proceedings

Abstract

Catalytic Pyrolysis of Reed for Bio-Oil and Biochar Production †

Andreea-Luiza Mirt [1,2], Alexandru Vlaicu [1,*], Mihaela Ciltea-Udrescu [1,2], Grigore Psenovschi [1,2] and Gabriel Vasilievici [1]

1 INCDCP-ICECHIM Bucharest, 202 Spl. Independentei, 6th District, 060021 Bucharest, Romania; luiza.mirt@icechim.ro (A.-L.M.); mihaela.ciltea@icechim.ro (M.C.-U.); gregorypshenovschi@gmail.com (G.P.); gvasilievici@icechim.ro (G.V.)
2 Faculty of Chemical Engineering and Biotechnologies, National University of Science and Technology Politehnica Bucharest, 313 Spl. Independenței, 6th District, 060042 Bucharest, Romania
* Correspondence: alexandru.vlaicu@icechim.ro
† Presented at the 19th International Symposium "Priorities of Chemistry for a Sustainable Development", Bucharest, Romania, 11–13 October 2023.

Abstract: Indigenous available common reed stalk has been investigated as potential feedstock for pyrolysis at temperatures between 400 and 600 °C. The performance of this type of feedstock was evaluated in terms of yield towards pyrolysis products. The two main products of interest, biochar and bio-oil, have been characterized through textural analysis and GC-MS, respectively, with the relation between temperature and characteristics being highlighted. Increasing the pyrolysis temperature led to smaller yields in biochar and an improvement of textural properties, such as specific surface area and total pore volume, while the composition of the bio-oil changed significantly as the temperature increased.

Keywords: lignocellulosic biomass; pyrolysis; biochar; bio-oil

Citation: Mirt, A.-L.; Vlaicu, A.; Ciltea-Udrescu, M.; Psenovschi, G.; Vasilievici, G. Catalytic Pyrolysis of Reed for Bio-Oil and Biochar Production. *Proceedings* **2023**, *90*, 8. https://doi.org/10.3390/proceedings2023090008

Academic Editors: Mihaela Doni, Florin Oancea and Radu Claudiu Fierăscu

Published: 6 December 2023

1. Introduction

The aim of this paper is to study the potential of the indigenous common reed as feedstock for pyrolysis in a batch-operated reactor [1,2], as well as to evaluate its productivity in solid and liquid fractions, the structural characteristics of the biochar and the composition of pyrolysis oil, in relation to the temperature at which the process is carried out.

2. Materials and Methods

Indigenously available common reed was considered for this study. Prior to the pyrolysis process, mechanical pretreatments of the reed stalks were proposed to increase the surface area and facilitate a shorter reaction time. A primary mechanical pretreatment consisted of cutting the reed stalks to shorter lengths, of about 1–2 cm, followed by further reduction to smaller fractions by using a laboratory grinder. Size distribution was made using a mechanical sieve shaker, with fractions bigger than 1.25 mm being grinded again. The processed reed stalks were also analyzed via thermogravimetric analysis, using simultaneous TGA/DSC equipment, SDT Q600 from TA Instruments (New Castle, DE, USA), by heating the samples at a rate of 10 °C/min, under a synthetic dry airflow of 50 mL/min. After loading the stainless-steel pyrolysis reactor with mechanically treated common reed, nitrogen was supplied to the installation for 20 min at a flow rate of 100 Ncm^3/min to ensure the complete removal of oxygen prior to starting the pyrolysis reaction. The reaction was carried out by heating the reactor to the operating temperature over the span of 30 min and then maintaining the working temperature for 2 h. The products were cooled before entering the gas–liquid separator, where the liquid fraction was collected and processed for gas chromatography analysis using a GC-MS TRIPLE QUAD (7890 A from Agilent Technologies, Santa Clara, CA, USA) system, with DB-WAX capillary column and helium as carrier gas.

3. Results

The obtained results highlight the distribution of reaction products between the solid phase, represented by biochar, and the liquid fraction consisting of pyrolysis oil, for each experimental set. It was observed that, by raising the reaction temperature from 400 to 450 °C, the productivity of pyrolysis oil nearly doubled, while biochar production decreased by 26%. Further increasing the temperature up to 600 °C only led to a small variation in oil production and a slight decrease in biochar production. However, when considering the composition of the pyrolysis oil obtained, the differences are significant, with higher temperatures allowing for a wider array of compounds to be formed, which were identified through GC-MS analysis using the NIST database.

4. Discussion

Liquid and solid fractions were obtained through the pyrolysis of mechanically treated common reed stalks at various temperatures between 400 and 600 °C, using a batch-operated tubular reactor. The liquid fraction, consisting of pyrolysis oil, was separated from the gaseous effluent, and GC-MS analysis highlighted the variety of oxygenated compounds and the dependency between pyrolysis temperature and the composition of the pyrolysis oil. Regarding the biochar production and characteristics, it was observed that the pyrolysis temperature had two different effects. Increasing the temperature led to a decrease in biochar production, and the formation of biochar with better textural characteristics. Even though increasing the temperature from 400 to 600 °C led to a 30% decrease in biochar production, the specific surface area and total pore volume increased 10-fold and 5-fold, respectively.

Author Contributions: Conceptualization, G.V.; methodology, G.V. and M.C.-U.; validation, G.V.; investigation, A.-L.M., M.C.-U., G.P. and A.V.; data curation, A.-L.M. and M.C.-U.; writing—original draft preparation, A.V. and A.-L.M.; writing—review and editing, A.V. and G.V.; supervision, G.V. All authors have read and agreed to the published version of the manuscript.

Funding: This work was carried out through the PN 23.06 Core Program-ChemNewDeal within the National Plan for Research, Development and Innovation 2022–2027, developed with the support of Ministry of Research, Innovation, and Digitization, project no. PN 23.06.02.01 (InteGral).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are available from the authors on request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Yogalakshmi, K.N.; Poornima Devi, T.; Sivashanmugam, P.; Kavitha, S.; Kannah, Y.; Varjani, S.; AdishKumar, S.; Kumar, G.; Rajesh Banu, J. Lignocellulosic biomass-based pyrolysis: A comprehensive review. *Chemosphere* **2022**, *286*, 131824.
2. Garrido, R.; Reckamp, J.; Satrio, J. Effects of Pretreatments on Yields, Selectivity and Properties of Products from Pyrolysis of *Phragmites australis* (Common Reeds). *Environments* **2017**, *4*, 96. [CrossRef]