proceedings

MDPI

Extended Abstract

Life Cycle Analysis of Integrated Production of Ferulic Acid, 2,3 Butanediol and Microbial Plant Biostimulants from Lignocellulosic Biomass by a Two-Step Cascading Process †

Valentin Zamfiropol-Cristea [1,2], Lucian Vlădulescu [3], Diana Constantinescu-Aruxandei [1,*] and Florin Oancea [1,2,*]

[1] National Institute for Research & Development in Chemistry and Petrochemistry—ICECHIM, 202 Spl. Independentei, 060021 Bucharest, Romania; alin.zamfiropol@icechim.ro
[2] University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Biotechnologies, 59 Mărăști Blvd., 011464, Bucharest, Romania
[3] Enpro Soctech, 31 Sf. Elefterie Str., 5th District, 050524 Bucharest, Romania; lucian.vladulescu@tesospec.com
* Correspondence: diana.constantinescu@icechim.ro (D.C.-A.); florin.oancea@icechim.ro (F.O.)
† Presented at the 16th International Symposium "Priorities of Chemistry for a Sustainable Development" PRIOCHEM, Bucharest, Romania, 28–30 October 2020.

Published: 9 November 2020

Keywords: life cycle analysis; small scale biorefinery; 2-3 butanediol; microbial plant biostimulants

---

A small scale biorefinery process, which includes two main steps: (1) biomass pre-treatment with natural deep eutectic solvents (NADES) and feruloyl-esterase (FAE); and (2) one pot production of a versatile chemical, 2,3 butanediol (2,3-BD), from NADES and FAE pre-treated lignocellulose biomass, by simultaneous saccharification and fermentation (SSF), performed by a plant biostimulant microbial consortia, was developed. Ferulic acid is a value-added product, with a market value that will exceed 100 million USD, because of its variety of biological activities, including skin anti-ageing [1]. In addition, 2,3-BD is a versatile chemical, with a global market value of more than 5 billion USD [2]. It has applications as an antifreeze agent, fuel additive/octane booster (methyl ethyl ketones precursor) and in producing synthetic rubber (butadiene precursor) and plasticizers [2]. Plant biostimulants are an emerging class of agricultural inputs and represent a fast-growing market, which could exceed 5 billion dollars by 2025. Such market development should be related to an enhanced eco-efficiency. The aim of this work was to assess the eco-efficiency of the developed process by using the Life Cycle approach.

The Life Cycle Assessment (LCA) was done in accordance with the standard method presented in ISO 14041 and ISO 14042. The system boundary was established as a "cradle to biorefinery gate" to evaluate ferulic acid and 2,3 butandiol production. System expansion was considered for the microbial plant biostimulants based on the used microbial strains, which include a consortium based on *Trichoderma harzianum* Td50b, National Collection of Agricultural and Industrial Microorganisms (NCAIM) (P) F 001412, *Trichoderma asperelum* Td36b, NCAIMP (P) F 001434, and the compatible bacteria *Paenibacillus graminis* FL400, NCAIM (P) B 001365. A functional unit of 1 tone of 2,3-butandiol that resulted from the small biorefinery system was considered for the LCA. The main impact was considered on Global Warming Potential (GWP). The results from the used LCA scenario were compared to cracked petroleum-based production of 2,3 butandiol. An allocation assessment was done, to integrate the export of lignin together with plant microbial plant biostimulant biomass.

The GWPs calculated for both production scenarios reveal that the biorefinery approach reduces the estimated CO_2 eq. per ton of 2,3 butandiol by less than 20%. The eco-efficiency of the biorefinery approach is affected by: (i) the energy (heat supply) necessary for the 2,3 butandiol production by fermentation process and its separation by distillation and (ii) the production of the feed-stock (wheat straw). The export of lignin together with plant microbial plant biostimulant biomass reduce the GWP's impact of the proposed small biorefinery process.

The utilization of the residual lignin and biomass of the microbial consortia with plant biostimulant effects is important for an enhanced eco-efficiency of the proposed small scale biorefinery.

Funding: This research received funding from a grant of the Romanian Ministry of Education and Research, CCCDI—UEFISCDI, contract 43/2017.

Acknowledgments: The work on this paper was supported by a grant of the Romanian Ministry of Education and Research, CCCDI—UEFISCDI, project ERANET FACCE-SURPLUS "Production of ferulic acid, 2,3-Butanediol and microbial plant biostimulants from lignocellulosic biomass by a two-step cascading process—DEBUT", within PNCDI III.

References

1. Taofiq, O.; González-Paramás, A.; Barreiro, M.; Ferreira, I. Hydroxycinnamic Acids and Their Derivatives: Cosmeceutical Significance, Challenges and Future Perspectives, a Review. *Molecules* **2017**, *22*, 281.
2. Koutinas, A.A.; Yepez, B.; Kopsahelis, N.; Freire, D.M.G.; de Castro, A.M.; Papanikolaou, S.; Kookos, I.K. Techno-economic evaluation of a complete bioprocess for 2,3-butanediol production from renewable resources. *Bioresour. Technol.* **2016**, *204*, 55–64, doi:10.1016/j.biortech.2015.12.005.

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

© 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).