Crude Biodiesel fom Virgin Vegetable (VVO) and Waste Vegetable Oil (WVO)

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Biodiesel is a diesel fuel substitute made from the triglycerides of vegetable oils or animal fats. Using various catalysts, biodiesel can be produced from vegetable oils (VVO) such as palm oil, sunflower oil, soybean oil, rapeseed oil, and castor oil [1]. In this study, „waste vegetable oil" (WVO) refers to edible oil that was previously used for frying but is no longer used for that purpose. WVO biodiesel production is environmentally friendly because it recycles used cooking oil and produces renewable energy with lower pollution [2]. The development of heterogeneous catalysts has become necessary due to the limitations of homogeneous catalysts used in biodiesel production [3]. These drawbacks include the washing of products with water to remove the catalyst, which results in waste water generation and biodiesel loss as a result of washing, the use of an intensive biodiesel separation protocol, the corrosive nature of the catalysts, and the inability to reuse the catalysts. The primary goal of this research is to improve biodiesel production from waste cooking oil feed stock by using homogeneous catalysators and optimizing the major transesterification reaction parameters. The biodiesel production reaction parameters such as WCO/methanol ratio, catalyst dose, and reaction temperature were optimized at the laboratory scale for optimum biodiesel yield.

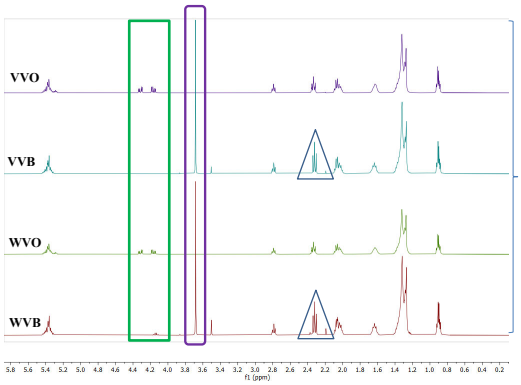

Figure 1: ^{1}H NMR spectrum of vegetable oils and biodiesels in $CDCl_3$ (600 MHz)

Waste vegetable oil sample preparation. Waste cooking oil was collected from café, restaurants and street fast food sellers in Cluj Napoca city which has been used for food frying. The waste cooking oil was settled for 4−6 days at room temperature and filtered by sieves (hole size 100 nm) and activated carbon to remove any suspended food particles and inorganic residues and followed by heating at 110 °C for water removal.

The conversion is illustrated by the following equation, as previously described by Knothe [4]:

$$C = 100 \cdot \frac{2A_{Me}}{3A_{CH2}}$$

where:
C = conversion of triacylglycerol feedstock to the corresponding methyl ester.
A_{Me} = integration value of the protons of the methyl esters
A_{CH2} = integration value of the methylene protons.

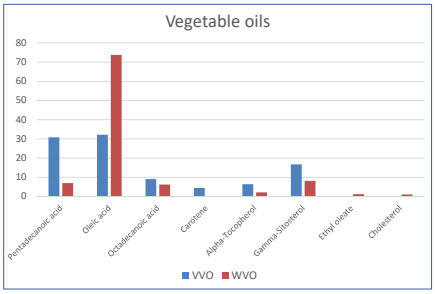

Figure 3: GC-MS analysis results of raw materials

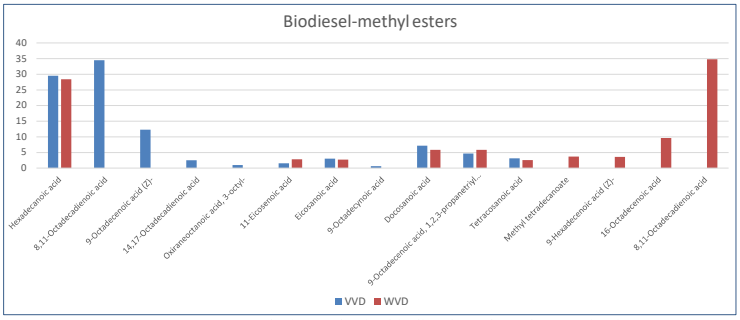

Figure 4: GC-MS analysis results for biodiesel product characterization

The biodiesel produced from vegetable oil using sodium hydroxide catalyst was characterized by ^{1}H NMR spectroscopy and its spectrum is shown in Figure 1. According to Deka et al. [5] it should be noted that the major difference between the ^{1}H NMR spectra of the oil and the biodiesel is the disappearance of the signals representing protons of the glycerol moiety of the glyceride at 4.15, 4.30 and 5.23 ppm. The appearance of a singlet signal at 3.68 ppm represents methoxy protons of the ester functionality on conversion of the oil to methyl ester ($-CO_2CH_3$). The signals at 2.3 ppm result from the protons on the CH_2 groups adjacent to the methyl or glyceryl ester moieties ($-CH_2COOCH_3$ for methyl esters). These signals can be used for quantitation using the equation as described above. The percentage yield of triglycerides to corresponding methyl esters was 96% from VVO and 93% from WVO.

The produced biodiesel was also studied by the ^{13}C NMR spectrum (Figure 2), which shows the characteristic peaks of ester carbonyl (-COO-) and C-O at 174.3 and 51.4 ppm, respectively.

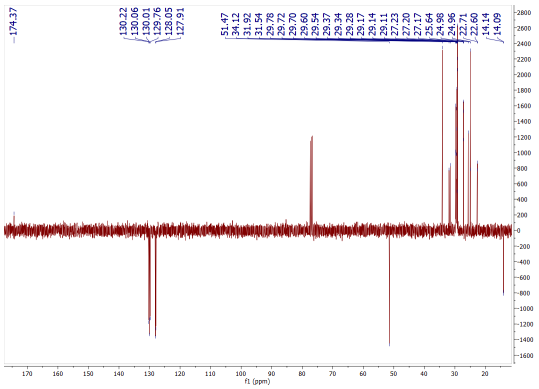

Figure 2: ^{13}C NMR spectrum of biodiesel from WVO in $CDCl_3$ (150 MHz). Reaction conditions: 1 wt.% NaOH catalyst and a 1:5 methanol-to-oil mass ratio.

Equipments:

Bruker NMR 600MHz spectrometer;
Bruker FT IR Vector 22 spectrophotometer;
Ostwald viscometer tube;
Shimadzu QP-2010 PLUS mass spectrometer;

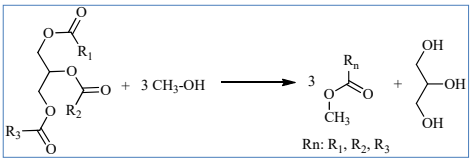

Table 1: Characteristics of produced biodiesel.

Characteristics	VVB	WVB	EN 14214	ASTM D6751
Density at 20°C (kg/L)	0.87	0.863	0.86-0.90	-
Viscosity at 20°C (mm^2/s)	6.37	6.51	3.50-5	1.9-6.0
Flash point PM (°C)	110	104	120 (min)	130 (min)
Water content (%)	0.04	0.05	-	0.05 (max)

ASTM D6751: American Society for Testing materials;
EN 14214: European standard;

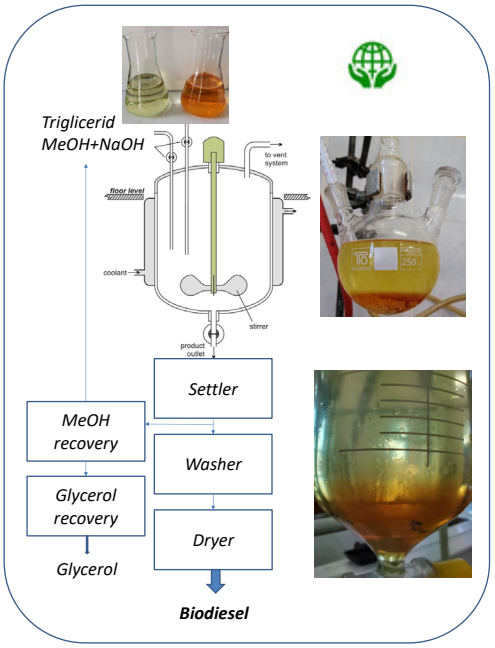

Figure 5: Transesterification batch process catalysed by homogenous base catalyst

Conclusions:

Sodium hydroxide were successfully utilized as a catalyst in the transesterification of waste vegetable oil into biodiesel. This results in a good biodiesel yield of 96% from transesterification at 60°C in 40 min, using 1% catalyst and a methanol to oil mass ratio of 1:5. The fuel properties, analyzed according to international standards, were good in comparison to those of conventional diesel.

References

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2) Jahirul M. I., Brown R. J., Senadeera W., *Energies,* **2013**, 6, 3764–806.
3) Patel R., Patel S., *Clean Energy,* **2017,** 1, 90–101.
4) Knothe G., *J Amer Oil Chem Soc*. **2001**, 78, 1025–1028.
5) Deka D. C., Basumatary S., *Biomass Bioenergy,* **2011**, 35, 1797–1803