

BIOCHAR FROM MICROWAVE PYROLYSIS OF SELECTED FEEDSTOCKS

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This is a brief summary of work carried out by a team of researchers to produce biochar using microwave pyrolysis system developed at Bioenergy, Bioproducts Research Lab (BBRL), at UNB. Various feedstocks such as corn stalk, spruce, maple, switchgrass, and wood pellets were used to produce biochar. A batch type microwave reactor with a frequency of 2.45 GHz and a power generator of 3 kW was used in the pyrolysis experiments. The amount of biochar obtained depends on the microwave pyrolysis conditions and type of feedstock. For corn stalk briquettes, the yield of biochar ranged from 30.9 to 41.1 wt%. The average biochar yield for spruce, maple, and switchgrass was found to be 22.2 wt%, 22.0 wt%, and 24.4 wt% respectively. The yield of biochar produced from wood pellets ranged from 26.0 to 32.4 wt%. It was found that the biochar yield increased with an increase in biomass loading and decreased with an increase in power level for the microwave pyrolysis of wood pellets.

Elemental analysis was primarily used to determine the carbon content of the biochar. A higher carbon content results in a higher heating value, which is desirable for bioenergy applications. The carbon content of the corn stalk briquettes ranged from 63 to 74 wt%. The average carbon content was found to be 80.1 wt% for spruce, 79.5 wt% for maple, and 69.6 wt% for switchgrass. The carbon content of the wood pellets biochar ranged from 69.6 to 85.7 wt% and the highest carbon content was found for biochar produced at 2500 W and 1.5 kg. From the research on wood pellets, it was found that as the biomass loading increased the carbon content of the biochar decreased and as the power level increased the carbon content of the biochar increased.

Scanning electron microscopy (SEM) analysis was used to determine the morphology of the solid biochar. The SEM images of the spruce, maple, switchgrass, and wood pellets indicate that the biochar is highly porous and has a honeycomb-like structure. There was significant variation in the pore sizes; however, spruce had a high quantity of small pores and maple had the cleanest pores. The surface of the raw wood in pellet form was found to be smooth and non-porous, and the resulting grinded biochar had well-defined pores which indicate potential applications in adsorption.

BET analysis was performed to determine the pore volume and surface area of the biochar. The pore volume found for spruce was 12.12×10^{-2} cc/g. The pore volume of maple and switchgrass was 7.712×10^{-2} cc/g and 5.394×10^{-2} cc/g respectively. The average surface area of spruce, maple, and switchgrass was found to be 203.9, 155.7, and 116.5 m²/g. The surface area ranged from 108.91 to 366.51 m²/g and the mean pore diameters ranged from 0.69 to 0.94 nm for the biochars produced from wood pellets.

The higher heating value (HHV) of the biochars produced from corn stalk briquettes was found to decrease with increase in microwave power and biomass loading. The HHV ranged from 23.00 to 31.70 MJ/kg with the highest HHV produced at 900 W and 0.5 kg. The results from the HHV analysis indicate potential for biochar to be used as fuel for bioenergy applications.

References to work:

- Salema A A., M.T. Afzal, and L. Bennamoun. 2017. Pyrolysis of corn stalk biomass briquettes in a scaled-up microwave technology. *Bioresource Technology* 233: 353-362.
- Bowlby, L., G. Saha., and M. T. Afzal. 2017. Synthesis of high-surface area biochar particles using microwave pyrolysis technique. Paper No. CSBE17-164, accepted in CSBE/SCGAB 2017 Annual Conference, Canada Inns Polo Park, Winnipeg, MB. August 6-10, 2017.
- Dreise, T. M., Nhuchhen, D.R., and Afzal, M. T. 2017. Microwave pyrolysis of wood pellets using a scaled-up microwave reactor. Manuscript under preparation.