CIEEMAT`22

CIEEMAT 2022
VII Ibero-American Congress on Entrepreneurship, Energy, Environment and Technology

Book of Abstracts

6-8 July 2022
Bragança, Portugal

ipb INSTITUTO POLITÉCNICO DE BRAGANÇA

CEFET/RJ

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CIMO Centro de Investigação de Montanha

SUSTEC Associate Laboratory for Sustainability and Technology in Inland Regions

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ABOUT THE EVENT

The VII Ibero-American Congress on Entrepreneurship, Energy, Environment and Technology (CIEEMAT 2022), coordinated by the Federal Centre of Technological Education from Rio de Janeiro (CEFET/RJ), was held for the third time in Portugal, and for the second time in the city of Bragança, under the organization of the Polytechnic Institute of Bragança (IPB), the Research Centre in Digitalization and Intelligent Robotics (CeDRI), the Mountain Research Centre (CIMO) and the Associated Laboratory for Sustainability and Technology in Inland Regions (SusTEC). The event aims to consolidate the Luso-Brazilian and Ibero-American cooperation in those areas, gathering the multinational contribution and enhancing collaboration in academic and scientific fields.

The CIEEMAT 2022 took place on July 6-8 2022 and had the Energy Transition as its specific theme.
The current energy context and the transition of energy generation and consumption typologies are unavoidable in defining the profiles of national and international societies and energy policies. The dynamism to which the energy sector is currently subjected is imposed by environmental and safety concerns, the fluctuation of the fossil fuels price and shifting technologies, which translates into challenges and opportunities across various sectors as research and innovation, education, policy and environmental governance. The opportunities and challenges of the energy transition are outlined, for instance, in the exploitation of natural assets, the decarbonisation of the economy and the transport sector and the flexibility of energy infrastructure through smart grids.

The CIEEMAT 2022 followed a program addressing various perspectives of action of higher education institutions and R&D units and their cooperation with society: i) the academic perspective (why, what and how to teach the challenges of energy transition); ii) the perspective of international cooperation, defining new cooperation programs between Portugal and Brazil in the energy field, with emphasis on the Brazilian EnergIF program and its potential for international cooperation with Portugal; iii) and the research and innovation perspective, with the contribution of academic experts and the business sector regarding the challenges that the necessary and emerging energy transition poses.

At the same time, the CIEEMAT 2022 provided also a forum to disseminate and share ongoing research in various academic and scientific institutions, through oral communications in the areas of sustainable urban mobility, energy generation and self-consumption, environmental challenges, decarbonisation and climate change.

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CONTENTS

Valorisation of Waste Cooking Oils through Conversion Processes to Biodiesel Catalysed by Ionic Liquid [HMIM][HSO4]

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Abstract

To date, fossil fuels prevail as the primary source of energy, with a high consumption in transport and industries, making them a major problem for our planet, given its weak environmental sustainability due to its high greenhouse gas emissions to the atmosphere and the limited reserves [1]. In this context, biodiesel emerges as a biofuel, biodegradable, environmentally sustainable and less toxic when compared to fossil diesel, which has been acquiring much attention over the years, and it has been used commercially blended with diesel. Chemically it can be defined as a mix of fatty acid methyl esters (FAME), produced through transesterification reactions of vegetable oils or animal fats, with an alcohol, usually methanol, in the presence of basic catalysts, which are highly corrosive and difficult to recover [2]. Therefore, conventional catalysts present several problems for the environment, and for this reason, there is a need to develop more environmentally friendly catalysts. Ionic Liquids (IL) have attracted a lot of attention in recent decades, presenting themselves as the main alternative to traditional catalysts, being green, non-toxic and non-flammable solvents [3]. On the other the production of 1st generation biodiesel using raw materials from edible vegetable oils such as palm oil, sunflower oil, rapeseed oil, among others, has the potential of causing socio-economic conflicts since these oils compete directly with the food sector. This promoted the search for alternatives, such as the use of waste cooking oils (WCO), since it is a residue that can be reused and with high energy content. However, these processes still need better studies, due to the problems associated with the production through transesterification, with regard to the high content of Free Fatty Acids [1].

Hence, the objective of this work is the study of the application of the IL 1-methylimidiazolium hydrogen sulfate ([HMIM][HSO_4]) in the catalysis of esterification/transesterification reactions of a WCOs with high free fatty acids contents, through the application of a Response Surface Methodology (RSM) based in a Box-Behnken Design (BBD) in order to determine the optimal reaction conditions (reaction time, catalyst dosage, molar ratio methanol:oil and incorporation of oleic acid (OA) in WCO to simulate an oil with high acidity) for the esterification reaction of waste cooking oil with methanol.

Table 1 - ANOVA table for R1.

Source	Sum of squares	df	Mean Square	Calculated F-value	Tabulated F-value	p-value	
Model	7495.56	14	535.40	218.70	2.637	3.21×10^{-12}	significant
Residual	29.38	12	2.45				
Lack of Fit	29.05	10	2.90	17.74	19.40	0.0545	not significant
Pure Error	0.33	2	0.16				
Cor. Total	7524.94	26					

Design Expert 11 software was used for the construction of the BBD. An experimental design was used to generate a matrix with four factors with three levels and two extra central points. The chosen factors were: percentage of incorporated OA (20, 40 and 60% wt), oil/methanol molar ratio (1:5, 1:10 and 1:15),

catalyst dosage (5, 10 and 15% wt) and reaction time (2, 4 and 6 h). Through this methodology a set of 27 runs was established to quantify the influence of each factor on the two responses: acidity reduction (R1) and FAME content (R2). Acidity reduction was estimated by acid-base titrimetry and FAME content was measured by GC-FID using the internal standard method. A temperature of 65°C was maintained during all reaction tests. In Tables 1 and 2, the ANOVA tables for R1 and R2 are presented, respectively.

Table 2 - ANOVA table for R2.

Source	Sum of squares	df	Mean Square	Calculated F-value	Tabulated F-value	p-value	
Model	1941.39	14	138.67	22.13	2.637	2×10^{-6}	significant
Residual	75.21	12	6.27				
Lack of Fit	73.88	10	7.39	11.10	19.396	0.0854	not significant
Pure Error	1.33	2	0.67				
Cor. Total	2016.60	26					

Corresponding to the following models represented by equations (1) and (2), also for responses R1 and R2, respectively:

$$Y = 45.92 + 10.18A + 1.56B + 21.87C - 3.56D - 3.59AB + 2.23AC - 2.20AD + 1.70BC - 0.2183BD - 4.21CD - 2.00A^2 + 0.0055B^2 - 1.65C^2 + 3.58D^2 \quad (1)$$

$$Y = 20.44 + 5.50 + 0.5500B + 7.76\mathrm{C} + 7.88D - 0.7125AB + 2.31AC + 3.09AD + 0.8975BC - 1.00BD + 1.77CD + 1.25A^2 + 0.9925B^2 - 0.8500C^2 - 0.5250D^2 \quad (2)$$

For response R1, the most significant factor for the conversion was the molar ratio oil/methanol, followed by the reaction time and then by the OA incorporation, while for response R2, the most relevant factor was the incorporation of OA, followed by the molar ratio oil/methanol and finally by the reaction time. For both responses, the least significant factor was the catalyst dosage. The ideal conditions for acidity reduction were: reaction time at 6 h, catalyst dosage at 5 %wt, molar ratio oil/methanol for 1:20 and 20 %wt OA incorporation, leading to a conversion of 76.70 %. The optimal conditions, which leads to the highest FAME content of 42.02 %wt were estimated at 6 h of reaction time, 15 %wt of catalyst dosage, molar ratio oil/methanol for 1:20 and 60 %wt of OA incorporation.

Keywords: Biofuels, Biodiesel, Ionic Liquid Catalyst, Esterification.

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