Biodiesel manufacture as a solution to waste cooking oil disposal: is it feasible? Will any type of oil do?

V. Cordero (1), J. Schallenberg-Rodriguez (1), A. López-Guerra(1)
(1) Universidad de Las Palmas de Gran Canaria. Escuela de Ingenierías Industriales y Civiles,
Campus de Tafira, 35107 Tafira Baja, Las Palmas.
0034 619 026 801, virginia.cordero90@gmail.com

1. Introduction

Biodiesel production might be the solution to the disposal of waste cooking oil (WCO) and its associated contamination. Every year, tons of WCO are dumped into sinks and toilets, polluting water supplies. Biodiesel from WCO could also help secure food supplies in countries where fuel crops have displaced food crops, eliminating the controversy associated to this substitution.

This work represents an attempt to determine if the use of a particular type of WCO results in a better fuel quality.

2. Methodology

Seven samples of different oils have been used for the experiments. Oil types, oil crop and status, are summarized in figure 1.

Sample	Oil crop	Status
1	Sunflower	Poor use
2	Sunflower	Heavily used
3	Olive	Moderately used
4	Olive	Poorly used
5	Maize	Heavily used
6	Olive	Few uses
7	Olive	Heavily used

Fig. 1. Oil samples used for the experiments

The goal is to determine whether there is a significant difference in quality depending on which type of oil is used, either as a function of the oil crop (sunflower, olive or maize) or its degree of use.

Each of the samples went trough a transesterification process, using methanol as alcohol and NaOH as catalyst. These reagents were selected to keep the process as simple and cheap as possible. The process includes washing and drying of the final fuel, and it is undertaken twice for each sample to contrast the results obtained. A summary of results showing the average for each sample is presented in the next section figure 4. Figure 2 shows the samples after drying.

Fuel quality is assessed according to the EN ISO 14214:2013 standard, which is required to commercialize a fatty acid methyl ester (FAME) based fuel. To select the parameters to be tested, the criterion was that their measurements together should provide a reliable assessment of the quality of the biodiesel produced.

- **Density at 15ºC**

  A density value in the allowed range means a high FAME content. A lower value is related to a higher methanol content and a higher one to a high water or glycerol contents.

- **Kinematic viscosity at 40ºC**

  It can be related to methanol, water or glycerol contents; but also to the free fatty acid or linolenic acid esters contents, which cause a higher or lower value, respectively.

- **Acid value**

  As a measurement of free fatty acid (FFA) content in biodiesel, it can be related to copper strip corrosion. It is also related to the water content, as it contributes to hydrolysis and, therefore, to acid compound formation.

- **Iodine value**

  As a measurement of oxidation propensity and total content of insaturations, it can be related to oxidation stability and poliinsaturated methyl ester content.

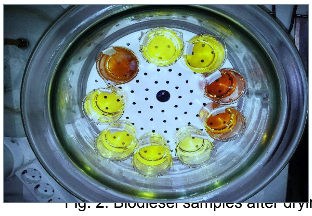

Fig. 2. Biodiesel samples after drying

3. Results and Discussion

As shown if figure 4, all parameters fulfill the standard except for the kinematic viscosity, which should be around 10% of the value of the kinematic viscosity of the corresponding oil (values of the oil viscosity are shown in figure 3), but it is higher, which points to incomplete transesterification [1]. With the results obtained, no specific type of crop stands out as clearly better than the rest for fuel production, but it was found that heavily used oils produce worse quality biodiesel (higher iodine and acid number values, and higher density values).

It must be pointed out that, for oils with an acid value of 1.6 or higher, such as oil 7, one-step transesterification might not be enough, and a previous esterification process could be necessary. It will also be important to closely monitor the reaction parameters (temperature, stirring, time) to ensure a complete reaction has taken place.

It was also found that the biodiesel iodine value is similar to that of the original oil. Therefore, oils with an iodine value that surpasses the limit set by the EN ISO 14214:2013 standard should not be used for biodiesel production.

Oil	Density at 15ºC (kg/m^3)	Kinematic viscosity at 40ºC (mm^2/s)	Acid Value (mg KOH/g)	Iodine Value (I_2 g/100 g)
1	922	50.23	0.34	141
2	926	44.63	0.56	91
3	919	46.26	0.73	83
4	919	51.51	1.4	98
5	922	39.60	0.50	126
6	915	44.23	0.65	53.3
7	929	74.87	1.6	119

Oil used	Density at 15ºC (kg/m^3)	Kinematic viscosity at 40ºC (mm^2/s)	Acid Value (mg KOH/g)	Iodine Value (I_2 g/100 g)
1	893	6.479	0.24	81
2	895	5.751	0.11	118
3	894	7.517	0.07	78
4	889	8.590	0.06	78
5	893	7.844	0.03	119
6	886	7.043	0.21	63
7	911	6.952	0.69	283

4. Conclusions

It has been determined that the oil crop (sunflower, olive or corn) used does not have a big impact in the fuel quality obtained, but its degree of use does (indicated by its acidity and viscosity increase). It is crucial to accurately determine the WCO condition to adjust the whole process.

One-step transesterification using an alkaline catalyst is appropriate for WCO whose quality is similar to the ones used in this study. In other cases, such as oils with iodine values of 1,6 KOH mg/g or higher, this process might be insufficient. It is also crucial to keep a close eye on reaction parameters (temperature, stirring, time).

Moreover, iodine value can be used to indicate whether a WCO should be transesterified or not (since it does not change significantly after the process).

It can also be concluded that biodiesel production using WCO is a feasible way to manage this waste, a substance with a great polluting potential.

WCO biodiesel alone can't be a solution to the energy dependency, but its production could be helpful to reduce fossil fuel dependency. The use of WCO can also help biofuels overcome social, environmental, technical and political barriers they face today.

5. References

1. Kulkarni MG, Dalai AK. Waste cooking OilAn economical source for biodiesel: A review. Ind Eng Chem Res. 2006;45(9):2901-2913. http://dx.doi.org/10.1021/ie0510526. Accessed Mar 15, 2017. doi: 10.1021/ie0510526.
2. Knothe G, Krahl J, Van Gerpen J. The biodiesel handbook. Elsevier; 2015
3. Vargas FAA. Produccin y caracterizacin de biodiesel de palma y de aceite reciclado mediante un proceso batch y un proceso continuo con un reactor helicoidal: Tesis doctoral. Universitat Rovira i Virgili; 2010.

7th International Congress
Energy and Environment Engineering and Management