CIEEMAT`22

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

Book of Abstracts

6-8 July 2022
Bragança, Portugal

INSTITUTO POLITÉCNICO DE BRAGANÇA
CEFET/RJ
CeDRI
Centro de Investigação de Montanha
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

Biomass Characterization and Pyrolysis, the Effect of Heating Rate on Products Yield

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Abstract

Biomass is widely recognized as one of the main potential sources for renewable and sustainable generation of fuels, chemicals and other carbon-based materials for a long time. According to International Energy Agency, biomass energy accounts for about 14% of the world's total primary energy supply in 2017. There are many advantages in using biomass as an energy source, namely its carbon neutrality and being a non-polluting energy source. Many processes can be used to obtain fuels and chemicals from biomass, and the pyrolysis process is a renewable, economical, and efficient way to produce energy [1].

Pyrolysis is one of the main technologies for biomass conversion into energy. It consists of a thermal decomposition process in an inert atmosphere with absence of oxygen, to convert biomass into biochar (solid fraction), bio-oil (liquid fraction) and gases. Pyrolysis is a recognized industrial process for biomass conversion. No waste is generated in the process, as the bio-oil and biochar can each be used as a fuel and as fertilizer respectively, and the gases can be recycled back into the process [2].

A biomass sample (pellets) was characterized by proximate analysis, determining the fixed carbon (F.C.), moisture, volatiles and ashes composition, and by ultimate analyses, determining the content of C, H, N, S and O. The content of hemicellulose, lignin and cellulose was also determined. The methodologies are described elsewhere [3]. All characterizations were performed on a dry basis, at the conditions in which the sample was previously dried. Pyrolysis tests were performed in a fixed-bed vertical pyrolysis oven, with a maximum temperature of 500 °C, a heating rate of 10, 20, 35 and 40 °C/min, a retention time of 0.5 h and an N_2 flow of 20 mL/min. The bio-oil produced was qualitatively characterized using FTIR.

The results of the biomass ultimate and proximate characterization are shown in Table 1.

Table 1: Biomass ultimate and proximate characterization results.

Biomass type	Volatile (wt%)	Ashes (wt%)	F.C. (wt%)	C (%)	H (%)	N (%)	S (%)	O (%)
Pellets	79.305	0.377	20.318	46.526	5.576	0.119	0.000	47.402

It is noteworthy that the composition of the pellets shows a low value for ashes, lower than 1 %, being a suitable feedstock for the pyrolysis, as a high concentration of ashes biomass could cause clogging of the equipment during the pyrolysis, due to the formation of big particle deposits. The volatile content, around 80 %, is in the same range as other biomass sources, and it is known that higher volatile matter content implies a higher amount of bio-oil production via pyrolysis [4]. According to the ultimate analysis, the average chemical formula of this biomass would be $C_1H_{1.42}N_{0.002}O_{0.76}$. The CHO index is a parameter that describes the oxidation state of organic matter and varies from -4 to +4. The CHO index is described in Equation (1), where [C], [H] and [O] are the molar ratios of the elements.

$$CHO_{index} = \frac{2*[O]-[H]}{[C]} \quad (1)$$

The analyzed biomass CHO index is 0.104. A CHO index above 0 indicates the presence of more oxidized compounds on the sample, meaning that this biomass sample has a slightly high oxygen content whereas the hydrogen content is slightly low. The CHO index plays an important role in the quality of the bio-oil produced, as biomasses with a high CHO index are more likely to produce bio-oils concentrated with oxygen-rich compounds, lowering its quality.

The results of the biomass pyrolysis tests, with different heating rates, are shown in Table 2.

Table 2: Products yields for the biomass pyrolysis tests.

Heating Rate (°C/min)	Biochar Yield (wt%)	Bio-oil Yield (wt%)	N.C.G.* Yield (wt%)
10	23.975	28.310	47.715
20	23.471	28.017	48.513
35	22.873	24.378	52.749
40	22.307	24.221	53.472

*N.C.G. = Non-condensable gases

The increment of the heating rate induced a difference in the products yields. For the solid and liquid fraction of the pyrolysis products, the increment of heating rate diminished the yield of those products, whereas raised the yield of the gas fraction. This phenomenon could be caused by the cracking of biomass components, as this is an endothermic reaction, therefore, the increase in heating rate could facilitate the cracking of heavy molecules to produce smaller ones, generating more gaseous particles at cost of solid and liquid yield [5].

Pyrolysis of the biomass proved to be a viable technology for the valorization of a worldwide produced waste, as biomass withal producing renewable energy. Bio-oil was successfully obtained by the pyrolysis of the biomass, with yields in the range of 24 to 28%. The heating rate proved to influence the yields of the products, for higher heating rates it is observed a bigger yield of N.C.G.s, meanwhile lower heating rates tend to prioritize the formation of biochar and bio-oil.

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Keywords: Pyrolysis, Biomass Valorization, Renewable Energy, Optimization.

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