RETASTE Conference Abstracts
Vol. 3 RETASTE-W2E-498-Oral
Athens, Greece, 27-29 September, 2023

rethink food resources, losses, and waste 2023 retaste

Thermochemical Conversion of Biowaste to Bioenergy Using the Thermocatalytic Reforming Technology

Hillary Onyebuchi Onyishi, Johannes Neidel, Robert Daschner, Andreas Apfelbacher and Andreas Hornung

Fraunhofer UMSICHT and Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

Abstract

This work outlines how the thermo-catalytic reforming (TCR®) technology is used to produce biofuels, namely biochar, biooil and biogas, from biowaste containing mostly food waste. About a decade ago, the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT invented the TCR® technology for the conversion of biomass into biofuels. Essentially, it involves the combination of intermediate pyrolysis and catalytic reforming leading to the production of biofuels of improved quality compared to those from pyrolysis. While the generation of biowaste worldwide is quite high, the traditional utilisation is mostly composting for soil improvement. However, the presence of plastics in them causes problems in this direction. Hence, with thermochemical conversion such as the TCR® employed in this work, the plastics are thermally decomposed leaving the char, which can still be used for soil improvement, free of plastics. Moreover, while the abundance of other renewable energy resources like solar and wind vary from place to place, and season to season depending on the place, that of biomass is quite uniform. Even so, while the abundance of the other sources of biomass like wood waste and animal dungs may vary from place to place regardless of the human population, that of biowaste is very dependent on human population. Meanwhile, since energy demand is also dependent on human population and with the need to increase the harnessing of renewable energy resources to reduce greenhouse emissions and ultimately achieve carbon neutrality, generating energy from biowaste is of significant economic importance. More so, while the biofuels can be employed in meeting energy demand with the char being additionally applicable in soil improvement and carbon sequestration, a good quantity of water can be recovered from biowaste to meet water demand. Specifically, water can be recovered from biowaste through both controlled drying (pre-processing) and treatment of the product water from thermochemical conversion (post-processing). This underscores the importance of this work. The feedstock used is biowaste procured from the Sulzbach-Rosenberg Waste Disposal Site. The feedstock is mashed, dried and pelletised. It is then thermochemically converted into biofuels and a reaction product water using a lab-scale TCR® plant with a throughput of 2 kgh-1. Two experiments at post-reformer temperatures of 550 °C and 750 °C, with a reactor temperature of 450 °C each, are carried out. The results show up

to 84% (by weight) of the dried feedstock can be converted into biofuels at a post-reformer temperature of 550 °C while up to 90% of it can be converted when the post-reformer temperature is raised to 750 °C. Precisely, when the post-reformer temperature is increased, the yields of the products decrease except that of the biogas which increases enough to bring about a net increase in the yields of the biofuels. Moreover, analyses of the biogases produced from both experiments show they are rich in green hydrogen with a hydrogen fraction of 31% (by volume) at a post-reformer temperature of 550 °C and 39 % at 750 °C. Analysis of the other products and various applications of the products are also discussed in this work. Overall, the successful conversion of biowaste into biofuels and treatable product water using the TCR® technology is a fundamental feat in waste management, circular economy, and sustainable energy production.

Keywords: biowaste, biofuels, pyrolysis, catalytic reforming, green hydrogen

References

Bellemare M, Çakir M, Hanawa Peterson H, Novak L, Rudi J. 2017. “On the measurement of food waste.” American Journal of Agricultural Economics 99 (5): 1148-1158.
Dung TN, Sen B, Chen CC, Kumar G, Lin CY. 2014. “Food waste to bioenergy via anaerobic processes.” Energy Procedia 61: 307-12.
Farooq A, Jang SH, Lee SH, Jung SC, Rhee GH, Jeon BH, Park YK. 2021. “Catalytic steam gasification of food waste using Ni-loaded rice husk derived biochar for hydrogen production.” Chemosphere 280: 130671.
Hornung A. . 2014. Transformation of biomass: theory to practice. John Wiley & Sons.
Ko MK, Lee WY, Kim SB, Lee KW, Chun HS. 2001. “Gasification of food waste with steam in fluidized bed.” Korean Journal of Chemical Engineering 18: 961-4.
Kurian V, Gill M, Dhakal B, Kumar A. 2022 . “Recent trends in the pyrolysis and gasification of lignocellulosic biomass.” In Biofuels and Bioenergy: A Techno-Economic Aproach, 511-552. Amsterdam: Elsevier.
Opatokun SA, Strezov V, Kan T. 2015. “Product based evaluation of pyrolysis of food waste and its digestate.” Energy 92: 349-54.
Ouadi M, Jaeger N, Greenhalf C, Santos J, Conti R, Hornung A. 2017. “Thermo-Catalytic Reforming of municipal solid waste.” Waste Management 68: 198-206.
Santos J, Ouadi M, Jahangiri H, Hornung A. 2020. “Thermochemical conversion of agricultural wastes applying different reforming temperatures.” Fuel Processing Technology. 203: 106402.
Saravanakumar A, Chen WH, Arunachalam KD, Park YK, Ong HC. 2022. “Pilot-scale study on downdraft gasification of municipal solid waste with mass and energy balance analysis.” Fuel 315: 123287.
Schmitt N, Apfelbacher A, Jäger N, Daschner R, Stenzel F, Hornung A. 2019. “Thermo-chemical conversion of biomass and upgrading to biofuel: The Thermo-Catalytic Reforming process–A review.” Biofuels, Bioproducts and Biorefining. 13 (3): 822-37.
Yanik J, Kornmayer C, Saglam M, Yüksel M. 2007. “Fast pyrolysis of agricultural wastes: Characterization of pyrolysis products.” Fuel processing technology 88 (10): 942-7.

Acknowledgments: The corresponding author, Hillary O. Onyishi, appreciates the Deutscher Akademischer Austausch Dienst (DAAD, Germany) for sponsoring his PhD research work at Fraunhofer UMSICHT in collaboration with the Petroleum Technology Development Fund (PTDF), Nigeria.