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Determination of the impact of the type of animal fat used for production of biofuels on the fractional composition of AME

G. Wcisło, N. Labak

Faculty of Production Engineering and Power Technologies,
University of Agriculture in Krakow, Poland
Tel. 0048 12 662-46-46, (kom) 0048513-157-977, e-mail: grzegorz.wcislo@ur.krakow.pl

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Summary. The aim of the study was to determine the impact of the frying process on the fractional composition of AME Biodiesel in comparison to the AME obtained from unused (fresh) animal fat. The fresh animal fat was divided into two portions. One was used for frying chips at 63^{o}C for a period of 4 hours. The study showed the AME biodiesel produced from unused (pure) animal fat generally has better distillation properties. The temperatures at the start of distillation were similar for both of the AMEs. Within the 45-60% mid-range temperatures, the AME produced from the used cooking animal fat was characterized by higher distillation temperatures for the same volume of fuel. The largest differences were observed for the 85% and 95% distillation temperatures and the final temperature of the distillation process. This may testify to lower purity of the AME produced from the used cooking oil. In such a biofuel may consist less volatile mono-diglycerides or other chemicals which 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, AME – Animal Fat Methyl Esters, diesel engine, fractional composition, temperature distillation.

INTRODUCTION

In accordance with the Act on bio-components and liquid fuels (adopted by the Polish Government on 25th August 2006), biofuels may be produced and distributed legally in Poland as of 1st January 2007 [15]. So far there has been launched 10 major installations in Poland, intended for the production of FAME (RME) biofuels, which 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 7% (v/v) of bio-component necessitates production of approx. 525 000 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 [3,4,5].

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 AME biofuels: one produced from pure animal fat 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^{o}C.

A growing demand for biofuels produced mainly from rape-seed oil makes producers search for new alternative plants, a dicotyledons belonging to brassicas (plants of the cabbage family) being one of them [7,11,12,13]. For the production of FAME are increasingly willing to use the animal fat Biofuel of the AME Biodiesel type (Animal Fat Methyl Esters) was produced in a GW-10 reactor constructed by one of the authors (G.W).

PRODUCTION OF AME BIOFUELS IN THE PROCESS OF TRANSESTERIFICATION FROM PURE FAT AND USED FAT

Calculating the optimum (stoichiometric) amount of reactants needed to carry out the transesterification process usually involves the usage of simplified models [6]. 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 [8,10]. 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 0.15 dm^3 of CH_3OH was used. Transesterification was performed in a single step, with the temperature of the start of the process being 63^{o}C 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.

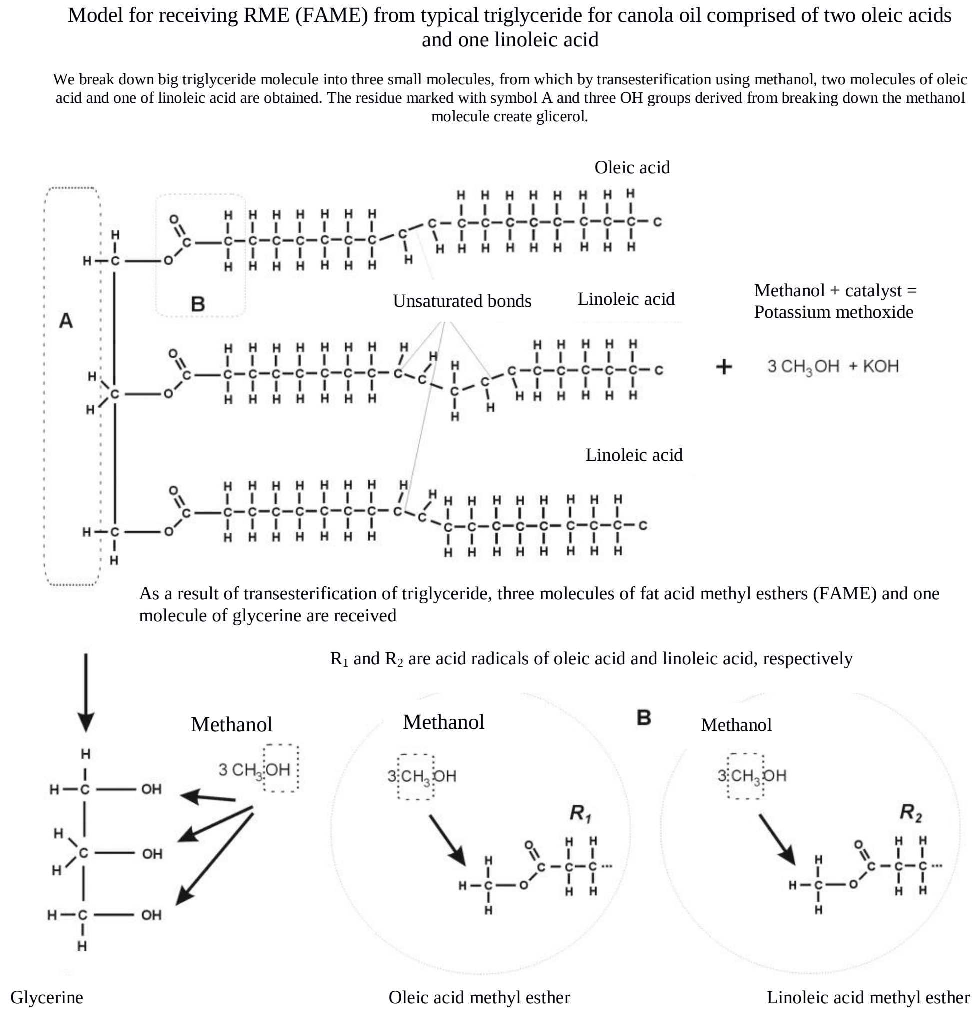

Fig. 1. Diagram of rapeseed oil transesterification [10]

The process of transesterification was carried out in two stages and the obtained degree of oil transition into methyl esters was equal to 98.1% (m/m). The result has proved that the obtained AME 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 ANIMAL FAT USED FOR BIOFUEL PRODUCTION ON THE FRACTIONAL COMPOSITION OF AME BIODIESEL

Biofuel of the AME Biodiesel type (Animal Fat Methyl Esters) was produced in a GW-200 reactor constructed by one of the authors (G.W) - Fig. 2. A very important parameter used for the assessment of fuel/biofuel operating properties is their fractional composition.

Mentioned 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 [9,14,15].

Vegetable oils or animal fats have worse distillation properties, and thus worse engine-starting properties, compared to FAME [1,2,8].

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 AME biofuels obtained from pure and used animal fat was carried out in the biofuels laboratory of "BioEnergia" Malopolski Centre for

Renewable Energy Sources at a workstation equipped with a AME for determining the composition of the fuels and biofuels with the method of normal distillation – Fig 3.

Fig. 2. Reactor GW 200 for production of Biodiesel FAME (FAEE)

Fig. 3. 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 AME 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 Eurodiesel fuel obtained from LOTOS S.A. 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 AME Biodiesels and RME Biodiesel from BLISKA service stations and diesel fuel

% [v/v] of distillation	AME Biodiesel from pure fat	AME Biodiesel from used fat	RME Biodiesel BLISKA	Fuel diesel LOTOS S.A.
0	296	299	304	172
5	304	308	310	187
10	313	317	319	197
15	326	329	334	206
20	333	335	339	216
25	337	340	345	227
30	343	346	347	235
35	346	349	350	241
40	348	350	353	248
45	350	356	357	257
50	352	360	358	265
55	353	362	361	274
60	355	364	363	283
65	358	365	364	290
70	361	366	365	300
75	365	367	366	307
80	366	369	368	316
85	368	377	376	327
90	371	379	379	335
95	372	380	381	348
100	381	387	389	357

Table 2. Characteristic distillation curve points for diesel and AME 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 [%]
AME Biodiesel from pure oil	296	381	0	45
AME Biodiesel from used oil	299	387	0	37
RME Biodiesel BLISKA	304	389	0	35
Fuel Diesel LOTOS	172	357	41	97

CONCLUSIONS

The study has shown that AME Biodiesel produced from unused (fresh) animal fat is characterized by better distillation properties. The initial stages of distillation and the quantity of middle distillates in above mentioned AMEs are similar. The start of distillation for both AMEs occurred at approx. 298^{o}C. Approx. 40% (v/v) of AME was distilled up to 350^{o}C. Greater differences were observed for the 45-60% and 90-95% (v/v) distillation temperatures and at the end of the distillation process. AME obtained from the fresh animal fat was entirely distilled up to the temperature of 381^{o}C, while RME derived from the used animal fat vaporised on reaching 388^{o}C. This may testify to lower purity of the AME produced from used cooking oil. In such biofuel, there may be less volatile mono-diglycerides or other chemicals which result from the lower level of oil to biofuel conversion and are an effect of residues from the process of frying. 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 AMEs with a commercial RME biofuel obtained from BLISKA service stations, it turned out that biofuels from animal fat are characterized by slightly better 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 minor amounts – 10% (v/v) less than the AME produced from the pure oil and 6% more than the AME from the used cooking animal fat. Both the AMEs 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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