



CIEEMAT` 22

CIEEMAT 2022

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

Book of Abstracts

6-8 July 2022

Bragança, Portugal



**CIEEMAT 2022 - VII Ibero-American Congress on
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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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Biodiesel Production from Waste Cooking Oils Catalysed by Ionic Liquid [BMIM][HSO₄]

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Abstract

The environmental and energy problems related to the burning of fuels from fossil resources, i.e. non-renewable fuels such as oil, natural gas or coal, leading to an increased concern about global warming, have directed the scientific community to seek sustainable and renewable energy alternatives. In this context, biofuels have emerged as a promising way to replace non-renewable fuels, including biodiesel [1]. Biodiesel is defined as a mix of monoalkyl esters of long fatty acid chains (FAMES), and can be obtained by converting vegetable oils or animal fats through transesterification or esterification reactions. Due to its advantages, such as biodegradability, low viscosity, high flash point and low environmental impacts, it has potential to be used directly in diesel engines without any modification [2]. The raw materials used in biodiesel production can be divided into edible and inedible. However, the high cost of edible oils, which correspond to about 70% of the total value of production, as well as competition with the food market and soil degradation due to large planting scales, are disadvantages for the production and commercialization of biodiesel [3]. Inedible materials such as Waste Cooking Oils (WCOs) can also be used. The reuse of WCOs is a sustainable and environmentally friendly solution, preventing millions of tons of this raw material from being dumped into sanitation systems giving rise to serious problems in wastewater treatment. Still, one of the disadvantages of using WCOs is its high Free Fatty Acid (FFA) content that leads to saponification reactions [2]. Homogeneous alkaline catalysts are the most used in the biodiesel production industry. Compared to homogeneous acid catalysts, they have many advantages, such as high productivity, low price, allow high reaction speed, shorter reaction time, low alcohol molar ratio:oil and lower corrosiveness. However, catalysis is mainly affected by the presence of free fatty acids, leading to decreased reaction yields. In addition, when using these conventional catalysts, a high amount of clean water is used during the purification process, resulting in high flows of waste water, which is deposited in rivers, lakes, seas, contaminating the environment. To solve this problem, the possibility arises of using new catalysts, such as ionic liquids (ILs), which allow high reaction yields, and can be recovered and reused, making them greener and more economical [4].

Table 1 - ANOVA table for R1.

Source	Sum of squares	df	Mean Square	Calculated F-value	Tabulated F-value	p-value	
Model	1524.8916	14	108.9208	5.6959	2.637	0.0023	significant
Residual	229.4730	12	19.1228				
Lack of Fit	223.2512	10	22.3251	7.1764	19.396	0.1284	not significant
Pure Error	6.2218	2	3.1109				
Cor. Total	1754.3647	26					

Hence, the objective of this work is to assess the potential use of IL [BMIM][HSO₄] in the catalysis of esterification/transesterification reactions of a WCOs with simulated high FFAs content. For this purpose a Response Surface Methodology (RSM) from a Box-Behnken Design (BBD) was applied. Design Expert

11 software was used for the construction of this BBD and a matrix with four factors with three levels and two extra central points was generated. The chosen factors were: percentage of incorporated oleic acid (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). 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). R1 was estimated by acid-base titrimetry and R2 was measured by GC-FID using the internal standard method. A temperature of 65°C was maintained during all reaction tests. The ANOVA tables for R1 and R2 are presented in Tables 1 and 2, respectively.

Table 2 - ANOVA table for R2.

Source	Sum of squares	df	Mean Square	Calculated F-value	Tabulated F-value	p-value	
Model	1897.65	14	135.55	48.92	2.637	< 0.0001	significant
Residual	33.25	12	2.77				
Lack of Fit	32.74	10	3.27	12.92	19.396	0.0739	not significant
Pure Error	0.5067	2	0.2533				
Cor. Total	1930.9	26					

The following models represented below correspond also to responses R1 and R2, respectively:

$$Y = 37.11 + 0.896A + 2.16B + 5.53C + 8.35D + 1.29A^2 - 2.62B^2 - 2.19C^2 - 0.3637D^2 + 0.7637AB - 2.42AC - 0.1389AD + 83.15BC + 5.71BD + 1.61CD \quad (1)$$

$$Y = 26.23 + 1.02A - 0.2917B + 0.8225C + 10.08D - 3.95A^2 - 9.54B^2 - 4.61C^2 - 3.09D^2 + 1.91AB - 5.41AC + 0.055AD + 1.05BC + 0.8BD + 2.11CD \quad (2)$$

For both responses, the most significant and relevant parameter was the incorporation of OA, followed by the molar oil/methanol ratio and catalyst dosage. The optimal conditions that present the best conversion values in terms of acidity reduction and FAME content were defined. The optimal conditions for acidity reduction were: reaction time of 2 hours, catalyst dosage of 15%wt, oil/methanol molar ratio of 1:15, and incorporation of OA of 60%wt, for a value of 58.1%. A percentage of 33.7% was found in the FAME content response at the following optimised conditions: reaction time of 4 h, catalyst dosage of 10%wt, molar oil/methanol ratio of 1:12, and incorporation of OA of 60%.

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

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