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Research

Pyrolysis assessment of palm kernel shell waste valorization to sulfonated magnetic biochar from techno-economic and energy perspectives

Yee Xuan Seow[1] · Yie Hua Tan[2] · Jibrail Kansedo[1] · Inn Shi Tan[1] · Bridgid Lai Fui Chin[1] · Nabisab Mujawar Mubarak[2,3] · Mohd Nurfirdaus Bin Mohiddin[1] · Peter Nai Yuh Yek[4] · Yen San Chan[1] · Mohammad Omar Abdullah[5]

Received: 29 May 2024 / Accepted: 3 July 2024
Published online: 24 July 2024

Abstract
Most agricultural activities generate a significant quantity of biomass waste that has not been fully utilized. This study utilized palm kernel shells as the primary material to produce sulfonated magnetic palm kernel shell biochar. The post-sulfonation magnetic palm kernel shell biochar had a greater particle size of around 137 nm compared to the pre-sulfonation biochar. This increase in size can be attributed to the presence of the $-SO_3H$ group. The biochar that underwent post-sulfonation was chosen for a techno-economic evaluation to ascertain its viability in terms of economics and energy efficiency. Soybean straw and coconut shell-derived biochar were chosen for the techno-economic assessment. The energy intake for soybean straws, coconut shells, and palm kernel shells derived from biochar is 48.85 $MJ{\cdot}kg^{-1}$, 23.83 $MJ{\cdot}kg^{-1}$, and 52.44 $MJ{\cdot}kg^{-1}$, respectively. The energy output for soybean straws, coconut shells, and palm kernel shells derived biochar is determined to be 22.54 $MJ{\cdot}kg^{-1}$, 23.68 $MJ{\cdot}kg^{-1}$, and 31.55 $MJ{\cdot}kg^{-1}$, respectively. The ultimate profit-to-cost ratios of soybean straws, coconut shells, and palm kernel shells derived biochar are 0.21, 4.92, and 1.11, respectively. The techno-economic assessment indicates that coconut shell-derived biochar production is favourable, primarily due to its attributes of low net energy balance, high porosity, and lower density. Both coconut shells and palm kernel shells derived biochar productions are economically viable and efficient due to their high profit-to-cost ratio. The microwave-assisted technology is proven efficient and demands less energy to generate an equivalent quantity of biochar compared to traditional furnaces.

Article Highlights

1. Pyrolysis of sulfonated magnetic waste palm kernel shell are studied by economic and energy analysis.
2. A comparison between coconut shell-derived biochar and soybean straw-derived biochar is made.
3. Coconut shell-derived biochar performs better in energy and economic analysis.

Keywords Biochar · Pyrolysis · Techno-economic · Energy · Waste valorization

✉ Yie Hua Tan, yiehua.tan@utb.edu.bn | [1]Department of Chemical and Energy Engineering, Faculty of Engineering and Science, Curtin University Malaysia, CDT 250, 98009 Miri, Sarawak, Malaysia. [2]Petroleum and Chemical Engineering, Faculty of Engineering, Universiti Teknologi Brunei, Gadong BE1410, Brunei Darussalam. [3]Department of Chemistry, School of Chemical Engineering and Physical Sciences, Lovely Professional University, Phagwara, Punjab 144001, India. [4]Centre for Research of Innovation and Sustainable Development, University of Technology Sarawak, No.1, Jalan Universiti, 96000 Sibu, Sarawak, Malaysia. [5]Department of Chemical Engineering and Energy Sustainability, Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS), 94300 Kota Samarahan, Sarawak, Malaysia.