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Determining the effect of oil after frying fish for the production of biofuels with a fractional composition of FAME

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Abstract. The aim of the study was to determine the impact of the fish frying process on the distillation properties of FAME and its mixtures with diesel fuel.

The fish was fried at 160°C for 2 hours. Frying one serving lasted 6 minutes. The frying oil was a mixture of 50% (v/v) rapeseed oil and 50% (v/v) sunflower oil. The study showed that FAME biodiesel made from unused (pure) oil has similar distillation properties.

The largest differences were observed for distillation temperatures of 85% and 100% and the final temperature of the distillation process. This may indicate a slightly lower purity of FAME produced from used cooking oil. In such a biofuel there may be more less volatile mono- and diglycerides or other chemicals that, e.g. after frying, remain in oil. It must be said, however, that they are not solid particles because they have been separated from the oil by filtration.

Keywords: Biodiesel, FAME – Fatty Acid Methyl Esters, diesel engine, fractional composition, temperature distillation.

INTRODUCTION

FAME Biodiesel is a biofuel that is mainly produced in the transesterification process. Its parameters slightly differ from those of diesel, however, if the transesterification process is carried out correctly, the resulting biofuel can be used as an additive in the form of a diesel biocomponent or as a fuel 100% pure.

The growing demand for biofuels produced mainly from vegetable oils (rapeseed, soybean, sunflower or palm) causes that producers are looking for new alternative plants from which FAME can be produced [7,11]. Used (post-frying) oils or mixtures of various oils are also increasingly used in the production of FAME.

Biodiesel B100 FAME has better parameters compared to diesel: higher cetane number, better lubricating properties, higher flash point and low sulfur content [3,4,5].

One of the main parameters used to assess the suitability of FAME biodiesel for compression-ignition engines is the fractional composition, which is why the authors of this article selected this topic for research.

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The purpose of the research presented was to determine and compare the distillation properties of two FAME biofuels: one produced from pure oil (a mixture in the amount of 50% (v/v) rapeseed oil and 50% (v/v) sunflower oil. The other oil was a similar mixture only was used for fish frying. Fish was fried in total for 2 hours. Frying of one portion of fish fished for 6 minutes. Fish was fried at 160°C. For comparison, the results of Biodiesel B100 manufactured by the Trzebinia refinery were combined. Additionally, commercial diesel oil from PKN Orlen

Own biofuels were produced in the GW-10 reactor built 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 8.0g of KOH in 0.16 dm^3 of CH_3OH was used. Transesterification was performed in a single step, with the temperature of the start of the process being 64°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.

The process of transesterification was carried out in one stage and the obtained degree of oil transition into methyl esters was equal to 97.6%(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 FAME Biodiesel 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. 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 [9,12].

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 glicerol.

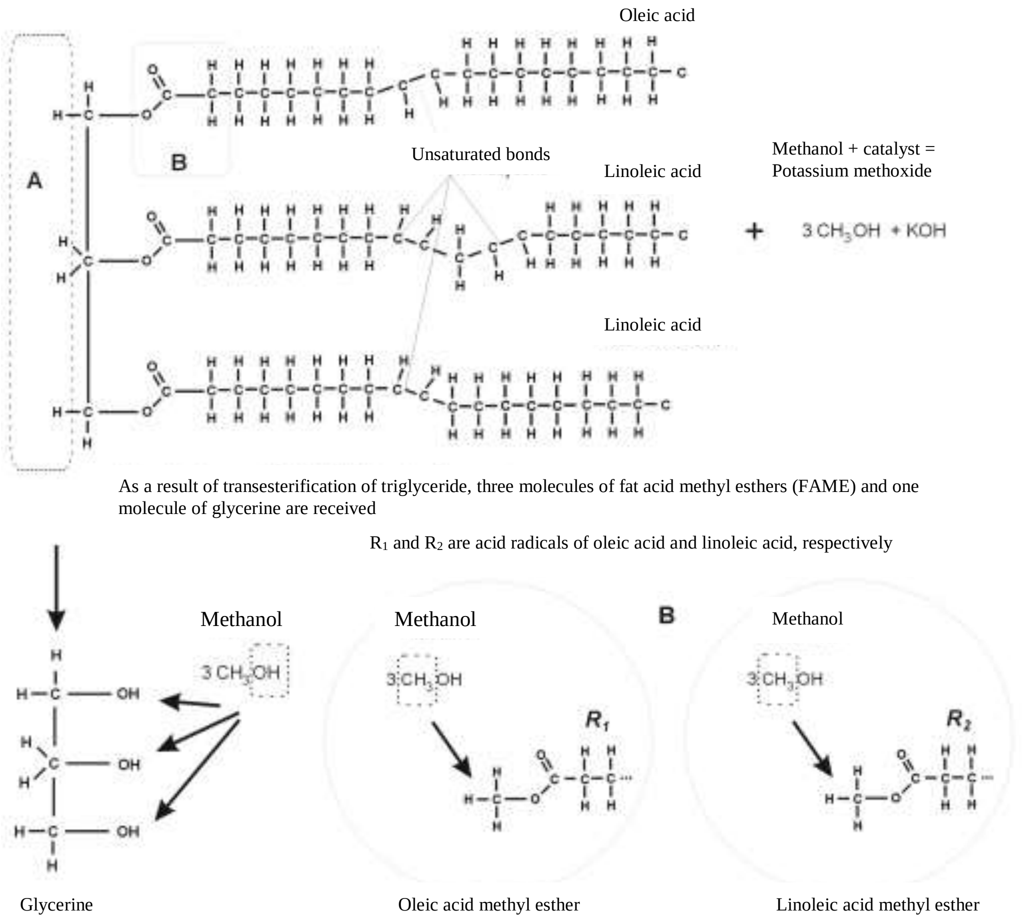

Fig. 1. Diagram of rapeseed oil transesterification [10]

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

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 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 Malopolski Centre for Renewable Energy Sources "BioEnergia" at a workstation equipped with a FAME for determining the composition of the fuels and biofuels with the method of normal distillation - Fig 3.

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 FAME B100 Biodiesels. For comparison purposes, the table shows the results of the research on the distillation temperatures of RME B100 Biodiesel obtained from PKN ORLEN group. In addition, Ekodiesel ULTRA fuels obtained from the same group.

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 FAME BIODIESELS AND RME BIODIESEL FROM PKN ORLEN SERVICE STATIONS AND DIESEL FUEL

% [v/v] of distillation	**FAME Biodiesel from pure fat**	**FAME Biodiesel from used fat**	**RME Biodiesel PKN ORLEN**	**Fuel diesel PKN ORLEN**
0	291	293	301	168
5	302	304	308	183
10	310	312	316	195
15	315	316	321	203
20	319	321	325	214
25	323	325	328	224
30	325	328	330	233
35	328	330	331	239
40	330	332	334	246
45	331	333	337	255
50	333	334	338	263
55	334	335	340	271
60	336	337	342	280
65	339	341	344	287
70	340	341	346	294
75	341	344	347	299
80	343	346	348	308
85	346	351	350	316
90	349	354	352	321
95	351	356	353	328
100	352	358	355	336

TABELA 2.CHARACTERISTIC DISTILLATION CURVE POINTS FOR DIESEL AND FAME BIOFUELS

Up to this temperature, % (v/v) was distilled				
fuel	***Start of distillation [ºC]***	***End of distillation [ºC]***	***up to 250ºC distils v/v [%]***	***up to 350ºC distils v/v [%]***
FAME Biodiesel from pure oil	291	352	0	93
FAME Biodiesel from used oil	293	358	0	84
RME Biodiesel PKN ORLEN	301	355	0	85
Fuel Diesel PKN ORLEN	168	336	36	100

CONCLUSIONS

The study has shown that FAME Biodiesel produced from unused (fresh) oil is characterized by similar distillation properties. The initial stages of distillation and the quantity of middle distillates in said FAMEs are similar. The start of distillation for both the FAMEs occurred at approx. 292°C. Approx. 90% (v/v) of FAME was distilled up to 350°C. Greater differences were observed for the 85-100% (v/v) distillation temperatures and at the end of the distillation process. FAME obtained from the fresh animal fat was entirely distilled up to the temperature of 352°C, while RME derived from the used animal fat vaporised on reaching 358°C. This may testify to lower purity of the FAME 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. 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 FAMEs 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. Both the FAMEs 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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