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Physiochemical and Thermal Characterization of Municipal Solid Waste and Agricultural Residue Blends for Torrefaction

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ABSTRACT

Municipal solid waste (MSW), together with other biomass resources, presents a viable feedstock for renewable energy production; however, its direct conversion is limited by high moisture content, ash content, and heterogeneous composition. These challenges can be mitigated through torrefaction, provided that suitable feedstock selection and optimization are achieved. This study investigates the physicochemical and thermal characteristics of MSW, coffee husks (CH), corn cobs (CC), and their blends to demonstrate how biomass quality can be improved through blending. MSW was blended with CH or CC at mass ratios of 25:75, 50:50, and 75:25 (db/db%). Proximate, ultimate, lignocellulosic, thermogravimetric, and calorific value analyses were conducted. Proximate analysis showed that MSW had the highest moisture ($10.102 \pm 0.141\%$), volatile matter ($71.115 \pm 0.759\%$), and ash content ($6.674 \pm 0.477\%$), whereas CH exhibited the highest fixed carbon content ($18.863 \pm 0.572\%$). Ultimate analysis revealed that MSW contained the highest hydrogen content ($6.911 \pm 0.183\%$), CH had the highest carbon content ($50.001 \pm 0.184\%$), and CC showed the highest oxygen ($44.185 \pm 0.273\%$), nitrogen ($1.395 \pm 0.045\%$), and sulfur ($0.057 \pm 0.035\%$) contents. MSW had the lowest hemicellulose ($11.941 \pm 0.269\%$) and cellulose ($19.334 \pm 0.294\%$) contents, while CC had the lowest lignin content ($12.304 \pm 0.219\%$). The calorific value of MSW (17.01 ± 0.292 MJ kg^{-1}) increased upon blending, reaching up to 17.59 ± 0.241 MJ kg^{-1}. Thermogravimetric analysis indicated enhanced thermal degradation rates with increasing MSW content in the blends. In conclusion, blending MSW with agricultural residues significantly improves its physicochemical and thermal properties, enhancing its suitability for torrefaction. The 25MSW75CH blend demonstrated the most favorable characteristics and is recommended as an optimal feedstock for torrefaction-based waste-to-energy applications at industrial scale.

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