**Valorisation of solid waste: Briquettes production from corn-stover**

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**Highlights**

* Effect of temperature, heating rate and hold time on the char HHV from the slow pyrolysis of corn-stover was investigated.
* The optimum conditions for maximal char HHV were found at a temperature of 431°C, 6°C/min heating rate and a hold time of 29 minutes.
* The biochar HHV was 28.64 MJ/kg comparable to that of coal (23.9-26 MJ/kg).
* Briquettes with high density and durability were obtained

**1. Introduction**

With increasing global population and industrial activities, the world is currently challenged with energy crisis and the associated global warming, and environmental pollution. These issues have been the subjects of intensive research in recent years. Energy shortage is a serious problem in developing countries and the energy sector is looking for alternative sources of energy, which are environmentally friendly and cheaper. South Africa is the largest producer of maize in Africa (10-12 million tonnes per year) (FAO, 2016). Approximately 9 million metric tonnes of corn residues, corncob and corn-stover are produced per annum as agricultural wastes in South Africa (FAO, 2015). Hence, this can be a major pollutant as a solid waste and the disposal thereof can be challenging which can pose as a harmful threat to the environment. Corn-stover is a naturally abundant domestic energy source that is promising to relieve energy scarcity (Morissette et al., 2014). It is sustainably available with no competition for resources with food/feed production and other biomass applications. While there have been comprehensive reports of laboratory-scale studies in South Africa for bioethanol, biochar, bio-oil and gases (Mohlala et al., 2016), there is dearth of literature reporting the use of corn-stover for the generation of briquettes. Briquettes are made from waste materials or partially compressed biomass waste (Morisette et al., 2014). They are eco-friendly alternatives as fuel instead of charcoal, firewood or coal. The purpose of this work is to promote material and energy valorisation of corn-stover. This study investigated the optimisation of the carbonisation of corn-stover. Densification process of biochar resulting in briquette production was carried out.

**2. Methods**

The corn-stover was collected from a maize farm. The collected samples were dried to 10% and milled to a particle size range of 3.5mm-0.63mm. Biochar was produced via slow pyrolysis using a retort reactor in the absence of oxygen by purging with nitrogen. The ASTM D3175-17 standard methods were used to obtain the ash content of the samples. A central composite design (CCD) of gram scale experiments was used to study the effects of the of temperature, heating rate and hold time on the char HHV. Design Expert® Software Version 10 (Stat-Ease, Inc., Minneapolis, USA) was used to study the CCD. With regards to the design of experiments (DoE), the selected DoE conditions were 300, 400 and 500°C for temperature, 5, 12.5 and 20°C/min for heating rate and 5, 17.5 and 30 minutes for holding time. Briquettes were produced by adding a starch binder (5 and 10%) to the biochar. Finally, the mixture was compressed using a piston press cylinder to densify the biochar/binder mixture.

**3. Results and discussion**

The optimum conditions for char production were 453°C, 5°C/min and 29 min. Under these conditions, an average char yield of 34.5% was determined. The final prediction equation obtained from Design Expert® software version 10 for char HHV by temperature ($x\_{1}$), heating rate ($x\_{2}$) and hold time ($x\_{3}$) of a fixed bed reactor is provided by equation 1. The positive quadratic factor coefficients (+1.48 and +0.26) indicate that char HHV tends to increase with a rise in temperature and hold time respectively (Equation 1). While the negative quadratic factor coefficient (-0.5) indicates that an increase in heating rate will result in a reduction in char HHV.

Char HHV=$ 24.06+1.48x\_{1}-0.5x\_{2}+0.26x\_{3}-0.54x\_{1}x\_{2}-0.071x\_{1}x\_{3}-0.41x\_{2}x\_{3}-2.46x\_{1}^{2}+0.15x\_{2}^{2}+0.68x\_{3}^{2}$ *equation 1*

The ash content of the untreated corn-stover was 4.96% while the biochar was 13.34%. This indicates its potential to produce smokeless solid fuel. Higher heating value (HHV) of the untreated corn-stover was found to be 18.7 MJ/kg while the biochar HHV was found to be 28.92 MJ/kg comparable to that of coal (23.9-26 MJ/kg) (Morissette et al., 2014). The carbon rich biochar is obtained with higher amounts of fixed carbon of 63.70% and ash content of 13.34%, but lower amounts of volatiles of 20.38% than corn-stover biomass feedstock which means that the biochar produced has improved burning properties because lower volatile matter results in increased burning time and no smoke during burning. The compressive strength obtained from densification was in the range 3.45-6.11 N/mm2 with increasing binder concentration between 5 and 10%. The density obtained through densification process (20-40MPa) ranges from 420-788 kg/m3 shows the durability obtained through densification which ranges from 97-100%.

**4. Conclusions**

Briquettes with high density, durability and fuel properties were obtained. These have potential to substitute or augment reliance on coal.

**References**

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