics. Copper rod corrosion values were measured according to ASTM D 130 standard.

4. Conclusions

In this study, canola oil was transformed into Canola Oil Methyl Esters (Canola Biodiesel) by transesterification method and biodiesel was produced. Biodiesel fuel obtained from canola oil was mixed with diesel fuel with 5% and 10% bioethanol addition and by inversion with volumetric proportions, and then fuels in the form of D_{100}, B_{100}, $E_5B_5D_{90}$, $E_{10}B_{10}D_{80}$, $E_{10}B_5D_{85}$ and $E_5B_{10}D_{85}$ were obtained.

Fuel properties of the obtained mixtures and diesel fuel, density, water content, kinematic viscosity, pH value, flash point, color specification, calorific value, clouding, pour and freezing point tests, CFPP test and copper rod corrosion tests were performed.

As a result of this study, it was determined that the physical properties of biodiesel produced from canola oil conform to TS EN 14214 standard.

In addition, compared to diesel fuel, due to the fact that the calorific values and other properties of biodiesel and mixtures with bioethanol were close to diesel fuel, it was concluded that biodiesel produced from canola oil could be used as 100% in diesel engines blending with bioethanol and without any modification on the engine; and it was an alternative fuel to diesel fuel. When all values were investigated, it was seen that $E_5B_5D_{90}$ fuel gives the best results.

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