# DEVELOPMENT OF AN ALTERNATIVE BIOFUEL FROM SOYBEAN OIL

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**Abstract-** The increasing use of fossil fuels in recent decades has been appointed as one of the main factors responsible for global warming. The intensification in global average temperature has resulted in stricter environmental laws, particularly regarding the need to reduce atmospheric emissions. In this context, it is evident the importance of researching alternative fuels capable of replacing totally or partially fossil fuels, such as biofuels. In this work, a pseudoternary phase diagram was designed by using soybean oil (non-polar phase), ethanol (polar phase), 2-butanol (cosurfactant (C)) and DBB 7104 (surfactant (S)), and the microemulsion region was identified as a biofuel. The microemulsion mixture containing 35% wt soybean oil, 5% wt ethanol and 60% wt C/S = 10 was obtained by magnetic stirring at room temperature, and characterized with respect to specific gravity at 20 °C (852 kg/m$^3$), kinematic viscosity at 40 °C (4.7 ± 0.2 mm$^2$/s) and flash point (105 ± 1.0 °C) using ASTM standards. The results showed that the measured properties of the formulated biofuel are comparable to the standards required for commercialization of biodiesel in Brazil.

**Index Terms-** biofuels, ethanol, vegetable oil.

## I. INTRODUCTION

Biofuels have an important role in the world, especially when it is aimed to reduce the dependence on fossil fuels. In Brazil, biodiesel and ethanol are examples of renewable fuels that contribute to the diversification of energy sources and the preservation of the environment.
Scientific investigations around biofuels are focused on the search for alternatives to make them more economically competitive. In this scenario it has been researched fuels based on emulsions and microemulsions. They appear from the need of mixing immiscible components aiming to obtain a final isotropic product [1], [2]. Micro emulsions are thermodynamically stable due to the presence of a surfactant and, in some cases, a cosurfactant. They can flow easily and are typically translucent because the polar and non-polar phases are dispersed nanometrically (10-100 nm) [3].
Researchers like [1] and [4]-[9] have investigated microemulsions using diesel, biodiesel and/or vegetable oil as a non-polar phase. Reference [1] reported that despite the cycle diesel engine requires a greater consumption when using the microemulsion consisting of diesel, biodiesel, ethanol, Span 80 and water, it was observed a significant reduction of CO, $CO_2$ and NO emissions.
Recently, [2] investigated on the formulation of microemulsion biofuels resulted from the mixture of waste cooking oil (non-polar phase), ethanol (polar phase) and 2-butanol (cosurfactant) in different proportions. The resulting biofuel was translucent and stable, showing properties compatible with those required for biodiesel (according to ASTM D 6751). Reference [2] suggested that further studies should be conducted in order to investigate the influence of surfactants on the properties of the microemulsions.
In this sense, the aim of this work is to investigate the microemulsion formed from the mixture of soybean oil, ethanol, 2-butanol and surfactant DBB 7104. The resulting formulation was characterized by specific gravity at 20 °C, kinematic viscosity at 40 °C and flash point.

## II. METHODS

To obtain a microemulsion biofuel from soybean oil (Soya®) and ethanol (99.5% ACS, Neon), it has been tested 2-butanol as cosurfactant (99.5% ACS, Sigma-Aldrich) and DBB 7104 as a surfactant.
The microemulsion region was determined through volumetric titration of the components employed in the study (Table I). In addition, the cosurfactant/surfactant ratio (C/S) was set at 10.

**Table I: Mass proportions of the components.**

| Run | C/S (% wt) | Soybean oil (% wt) | Ethanol (% wt) |
|---|---|---|---|
| 1 | 100 | 0 | Titrant |
| 2 | 90 | 10 | Titrant |
| 3 | 80 | 20 | Titrant |
| 4 | 70 | 30 | Titrant |
| 5 | 60 | 40 | Titrant |
| 6 | 50 | 50 | Titrant |
| 7 | 40 | 60 | Titrant |
| 8 | 30 | 70 | Titrant |
| 9 | 20 | 80 | Titrant |
| 10 | 10 | 90 | Titrant |
| 11 | 0 | 100 | Titrant |

The masses were measured at an analytical balance (Mars AD200, class II) and the mixtures were obtained by magnetic stirring (New Instruments, NY 1102) at room temperature.
During titration, the titrant was added dropwise via pipette. The turning point was observed when the translucent and clear mixture became cloudy. With this procedure, it was possible to calculate the final mass percentages of the components involved in the mixture and a pseudoternary phase diagram was generated by using graphic software.

One single mixture was selected from the pseudoternary phase diagram and this resulting biofuel was characterized by specific density at 20 °C (Viscometer Stabinger, SVM 3000. ASTM D 4052), kinematic viscosity at 40 °C (Viscometer Stabinger, SVM 3000. ASTM D 445) and flash point (Petrotest, PM4. ASTM D 93). The measurements were performed in duplicate.

## III. RESULTS AND DISCUSSION

From the performed titrations, it was possible to obtain the pseudoternary phase diagram as shown in Fig. 1.

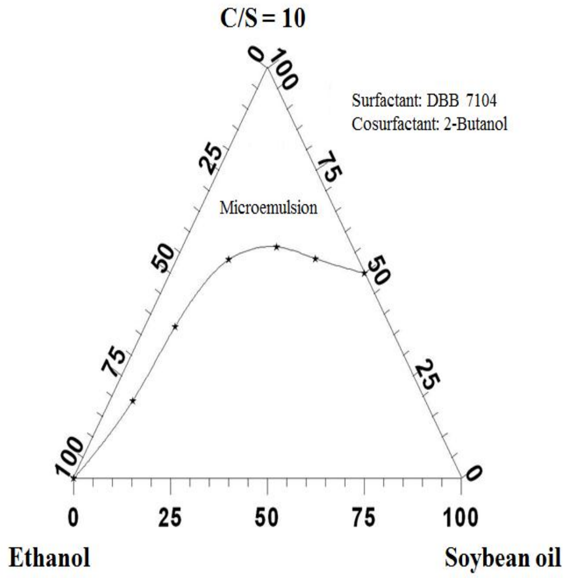


**Figure 1: Pseudoternary phase diagram. C/S = 10, soybean oil and ethanol**

According to Fig. 1 it can be seen that the mixture C/S = 10 was completely miscible in ethanol (Run 1, Table I). In contrast, the mixture C/S = 10 was partially miscible in soybean oil. It can be seen on Fig. 1 a miscible limit of 50% is reached. After this limit, the mixture C/S = 10 and soybean oil becomes blurred and even with the titration of ethanol in any proportion, no microemulsion region is observed. Once the pseudoternary phase diagram has been obtained, one single mixture inside the domain of the microemulsion region was selected for the formulation of the biofuel.

The mixture comprised of 35% wt soybean oil, 5% wt ethanol and 60% wt C/S = 10.
Fig. 2 shows the obtained biofuel after mixing the aforementioned components by magnetic stirring.

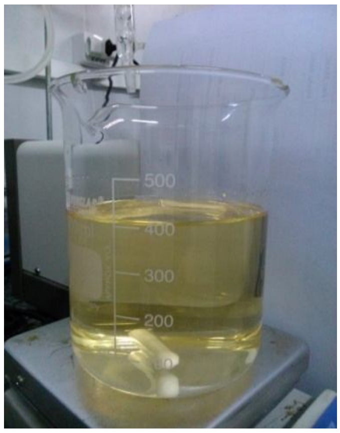

**Figure 2: Microemulsion Biofuel**

As shown in Fig. 2, the biofuel is clear and free of visible impurities at room temperature.
Table II shows the characterization of the sample regarding to specific gravity at 20 °C, kinematic viscosity at 40 °C and no flash point.

**Table II: Characterization of the formulated biofuel.**

| Properties | Value | Deviation | ANP Nº 45 |
|---|---|---|---|
| Specific gravity at 20°C (kg/m$^3$) | 852 | ±0.0 | 850 a 900 |
| Kinematic viscosity at 40°C (mm$^2$/s) | 4.7 | ±0.2 | 3.0 a 6.0 |
| Flash point (°C) | 105 | ±1.0 | Minimum 100 |

As shown in Table II, the formulated biofuel presents specific gravity at 20 °C, kinematic viscosity at 40 °C and flash point comparable to those values required for biodiesel according to the Resolution Nº 45 of the Brazilian National Agency of Petroleum and Biofuels (ANP), 25th August 2014 [10].

## CONCLUSION

Biofuels are a source of energy that can contribute positively to the diversification of the energy matrix of countries. These fuels must have satisfactory characteristics to be used in diesel engines and it should be homogeneous.
In this work it was successfully possible to obtain a microemulsion biofuel formed by a mixture of soybean oil (non-polar phase), ethanol (polar phase), 2-butanol (cosurfactant (C)) and DBB 7104 (surfactant (S)). It was chosen to formulate an alternative microemulsion biofuel from the mixture of 35% wt soybean oil, 5% wt ethanol and 60% wt C/S = 10. According to the characterization performed in this study, this biofuel was comparable to the standards required for commercialization of biodiesel in Brazil.

## REFERENCES

[1] G. R. KANNAN, R. ANAND, Experimental investigation on diesel engine with diestrolwater microemulsions. Energy, vol. 36, 2011, p. 1680-1687.

[2] P. BORA, J. BORO, L. J. KONWAR, D. DEKA, Formulation of microemulsion based hybrid biofuel from waste cooking oil - A comparative study with biodiesel. Journal of Energy Institute, article in press, 2015, p. 1-9.

[3] S. L. HOLT, Microemulsions: A contemporary overview. Journal of Dispersion Science and Technology. vol. 1, 1980, pp. 423.

[4] S. E. FRIBERG, E. G. FORCE, Diesel fuel. Patent, n. 2526814 GE. Sevenska Utvecklings AB. Germany, 1975.

[5] I. BLUTE, C. GENOVA, R. PAPPA, Diesel-water emulsion with good temperature stability-comprises diesel fuel, water glycolipid and aliphatic alcohol co-surfactant. Patent nº. 8920651 IT. ENIRICERCHE SPA (ENIE). Italy, 1989.

[6] M. D. SEXTON, A. K. SMITH, J. BOCK, M. L. ROBBINS, S. J. PACE, P. G. GRIMES, Microemulsion diesel fuel compositions and method of use. Patent, nº. 475620 USA. American, Exxon Research and Engineering co. United States, 1992.

[7] A. NAWRATH, T. SOTTMANN, R. STREY, Microemulsion useful as a fuel has both a continuous aqueous phase and hydrophobic fuel phase. Patent, nº. 2004EP51665, UNIV KOELEN (UIKO – N), 2004.

[8] R. CHANDRA, R. KUMAR, Fuel properties of some stable alcohol–diesel microemulsions for their use in compression ignition engines. Energy & Fuels. vol. 21, 2007, p. 3410-3414.

[9] T. NGUYEN, D. LINH, D. A. SABATINI, Biodiesel production via peanut oil extraction using diesel-based reverse-micellar microemulsions. Fuel, vol. 89, 2010, p. 2285-2291.

[10] ANP – Brazilian National Agency of Petroleum and Biofuels (Agência Nacional de Petróleo, Gás Natural e Biocombustíveis). ANP resolution Nº 45, 25th August 2014. Available in: <http://nxt.anp.gov.br/nxt/gateway.dll/leg/

[11] resolucoes_anp/2014/agosto/ranp%2045%20-%202014.xml>
. Accessed on 28th January 2016.

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