Biochars for the Adsorption of Environmental Pollutants

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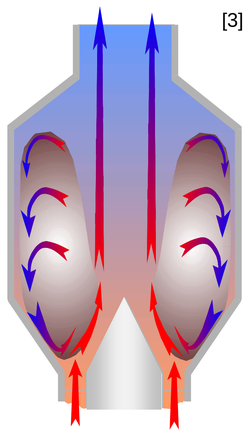
Introduction

✓ 'Biochars': High carbon product produced from thermal decomposition of biomass with limited O_2 [1].

✓ Has many applications including: Additive to soil, adsorption of CO_2 and water treatment [2].

✓ Torftech TORBED reactors thought to produce highly porous biochars. They provided us with two biomass chars and three lignite chars to test [3].



[3]

Figure 1: TORBED reactor

Methods

Chars
Gasification: Straw (690 ºC, Poland), Wood (750 ºC, Wales). Fast pyrolysis: Lignite chars(750 ºC, 830 ºC and 950 ºC).

- Surface area and porosity: Nitrogen desorption/adsorption isotherms.
- Surface oxygen functional groups: Thermal Analyser, Mass Spectrometer and a Fourier Transformed Infra-Red (STA-MS-FTIR).
- Measuring weight gain to assess CO_2 adsorption.

The char which demonstrated the highest surface area was then activated by chemical activation (KOH, 650 ºC, 1 hour 2:1 ratio) and physical activation (CO_2, 30 mins, 800 ºC), and the same analysis methods repeated.

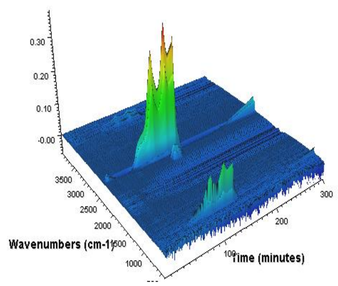
Results

✓ Wood has the lowest surface area and micropore volume. The straw char has a much higher surface area of 463.43 m^2/g.

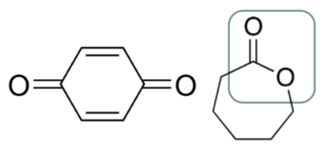
✓ From the STA-MS-FTIR, suggestions can be made as to the functional groups present on the surface of the char, depending on the temperature of CO and CO_2 evolution.

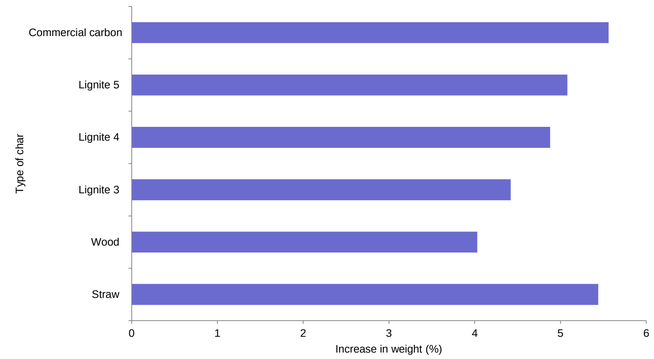
✓ Straw and wood chars evolved CO at temperatures characteristic of lactone groups, and CO_2 at temperatures characteristic of quinone/semiquinone groups.

Sample	Surface Area (m^2/g)	Micropore Volume (cc/g)
Straw Char	463.43	1.84E-1
Wood Char	86.51	3.65E-2
Lignite Char 750 ºC	489.97	1.92E-1
Lignite Char 830 ºC	484.97	1.85E-1
Lignite Char 950 ºC	665.20	2.57E-1



CO Peak (K)	Possible Functional Group	CO_2 Peak (K)	Possible Functional Group
1160	Quinone/ Semiquinone	879 1109	Lactone Uncertain





✓ Straw char adsorbed the most CO_2.

✓ Lignite chars absorbed more the higher the production temperature.

✓ Straw show marginally less adsorption than the activated commercial carbon.

	Yield (%)
CO_2 activation	54.56
KOH activation	71.34

Yields from both activation methods.

✓KOH activated char contained a higher number of ultra-micropores (<7 Å).

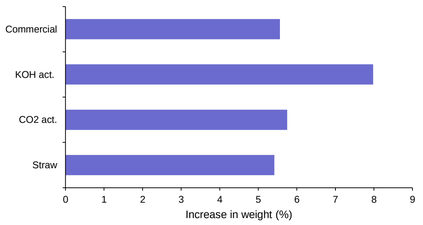
✓STA-MS-FTIR suggested the same functional groups as unactivated chars.

✓ CO_2 activation increased the uptake marginally.

✓KOH activation significantly increased uptake.

✓Both CO_2 and KOH activation increased uptake above the commercial carbon.

Sample	Surface Area (m^2/g)	Micropore Volume (cc/g)
Straw char	463.43	1.84E-1
CO_2 act. char	820.11	3.19E-1
KOH act. char	1177.04	4.56E-1



Conclusion

✓ Straw char demonstrated the highest surface area and micropore volume.

✓ Chemically activated straw char had significantly improved surface area and CO_2 uptake.

✓ Physical activation did not significantly improve the CO_2 uptake of the char.

References
[1] Gaunt, J.L. and Lehmann, J. Energy balance and emissions associated with biochar sequestration and pyrolysis bioenergy production. Environmental Science & Technology. 2008, 42(11), pp.4152-4158.
[2] Lehmann, J. et al. Bio-char sequestration in terrestrial ecosystems–a review. Mitigation and adaptation strategies for global change. 2006, 11(2), pp.395-419.
[3] R. Blissett, 'Upgrading low rank coal for metallurgical pulverised coal injection applications', 2015 International Conference on Coal Science & Technology, 2015.

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