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Progressing from Terra Preta de Índios to the Whole World

Production and characterization of different feedstocks

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Introduction

The diminishing stockpile of fossil fuels and the accompanying negative effects of their usage in terms of producing green house gases and shift in climate has also regenerate the interest in renewable energy sources [1, 2]. Biochar is a product of pyrolysis, which is carbon rich, with high heating value and relatively pollution free solid biofuel. The aim of this work is to produce and characterize biochar from different feed stocks (corn stover, switchgrass, miscanthus, big bluestem, and prairie cord grass) by conventional pyrolysis. The pyrolysis was carried out in a reactor (mild steel 20 cm long, diameter of 10 cm) placed in an Isotemp programmable muffle furnace. Before heating, nitrogen was flushed in to the reactor for 10 min to remove air from the system. The heating rate was varied from 20-40°C/min. The temperature was maintained from 300 to 600˚C. Corn stover was taken to evaluate the operating conditions, as consequence 4 mm particle size and 40°C/min has given the highest yield of biooil. The calorific value of the samples was measured by 1341 Plain Jacket Bomb Calorimeter. The elemental analysis of biomass and biochar was done according to ASTM D 1762-84 (2007). The physical characteristics such as particle density and porosity were measured according to ASTM D6683 (2001), geometrical mean diameter was determined according to ASAE S319.3 (2003). Fourier Transform Infrared Spectroscopic analysis of all the samples was obtained using ATR –FTIR Nicolet 380. The spectrum was obtained by using 64 scans with a resolution of 4 cm^{-1}. The FTIR spectra were recorded in the transmission mode between 4000 and 500 cm^{-1} for all the samples. All the experiments were carried out in triplicates and the data collected was analyzed using SAS 9.2.

Results and Discussion

Figure 1 shows that the yield of biochar was maximum at a heating rate of 20°C /min and 300 °C with a particle size of 6 mm. Table1 shows the physical and chemical characteristics of different biomass and their carbonized residues (char). Geometrical mean diameter of the biomass has decreased significantly when converted into char irrespective of the feedstocks. As a result of the pyrolysis process, the carbon content of char increased when compared to the original biomass. The highest percent increase of 49.7% was observed for prairie cord grass. The heating value of the char was higher than that of the raw biomass especially for prairie cord grass (36.6 %). The porosity of biochars was higher than that of respective biomass samples, with an obvious notice of 6% increase for prairie cord grass and a possible reason might be needle shape biomass and biochar.

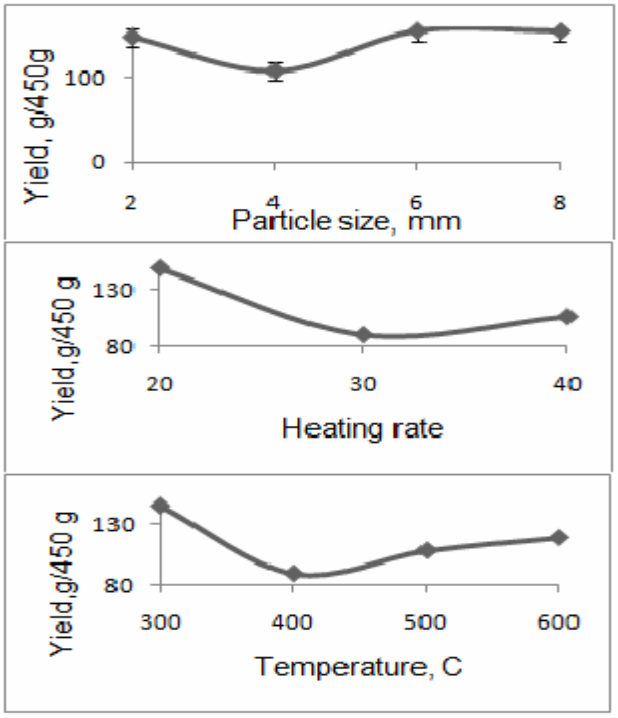

Figure1: Biochar (corn stover) yield as a function of particle size, heating rate, and temperature.

Table 1. Physical and chemical properties of biomass and biochar

	True density (kg/m^3)	Porosity (%)	GMD (mm)	C (%)	N (%)	LHV (MJ/kg)	Moisture (%)	Ash-total (%)
Cornstover	108.9	0.090	0.69^{a}	43.7	0.62	10.2	5.35	5.6
Char$_{CS(300C)}$	101.1	0.092	0.35^{ef}	35.5	1.67	11.4	TBR	TBR
Char$_{CS(500C)}$	100.6	0.092	0.32^{gf}	41.2	1.43	11.9	5.38	36.6
Switchgrass	109.9	0.092	0.64^{b}	46.8	0.60	15.6	7.40	5.3
Char$_{SG(300C)}$	80.6	0.089	0.44^{c}	50.3	1.72	16.5	TBR	TBR
Char$_{SG(500C)}$	97.1	0.093	0.36^{ef}	61.1	1.74	18.3	8.03	10.4
PrairieCGrass	139.1	0.089	0.35^{ef}	47.6	0.35	15.1	6.85	5.0
Char$_{PCG(300C)}$	75.2	0.091	0.36^{ef}	59.4	1.40	19.7	TBR	TBR
Char$_{PCG(500C)}$	104.0	0.095	0.30^{g}	71.3	1.66	20.7	1.64	11.4
Big Bluestem	130.3	0.089	0.40^{d}	47.0	0.70	13.9	6.51	10.4
Char$_{BB(300C)}$	79.9	0.089	0.39^{de}	45.9	1.73	11.0	TBR	TBR
Char$_{BB(500C)}$	100.6	0.092	0.35^{f}	59.0	1.39	14.4	1.88	21.0
Miscanthus	101.2	0.092	0.61^{b}	45.7	0.46	13.9	6.50	6.9
Char$_{miscan(300C)}$	80.2	0.089	0.39^{de}	45.6	1.02	14.9	TBR	TBR
Char$_{miscan(500C)}$	96.3	0.093	0.35^{ef}	56.0	1.03	14.7	4.91	24.6

GMD indicates Geometrical Mean Diameter TBR-To Be Reported

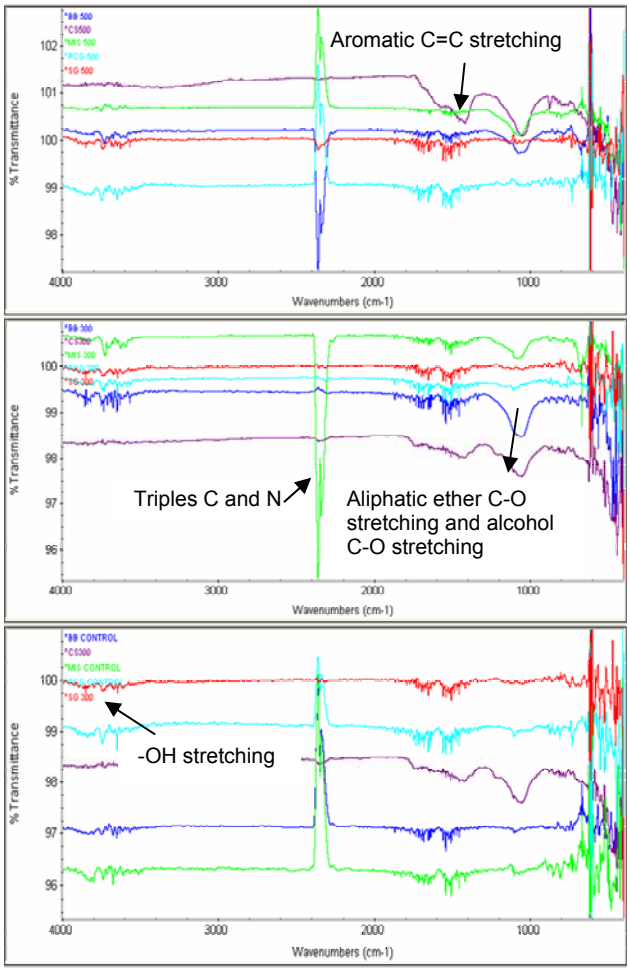

Figure 2. ATR-FTIR images of biomass and biochar.

The peaks were observed between 3600 and 4000 (-OH stretching), 2000 to 2400 (triple C and N), 900 to 1100 (aliphatic ether C-O and alcohol C-O stretching) and 1100 to 1600 cm^{-1} (aromatic C=C stretching).

Conclusions

The results have shown that the physical and chemical characteristics of biochar significantly differed with varying feedstocks and pyrolysis conditions such as heating rate and temperatures.

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