Preparation of biochar from sunflower husks

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1 Background

Biochar is a coal like substance produced as a solid fraction during thermochemical liquefaction of organic material[1]. Thermochemical liquefaction removes oxygen from biomass through a complex set of hydration, decarbonylation and decarboxylation reactions. Sunflower husks is a by-product from oil presses and is either directly burned for energy generation or deposited in landfill. Sunflower husks has a high lignin content that has been associated with high biochar yields from liquefaction. Processing conditions during liquefaction determines the ratio of biochar to bio-oil and biogas formed as well as the properties and higher heating value of the biochar for application in soil remediation or co-gasification.

The focus of this study was on thermochemical operating conditions that influence the biochar yield and characteristics. The study investigated:

- Significance of solvent used during liquefaction
- Effect of reaction atmosphere
- Effect of reaction temperature

4 Summary & Conclusions

The results from this study has shown that sunflower husks prepared through thermochemical liquefaction in ethanol as solvent and CO_2 as atmosphere has excellent properties for co-gasification with coal. The following specific conclusions could be drawn from the results:

- Surface areas for chars prepared at temperatures above 280°C were as high as 100 m^2
- Biochars prepared in this study compared well to lignite coal on a Van Krevelen plot
- FTIR spectra showed increased decomposition of lignocellulose material and increased formation of char with an aromatic surface with an increase in temperature
- Biochar yield decreased with an increase in temperature as larger polymers reacted with radicals to form bio-oils and gas
- Higher char yields were obtained with lower alcohols due to better solubility
- Although N_2 gave higher char yields, chars prepared in CO_2 showed better H/C and O/C ratios

2 Materials and methods

Sunflower husks

Item	Mass %
Dry matter	91.78
Ash	4.60
Protein	8.30
Fat	0.55
NDF	77.34
ADF	65.18
ADL	34.1
[a]Cellulose	30.47
[b]Hemicellulose	12.16
[c]Lignin	34.71

a. Cellulose content = ADF-ADL
b. Hemicellulose content = NDF – ADF
c. Lignin = ADL

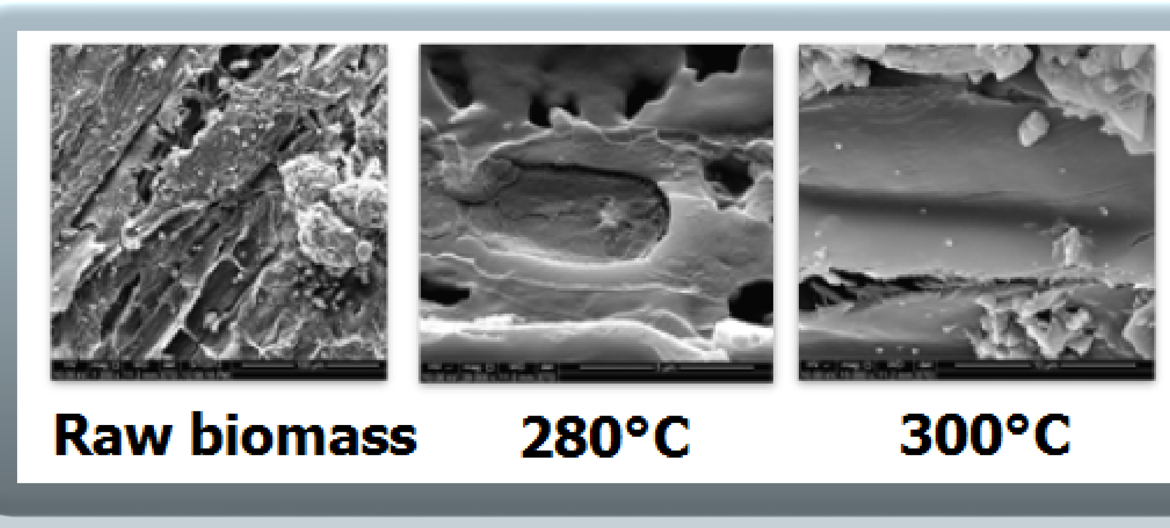
Liquefaction reactor system

Solvent
Water
Methanol
Ethanol
Propanol
n-butanol

Biochar

Reaction gas
CO_2 or N_2

Structural analysis



Compositional analysis

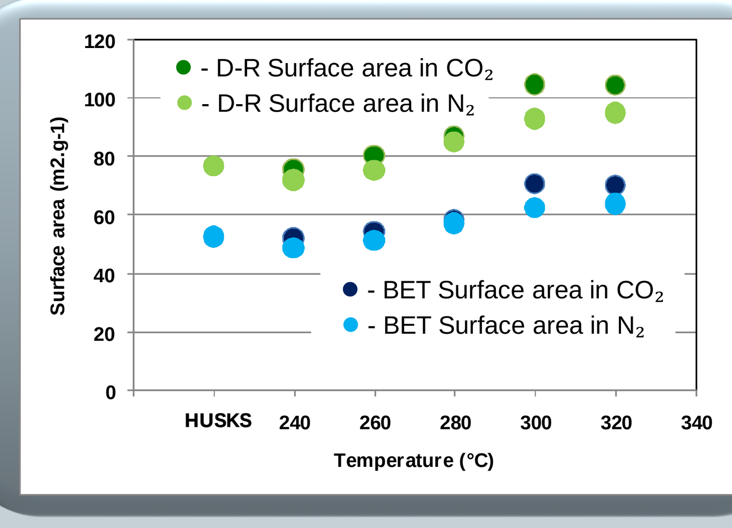


Figure 5 BET micro-pore surface analysis

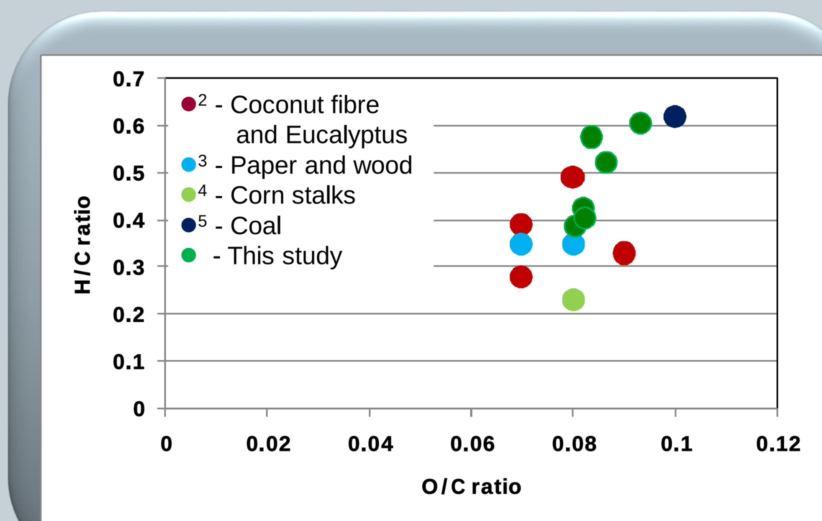


Figure 4 Van Krevel plot of various feedstock

N_2	VM %	FC %	Ash %	HHV (MJ/Kg)
Husks	52.6	15.7	8.4	19.9
240°C	50.8	32.7	5.2	19.7
260°C	47.1	34.9	8.7	18.7
280°C	45.0	38.8	9.0	21.8
300°C	41.4	42.8	10.9	23.0
320°C	39.0	47.1	10.9	26.1
CO_2	**VM**	**FC**	**Ash**	**HHV (MJ/Kg)**
240°C	63.01	30.1	6.8	20.8
260°C	61.0	31.6	7.5	21.2
280°C	50.8	40.1	9.2	21.7
300°C	41.4	48.8	9.8	25.7
320°C	38.6	48.9	12.4	26.8

3 Results

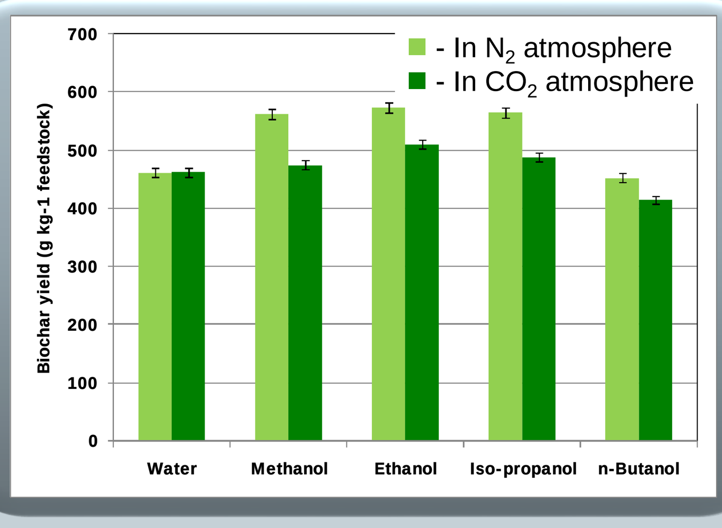


Figure 1 Effect of solvent

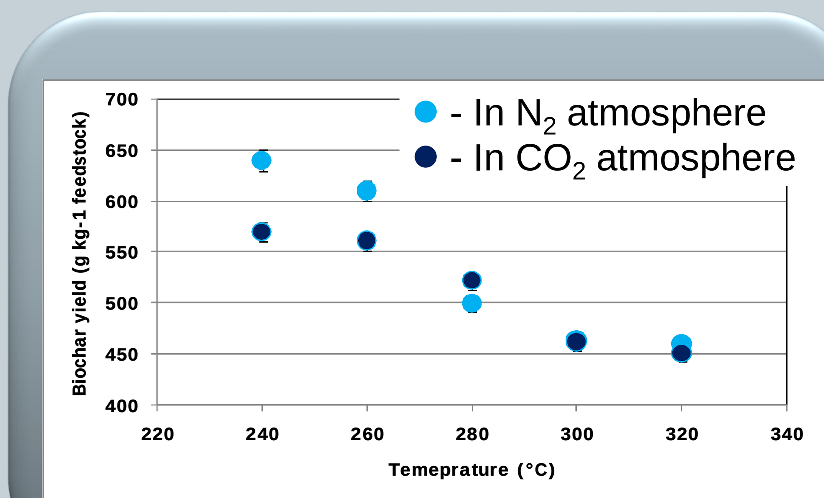


Figure 2 Effect of temperature

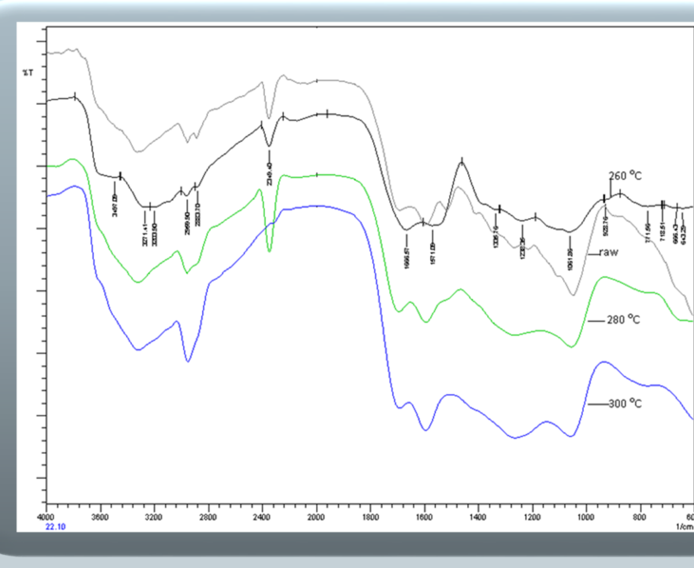


Figure 3 FTIR Spectra of biochar in N_2 (●- Husks, ●-260°C ● - 280°C, ● - 300°C)

Wave number	Characteristic vibration
3600-3040	-O-H cellulsose stretching[2,5,6]
2920-2880	-C-H stretching of asymmetric aliphatic –CH_x[6]
2360	Aliphatic –CH and CO vibrations[6]
1700-1600	-C=C and C=0 carboxyl, aldehydes, ketones, ester and conjugated aromatic groups[5,6]
1560-1480	-C-H stretching associated with lignin and cellulose
1400-1240	-C-O ether vibration[7]
1160-1180	-C-O-C stretching in lignocellulose[5]
1060-960	-C-O stretching and O-CH_3 vibration in lignin[5]
860	Associated with polycyclic aromatic structures[6,8,9]
740	Aromatic -C-H vibrations[5]

5 References

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