Biodiesel production through transesterification applying ionic liquids as catalysts

H. Goes[1], L. Lima[2], A. Queiroz[1], A. Ribeiro[1], P. Brito[1]*

[1]Mountain Research Center (CIMO), Polytechnic Institute of Bragança, Campus Santa Apolónia, 5300-253, Bragança, Portugal;
[2]Dept. of Chemical Engineering, Universidade Tecnológica Federal do Paraná, campus de Londrina, 86036- 370, Londrina-PR, Brasil.

*paulo@ipb.pt

INTRODUCTION

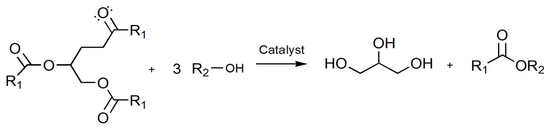
Biodiesel is a biofuel obtained from **renewable biomass** for internal combustion engines or energy generation, which can partially or totally replace fossil fuels. Biodiesel is chemically composed of FAMEs (fatty acid methyl esters), obtained from the chemical **reaction of triglycerides with an alcohol, in the presence of a catalyst** [1].

Vegetable oils – edible or inedible

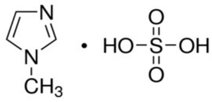
Waste oil

Animal fat

Transesterification



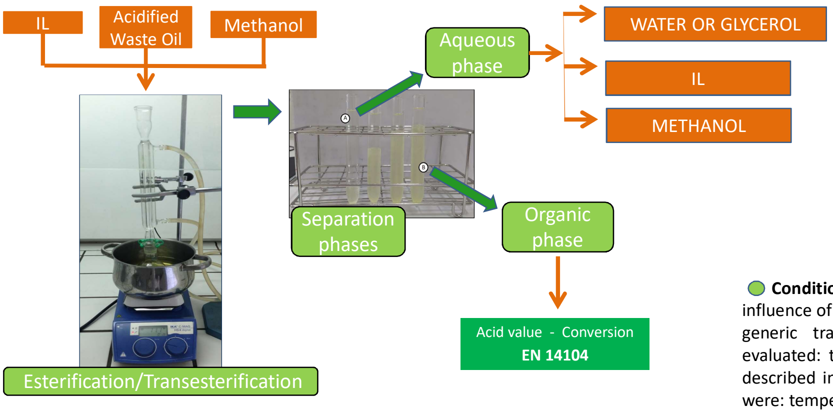
Catalysts: Acid and basic catalysts are applied **to accelerate the reaction rate**. For transesterification reaction, basic NaOH or KOH catalysts are the most commonly used. Alternative options for these catalysts are **ionic liquids (IL)**, which are being studied since they enable a more environmentally sustainable biodiesel production process. Among its properties, such substances have potential for **recyclability, high catalytic activity, simple operating conditions and high conversion rates for short reaction times** [2].



1-methylimidazolium hydrogen sulfate
[HMIM][HSO4]

Objectives: The objective is the study of the influence of **applying 1-methylimidazolium hydrogen sulfate** [HMIM][HSO4] IL on the catalysis of the **transesterification reaction** of a highly acidic waste vegetable oil (WVO), in order to assess the viability of the use of acidic imidazolium based IL as catalysts in biodiesel production processes, with further optimization of the main operational conditions: reaction time, reaction temperature, catalyst percentage and oil/methanol molar ratio.

METODOLOGY



Experimental design: An experimental design based on a total factorial was generated with three parameters at two levels (2^3) in duplicate.

Table 1. Levels chosen for experimental design.

Parameter	Code	-1	1
Oleic Acid incorporated (%)	A	20	40
Molar ratio oil/methanol (mol/mol)	B	1:20	1:40
Time (h)	C	4	8

Conditions: The used methodology defines 16 runs for understanding the influence of each factor on the response. Each run was carried out accordingly to the generic transesterification procedure already presented. One response was evaluated: the conversion of simulated oil, measured according to the procedure described in the European Standard EN14104/2008. The fixed reaction parameters were: temperature, 90°C, and percentage of catalyst, 10% wt.

RESULTS AND DISCUSSION

Fig. 1 shows the cube plot for the response R (reaction conversion) and the respective levels of oleic acid incorporated (%), molar ratio oil/methanol (mol/mol) and time (h).

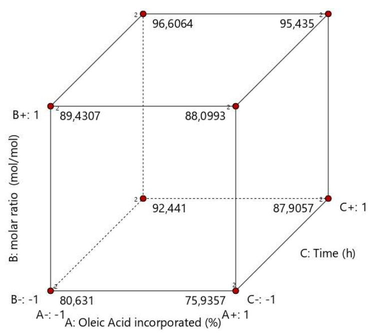


Figure 1. Cube plot for conversion (R).

The conversion of simulated oil can be expressed using the following equation:

$$R = 88{,}31 - 1.47A + 4.08B + 4.79C + 0.8410AB + 0.0400AC - 1.16BC$$

This function describes how the experimental variables and their interactions influence the reaction. The model presented an square correlation coefficient R^2 of 98% for the conversion of simulated oil, fitting well the experimental data.

Fig. 2 corresponds to interactions of effects between variables. A significant interaction results when the lines are not parallel.

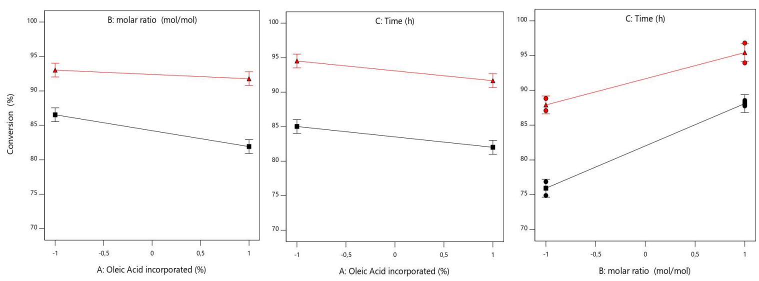


Figure 2. Interaction effects plot for conversion (R).

CONCLUSIONS

The factor of greatest influence in the conversion was the reaction time, followed by the molar ratio oil/methanol. The factorial experiments showed a significant interaction between the two variables of greater influence. These parameters had a positive influence on the conversion rate studied.

REFERENCES

[1] Lei nº 11.097/2005. Dispõe sobre a introdução do biodiesel na matriz energética brasileira. Brasil. Casa civil, 2005.
[2] Z. Ishak, N. Sairi, Y. Alias, M. Aroua, R. Yusoff, A review of ionic liquids as catalysts for transesterification reactions of biodiesel and glyerol carbonate production. Catalysis Reviews. Science and Engineering, 59 (2017) 44–93.