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Determination of the impact of the type of sunflower oil used for production of biofuels on the fractional composition of SFME

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Summary. The aim of the study was to determine the impact of the frying process on the fractional composition of SFME Biodiesel in comparison to the SFME obtained from unused (fresh) sunflower oil. The freshly pressed sunflower oil was divided into two portions. One was used for frying potato slices at 210°C for a period of 3 hours. The study showed the SFME biodiesel produced from unused (pure) sunflower oil generally has better distillation properties. The temperatures at the start of distillation were similar for both of the SFMEs. Within the 20-70% mid-range temperatures, the SFME produced from the used cooking sunflower oil was characterized by higher distillation temperatures for the same volume of fuel. The largest differences were observed for distillation temperatures from 85% to 100% and the final temperature of the distillation process. This may testify to lower purity of the SFME produced from the used cooking oil. In such a biofuel there may be more less volatile mono- and diglycerides or other chemicals which e.g. remain in the oil after frying. It must be said, though, these are not solid particles, as those were separated from the oil through filtration.

Key words: biodiesel SFME, biopaliwo, diesel engine, fractional composition, temperature distillation.

INTRODUCTION

Recently, there has been a great interest among individuals, including farmers, as well as companies and institutions being in possession of vehicle fleets in the possibility of producing biofuels for their own purposes. Under the law currently applicable in Poland, one may legally produce biofuels for their own purposes. Among especially privileged groups are farmers, who are allowed to produce raw material for the production of biofuels for their purposes, which significantly reduces the production cost for this energy carrier.

In accordance with the Act on bio-components and liquid fuels (adopted by the Polish Sejm on 25 August 2006), biofuels may be produced and marketed legally in Poland as of 1 January 2007. On the other hand, the annual national demand for diesel fuel is around 24,6 mln m^3 (20,4 mln tonnes) per year. The use of a fuel additive in the form of 7,8% (v/v) of bio-component necessitates production of approx. 1,99 mln m^3 (1,65 mln tonnes) of esters per year.

FAME Biodiesel is obtained in the process of transesterification. Its parameters deviate slightly from those of the diesel fuel, however, if the transesterification process is carried out properly, the resulting biofuel can be used as an additive in the form of a diesel bio-component or used as a 100% pure fuel. B100 FAME biodiesel has better parameters compared to the diesel fuel: higher cetane number, better lubricating properties, higher ignition temperature and low sulfur content [2,4].

One of the principal parameters used for assessing the suitability of FAME biodiesels for compression-ignition engines is the fractional composition, which is the reason why this very subject was chosen for investigation by the authors of this paper. The aim of the research presented below was to determine and compare the fractional compositions of two SFME biofuels: one produced from pure sunflower (sunflower oil) and the other derived from the same oil but used in the process of frying chips in a restaurant for a period of one week. When used in frying, the oil was heated to the temperature of 210°C.

A growing demand for biofuels produced mainly from rape-seed oil makes producers search for new alternative plants sunflower, a dicotyledon belonging to brassicas (plants of the cabbage family) being one of them [9,10].

Biofuel of the CSME Biodiesel type (Sunflower Methyl Esters) was produced in a GW-200 reactor constructed by one of the authors (G.W).

PRODUCTION OF RME BIOFUELS IN THE PROCESS OF TRANSESTERIFICATION FROM PURE OIL AND USED OIL

Calculating the optimum (stoichiometric) amount of reactants needed to carry out the transesterification process usually involves the usage of simplified models [3]. However, in order to determine the appropriate amount of reactants needed to produce RME (SFME), the authors of this paper used a model developed by one of the co-authors, which makes it possible to optimally determine the quantities of methyl alcohol and the catalyst necessary for the process of transesterification - Fig. 1 [5]. The following ratio was used for the purpose of transesterification of canola oils: for each 1 dm^3 of oil, a mixture obtained from dissolution of 7.0g of KOH in 0.14 dm^3 of CH_3OH was used. Transesterification was performed in a single step, with the temperature of the start of the process being 60^oC. P.a. purity CH_3OH methyl alcohol of a molecular weight of 32.04 g/mol was used for the transesterification process, along with p.a. purity KOH potassium hydroxide with a molecular weight of 56.11 g/mol as the catalyst.

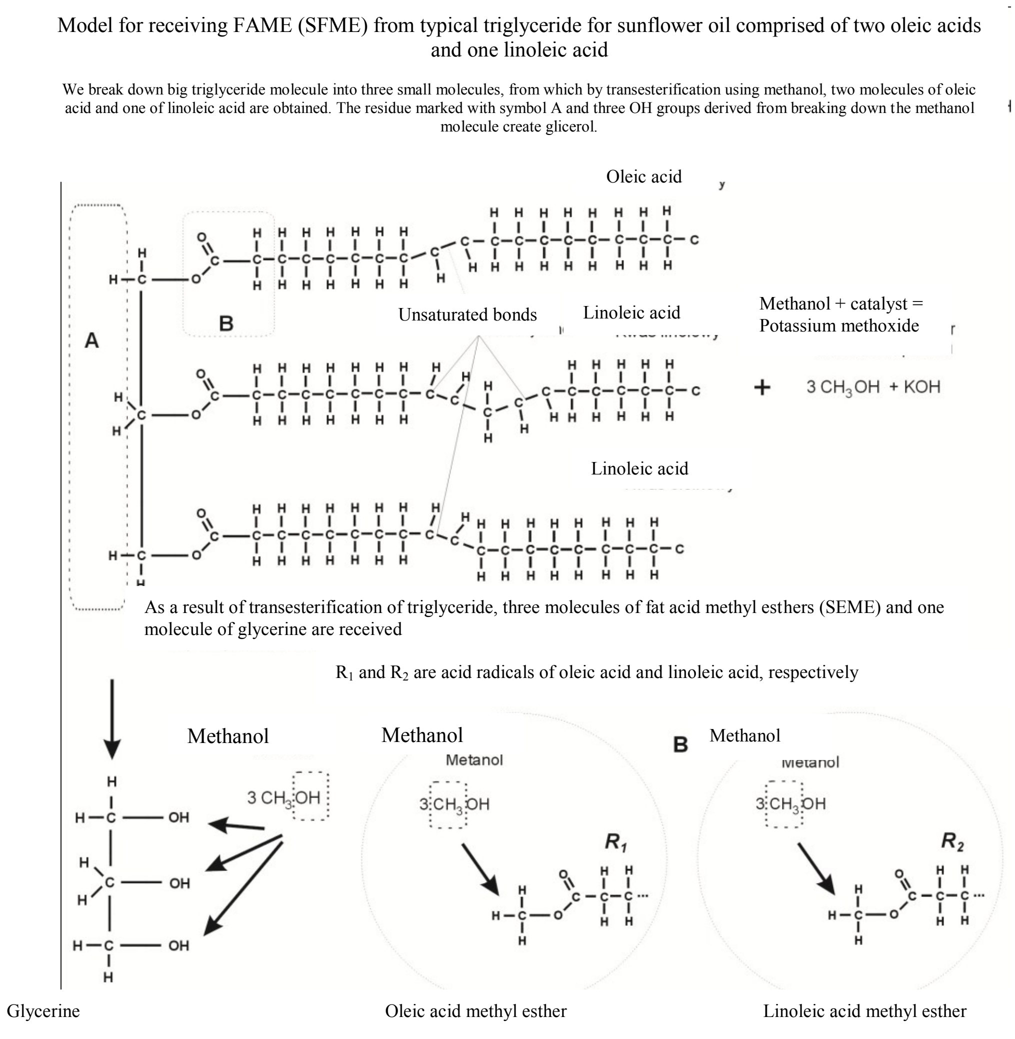

Fig. 1. Diagram of rapeseed oil transesterification – production of SFME biofuel

The process of transesterification was carried out in two stages and the obtained degree of oil transition into methyl esters was equal to 98.3% (m/m). The result has proved that the obtained CSME biofuel complies with EN 14214 standards of biofuel for a high pressure engine, as regards the ester content in FAME (Fatty Acid Methyl Esters).

DETERMINATION OF THE IMPACT OF THE TYPE OF SUNFLOWER OIL USED FOR BIOFUEL PRODUCTION ON THE FRACTIONAL COMPOSITION OF SFME BIODIESEL

A very important parameter used for the assessment of fuel/biofuel operating properties is their fractional composition. Said parameter is determined on the basis of the temperatures of distillation. The temperature of fuel ignition in an engine largely depends on the temperature of the start of distillation and the amount of fuel vaporized in the initial stage of distillation. The higher content of lightweight fractions is, the better self-igniting properties are, which translates directly into gentler way of starting the engine [6,11,12].

Vegetable oils have worse distillation properties, and thus worse engine-starting properties, compared to FAME [1,5].

In order to achieve proper starting and combustion properties, it is very important to establish five points. These are: the temperature at the start of distillation, the temperature for distillation of 10% (v/v) fuel, the temperature for evaporation of 65% (v/v) fuel, the temperature for distillation of 95% (v/v) fuel and the temperature at the end of the distillation process.

The research determining the fractional compositions of SFME biofuels obtained from pure and used canola oil was carried out in the biofuels laboratory of "BioEnergia" Malopolski Centre for Renewable Energy Sources at a workstation equipped with a camera for determining the composition of the fuels and biofuels with the method of normal distillation - Fig 2.

Fig. 2. Photo bench equipped with a distiller HAD 620/1 by Herzog

RESULTS

Table 1 summarizes the results of the research determining these distillation properties of SFME B100 Biodiesels. For comparison purposes, the table shows the results of the research on the distillation temperatures of RME B100 Biodiesel obtained from BLISKA service station chain owned by PKN ORLEN group and Ekodiesel fuel obtained from PKN ORLEN group service stations.

Table 2 summarizes the values of the most important points of the distillation curve for RME Biodiesels obtained from both of the canola oils, i.e. the temperatures at the start and end of the distillation process and the percentage (v/v) of distilled fuels at or below 250°C and 350°C.

Table 1. Comparison of distillation temperatures for two SFME Biodiesels and RME Biodiesel from BLISKA service stations and diesel fuel

% [v/v] of distillation	SFME Biodiesel from pure oil	SFME Biodiesel from used oil	RME Biodiesel BLISKA	ON PKN ORLEN
0	297	299	303	173
5	304	306	305	188
10	307	308	307	197
15	311	312	309	213
20	314	314	312	220
25	317	318	314	231
30	322	321	317	239
35	326	325	320	247
40	331	332	323	253
45	334	335	327	261
50	337	338	331	269
55	339	341	334	277
60	340	342	337	286
65	342	344	340	294
70	345	346	343	305
75	347	348	346	313
80	349	350	349	322
85	350	355	351	333
90	352	358	354	342
95	354	362	356	349
100	358	371	359	352

Table 2. Characteristic distillation curve points for diesel and SFME biofuels

Up to this temperature, % (v/v) was distilled				
fuel	Start of distillation [^{o}C]	End of distillation [^{o}C]	up to 250^{o}C distils v/v [%]	up to 350^{o}C distils v/v [%]
SFME Biodiesel from pure oil	297	358	0	85
SFME Biodiesel from used oil	299	371	0	75
RME Biodiesel BLISKA	303	359	0	82
ON	173	352	38	96

CONCLUSIONS

The study has shown that SFME Biodiesel produced from unused (fresh) sunflower oil is characterized by better distillation properties. The initial stages of distillation and the quantity of middle distillates in said SFMEs are similar. The start of distillation for both the SFMEs occurred at approx. 298^{o}C. Approx. 80% (v/v) of SFME was distilled up to 350^{o}C. Greater differences were observed for the 85% (v/v) distillation temperatures and at the end of the distillation process. 90% (v/v) SFME vaporised up to the temperature of 352^{o}C, whearas for biufuel derived from used oil the temperature was 358^{o}C. SFME obtained from the fresh sunflower oil was entirely distilled up to the temperature of 358^{o}C, while SFME derived from the used sunflower oil vaporised on reaching 371^{o}C. This may testify to lower purity of the SFME produced from used cooking oil. In such biofuel, there may be more less volatile mono- and diglycerides or other chemicals which result from the lower level of oil-to-biofuel conversion and/or are an effect of residues from the process of frying chips. It must be said, though, these were not solid particles, as those were separated from the oil through filtration.

Biodiesel produced from used sunflower oil SFME will not meet the requirements set out in EN 14214 for FAME biofuels due to the final distillation temperature. Under the above-mentioned standard, the temperature of 360°C needs to vaporise the entire amount of biofuel.

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OKREŚLENIE WPŁYWU RODZAJU OLEJU SŁONECZNIKOWEGO UŻYTEGO DO PRODUKCJI BIOPALIW NA SKŁAD FRAKCYJNY SFME

Streszczenie. Celem badań było określenie wpływu procesu smażenia oleju słonecznikowego na skład frakcyjny biodiesla SFME wyprodukowanego z takiego oleju w porównaniu z SFME uzyskanego z nieużywanego (świeżego) oleju słonecznikowego. Świeżo tłoczony olej słonecznikowy podzielono na dwie porcje. Jeden był używany do smażenia talarków ziemniaczanych w temperaturze 210°C przez okres 3 godzin. Badanie wykazało, że biodiesel SFME produkowany z nieużywanego (czystego) oleju słonecznikowego ma ogólnie lepsze właściwości destylacyjne. Temperatury na początku destylacji były podobne dla obu SFME. W zakresie średnich temperatur (20-70%), SFME wytworzony z użytego oleju słonecznikowego posmażalniczego charakteryzował się wyższą temperaturą destylacji dla tej samej objętości paliwa. Największe różnice zaobserwowano dla temperatur końca destylacji od 85% do 100% i końcowej temperatury procesu destylacji. Może to świadczyć o mniejszej czystości SFME wyprodukowanego z posmażalniczego oleju. W takim biopaliwie może znajdować się więcej mało lotnych mono i di-glicerydów lub innych związków, które np. pozostały w oleju po procesie smażenia talarków ziemniaczanych. Przy czym nie chodzi tu o cząstki stałe, ponieważ te zostały oddzielone od oleju podczas filtracji.

Słowa kluczowe: Biodiesel SFME, biopaliwo, silnik wysokoprężny, skład frakcyjny, temperatury destylacji.