Proceedings International
Platinum Open Access Journal (ISSN 2668-6384)

Proceedings, Abstract
Volume 3, Issue 4, 2021, 41 - 42
https://doi.org/10.33263/Proceedings34.041042

Comparative Evaluation of the Hydrothermal Gasification of Biomass Model Compounds to Generate Hydrogen-Rich Gas Products [†]

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† Presented at International e-Conference on Green Chemistry and Engineering towards Sustainable Development – An Industrial Perspective (16-18 June 2021), Surat, Gujarat, India

Received: 5.06.2021; Revised: 10.06.2021; Accepted: 12.06.2021; Published: 15.06.2021

Abstract: Supercritical water gasification is a promising thermochemical technology that can be used to convert lignocellulosic feedstock into hydrogen-rich syngas effectively. In this study, the response surface methodology based on the Box-Behnken design was used to optimize the process parameters during hydrothermal gasification of cellulose. The process parameters investigated include temperature (300–500 °C), reaction time (30–60 min), and feedstock concentration (10–30 wt%). The temperature was the most significant factor that influenced the yields of hydrogen and total gases. Furthermore, there was negligible interaction between lower temperatures and reaction time while the interaction became dominant at higher temperatures. Hydrogen yield remained at about 0.8 mmol/g with an increase in the reaction time from 30 min to 60 min at the temperature range of 300–400 °C. When the temperature was raised to 500 °C, hydrogen yield elevated at a longer reaction time. A maximum hydrogen yield of 1.95 mmol/g was obtained from supercritical water gasification of cellulose alone at 500 °C with a 12.5 wt% feedstock concentration in 60 min. Using these optimal reaction conditions, a comparative evaluation of the gas yields and product distribution of cellulose, hemicellulose (xylose), and lignin was performed. Among the three model compounds, hydrogen yields increased in the order of lignin (0.73 mmol/g) < cellulose (1.95 mmol/g) < xylose (2.26 mmol/g). Based on the gas yields from these model compounds, a possible reaction pathway of model lignocellulosic biomass decomposition in supercritical water was proposed.

Keywords: supercitical water; Box–Behnken design; soybean straw; gasification; hydrogen.

Funding

The authors would like to thank the Natural Sciences and Engineering Research Council of Canada (NSERC), the Canada Research Chairs (CRC) program, Agriculture and Agri-Food Canada (AAFC), and BioFuelNet Canada for funding this bioenergy research.

Acknowledgments

Special appreciation goes to Do Phuong Rosa (Laboratory Manager in the Department of Chemical and Biological Engineering at the University of Saskatchewan) for performing some of the analysis.

Conflicts of Interest

The authors declare no conflict of interest.