

Determination of the Impact of the Type of Camelina Oil Used for Production of Biofuels on the Fractional Composition of CSME

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Summary. The aim of the study was to determine the impact of the frying process on the fractional composition of CSME Biodiesel in comparison to the CSME obtained from unused (fresh) camelina oil. The freshly pressed camelina oil was divided into two portions. One was used for frying chips at 190°C for a period of 10 hours. The study showed the CSME biodiesel produced from unused (pure) camelina oil generally has better distillation properties. The temperatures at the start of distillation were similar for both of the CSMEs. Within the 30-70% mid-range temperatures, the CSME produced from the used cooking camelina oil was characterized by higher distillation temperatures for the same volume of fuel. The largest differences were observed for the 90% and 95% distillation temperatures and the final temperature of the distillation process. This may testify to lower purity of the CSME 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, Biodiesel, diesel engine, fractional composition, temperature distillation.

INTRODUCTION

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. So far the country has launched 10 major installations intended for the production of FAME (RME) biofuels, whose total production capacity is estimated to be as high as 1 million tonnes of esters a year. On the other hand, the annual national demand for diesel fuel is around 7.5 million tonnes per year. The use of a fuel additive in the form of 6% (v/v) of bio-component necessitates production of approx. 450,000 tonnes of esters per year.

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.

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 [3,4,6].

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 CSME biofuels: one produced from pure camelina / canola 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 190°C.

A growing demand for biofuels produced mainly from rape-seed oil makes producers search for new alternative plants, Gold of pleasure (Camelina Sativa), a dicotyledon belonging to brassicas (plants of the cabbage family) being one of them [10,11,12]. As far as soils are concerned Gold of pleasure is undemanding, compared with oilseed rape, and can be grown on soils of the 5th and 6th classes. Around 700dm³ of oil can be obtained from 1 hectare of land while applying a one-step method of cold pressing [9]. Biofuel of the CSME Biodiesel type (Camelina Sativa Methyl Esters)

was produced in a GW-10 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 [5]. However, in order to determine the appropriate amount of reactants needed to produce RME, 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 [7]. The following ratio was used for the purpose of transesterification of canola oils: for each 1 dm³ of oil, a mixture obtained from dissolution of 7.5g of KOH in 0.15 dm³ of CH₃OH was used. Transesterification was performed in a single step, with the temperature of the start of the process being 50°C. P.a. purity CH₃OH 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.

Methyl alcohol (methanol) was used for transesterification of Gold of pleasure oil with alkaline potassium hydroxide (potassium hydroxide pure p.a.) as a catalyst in the reaction.

The process of transesterification was carried out in two stages and the obtained degree of oil transition into methyl esters was equal to 97.2% (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 CAMELINA OIL USED FOR BIOFUEL PRODUCTION ON THE FRACTIONAL COMPOSITION OF CSME 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 vaporised 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 [8, 13, 14].

Model for receiving RME (FAME) from typical triglyceride for canola oil comprised of two oleic acids and one linoleic acid

We break down big triglyceride molecule into three small molecules, from which by transesterification using methanol, two molecules of oleic acid and one of linoleic acid are obtained. The residue marked with symbol A and three OH groups derived from breaking down the methanol molecule create glycerol.

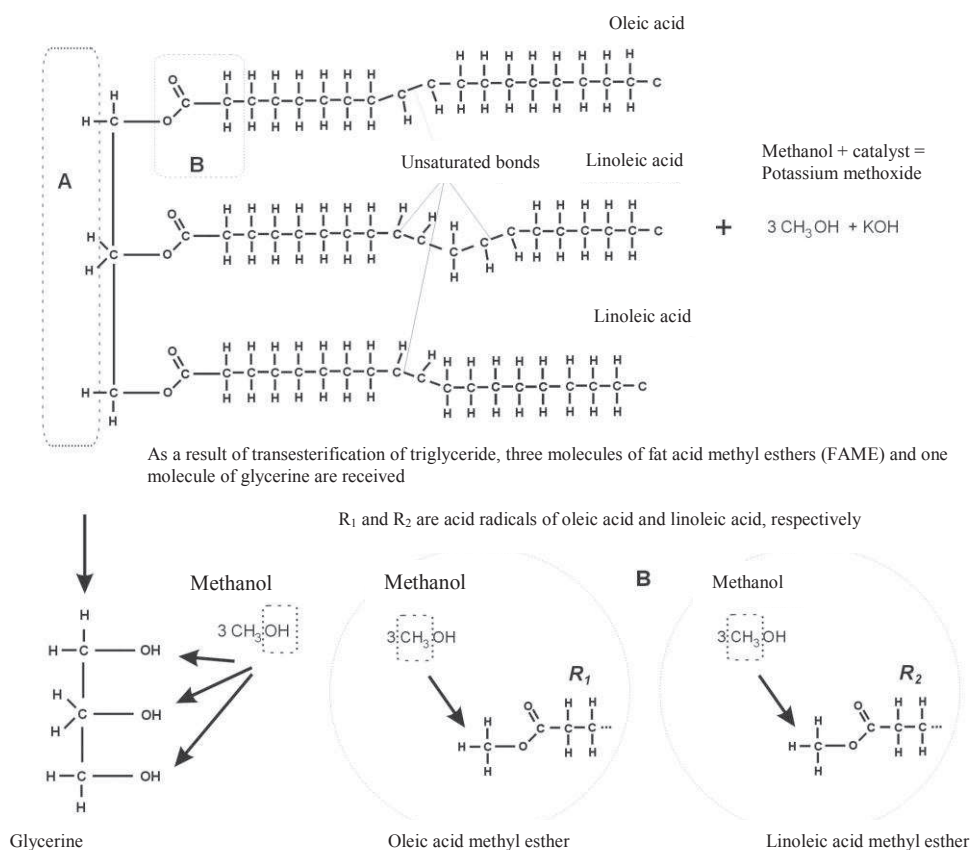


Fig. 1. Diagram of rapeseed oil transesterification

Vegetable oils have worse distillation properties, and thus worse engine-starting properties, compared to FAME [1, 2, 7].

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 CSME 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 CSME 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 CSME Biodiesels and RME Biodiesel from BLISKA service stations and diesel fuel

% [v/v] of distillation	CSME Biodiesel from pure oil	CSME Biodiesel from used oil	RME Biodiesel BLISKA	ON
0	306	308	304	178
5	314	315	310	192
10	322	322	319	202
15	334	336	334	216
20	341	343	339	222
25	346	347	345	234
30	351	356	347	241
35	355	361	349	248
40	358	363	351	255
45	362	367	352	263
50	364	370	356	270
55	365	372	358	279
60	368	375	360	287
65	370	377	361	295
70	372	379	362	305
75	373	381	363	313
80	376	383	365	322
85	379	387	368	333
90	381	392	370	341
95	384	395	372	353
100	391	402	389	361

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

fuel	Up to this temperature, % (v/v) was distilled			
	Start of distillation [°C]	End of distillation [°C]	up to 250°C distils v/v [%]	up to 350°C distils v/v [%]
CSME Biodiesel from pure oil	306	391	0	29
CSME Biodiesel from used oil	308	402	0	27
RME Biodiesel BLISKA	304	389	0	37
ON	171	361	36	93

CONCLUSIONS

The study has shown that CSME Biodiesel produced from unused (fresh) camelina oil is characterized by better distillation properties. The initial stages of distillation and the quantity of middle distillates in said CSMEs are similar. The

start of distillation for both the CSMEs occurred at approx. 305°C. Approx. 35% (v/v) of RME was distilled up to 350°C. Greater differences were observed for the 90% (v/v) distillation temperatures and at the end of the distillation process. 90% (v/v) CSME vaporised up to the temperature of 270°C, whereas for biofuel derived from used oil the temperature was 282°C. CSME obtained from the fresh camelina oil was entirely distilled up to the temperature of 386°C, while RME derived from the used camelina oil vaporised on reaching 392.0°C. This may testify to lower purity of the CSME 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.

After the comparison of the results for both the CSMEs with a commercial RME biofuel obtained from BLISKA service stations, it turned out that biofuels from camelina are characterized by slightly worse distillation properties. Notable is the difference in the quantity of RME distilled up to the temperature of 350°C, since BLISKA service station biofuels vaporized in greater amounts – 10% (v/v) more than the CSME produced from the pure oil and 14% more than the CSME from the used cooking camelina oil.

Both the CSMEs do not comply with the requirements set by EN 14214 for FAME plant 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 UŻYTEGO OLEJU RZEPAKOWEGO DO PRODUKCJI BIOPALIW NA SKŁAD FRAKCYJNY CSME

Streszczenie. Przeprowadzone badania pokazały, że niezależnie od rodzaju zastosowanego oleju lnianki do produkcji RME, czy będzie to olej nieużyty lub zużyty, zakresy temperatur destylacji były podobne. Niewielkie różnice zanotowano jedynie dla temperatur końca destylacji. CSME wyprodukowane z zużytego oleju lnianki potrzebowało wyższych temperatur do odparowania całej objętości FAME. Może to świadczyć o mniejszej czystości CSME uzyskanego ze zużytego oleju. W takim biopaliwie może znajdować się więcej małych lotnych mono i di-glicerydów lub innych związków, które np. pozostały w oleju po procesie smażenia frytek. Przy czym nie chodzi tu o cząstki stałe, ponieważ te zostały oddzielone od oleju podczas filtracji.

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