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 D100, B100, E5B5D90, E10B10D80, E16B4D85 and E5B10D85 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.
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_{5}B_{95}, E_{10}B_{90}, E_{10}B_{85} and E_{5}B_{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_{5}B_{95}    | 90     | 5          | 5                   |
| E_{10}B_{90}   | 80     | 10         | 10                  |
| E_{10}B_{85}   | 85     | 10         | 5                   |
| E_{5}B_{10}D_{85} | 85 | 5          | 10                  |
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, B100 and D100 fuels remained within the standards and the mixture fuels gave results close to D100 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 B100 and D100 fuels remained within the standards, while the canola oil and mixtures gave results close to the B100 fuel. Water content values were measured according to EN 61326-1 standard.

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Table 2. Analyses results [10]

| Characteristic Properties | Units | Canola | B100 | D100 | E0B7 | D0B7 | E0B9D0 | E0B9D3 | Bioethanol | Limiting Values |
|---------------------------|-------|--------|------|------|------|------|--------|--------|------------|-----------------|
| Density (15°C)            | g/cm³ | 0,915  | 0,883| 0,834| 0,835| 0,834| 0,833  | 0,837  | 0,791      | 0,82-0,86      |
| Water Content             | ppm   | 212,53 | 492,51| 34,52| 292,71| 490,87| 583,04  | 247,65  | 372,6      | 200-500        |
| Kinematic Viscosity (40°C)| mm²/s | 31,388 | 4,453| 3,071| 2,647| 2,492| 2,444  | 2,644  | 1,269      | 2-4,5          |
| Kinematic Viscosity (100°C)| mm²/s | 4,5127 | 2,044| 1,125| 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               | °C    | 150    | 125   | 61   |       |       |        |        | 55         | 50-120         |
| Color                     | ASTM  | 0,8    | 1,0   | 1,3  | 1,3  | 1,3  | 1,3    | 1,3    | 0,5        |               |
| Calorific Value           | Cal/gr|        |      |      |      |      |        |        |            |                |
| Cloud Point               | °C    | -9,8   | -5,9  | -8,4 | -6,9 | -7,3 | -7,2   | -7,1   |            |                |
| Pour Point                | °C    | -13,6  | -9,1  | -15,1| -9,2 | -10,1| -9,9   | -9,8   |            |                |
| Freezing Point            | °C    | -17,4  | -12,1 | -20  | -14,4| -15,2| -15    | -14,7  |            |                |
| CFPP                      | °C    |        | -7    | -17  | -18  | -17  | -17    | -18    | <-20       | -20-15         |
| Copper Strip Corrosion    |       | 1a     | la   | la   | la   | la   | la     | la     | 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 °C         |
| Water Content Measurement Device | Kem Kyoto Electronic MKC-501 | ±0,01                | 5 – 35 °C         |
| Kinematic Viscosity Measuring Device | Koehler / K23377 | ±0,01                | 25 – 150 °C       |
| pH Meter                    | Hanna Instruments / HI8314     | ±0,01                | 0 – 14 pH         |
| Flash Determination Device  | Koehler / K16270              | ±0,01                | 0 – 370 °C        |
| 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 °C     |
| Cold Filter Plugging Point Measurement Device | Tanaka / AFP-102 | ±0,01                | (- 60) – 0 °C     |
| Copper rod corrosion tester | Koehler / K25330               | ±0,01                | 0 – 190 °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 °C and B100 and D100 fuels remained within the standards. The lowest viscosity value at 40 °C is in E10B5D85 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°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 °C and the B100 and D100 fuels remained within the standards. The lowest viscosity value at 100 °C was in E10B5D85 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.

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 B100 fuel were lighter than other fuels. Color specification values were measured according to ASTM, CIE, Pt-Co/Hazen / APHA color scales.
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_{5}B_{5}D_{90} fuel among fuel mixtures. Calorific values were measured according to EN 50082 standard.

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.

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.

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.

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.
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$_{5}$B$_{95}$, E$_{10}$B$_{90}$, E$_{15}$B$_{85}$ and E$_{5}$B$_{10}$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$_{5}$B$_{95}$D$_{85}$ fuel gives the best results.

Acknowledgement

This study is prepared as a part of Tuğba ŞAHİN’s MS Thesis. (Advisor: Dr. Fatih AYDIN)

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