Pelletized biochar production and characterization from biobased waste textiles

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Project Rationale and Goals

- The presence of biobased waste textiles is an increasing problem in the current solid waste management system. However waste-textiles have the ability to be turned into a biochar and can be used for energy or for carbon sequestration.
- Biochar is a stable, carbon rich biomass that could then be used as a soil application or for an alternative source of power generation (Lehman and Joseph, 2015).
- At some point in the lifecycle of clothing or surpluses from the textile industry make their way to a landfill or a facility to be incinerated (Aizenshtein, 2004)
- Cotton makes up approximately one-third of the global market of textile (Miranda et. al, 2007) , and it is estimated that the US exports 7 billion pounds of used clothing (Claudio, 2007)
- Recycled biomass pellets can represent a more sustainable fuel source for industrial pellet burners

Methods

- Material was characterized using elemental analysis, finding calorific value, conducting TGA proximate analysis, and spectroscopy
- Three different binders were tested: 1) Corn Starch and Water , 2) Vegetable Oil, 3) Water only
- Using starch we tried three different thermo-treatments of the material, as follows:

Single Pyrolysis:
1. Grind the material
2. Form pellet with binder
3. Pyrolyze the pellet

Torrefaction:
1. Cut the material
2. Form pellet with water
3. Torrefact
4. Grind material
5. Form pellet with starch
6. Torrefact again

Double Pyrolysis:
1. Grind the material
2. Form pellet with water
3. Pyrolyze
4. Grind material
5. Form pellet with starch
6. Pyrolyze

- Torrefaction seemed to be the best method due to the decrease in time for material grinding, and using that we tested the following temperature combinations:
  - 300° C for 40 minutes, no second torrefaction
  - 300° C for 40 minutes, 300° C for 30 minutes
  - 300° C for 40 minutes, 275° C for 30 minutes
  - 300° C for 30 minutes, 275° C for 30 minutes
  - 275° C for 40 minutes, 275° C for 30 minutes
  - 275° C for 30 minutes, 275° C for 30 minutes

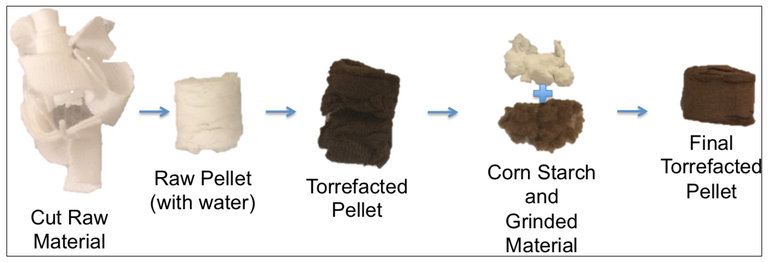
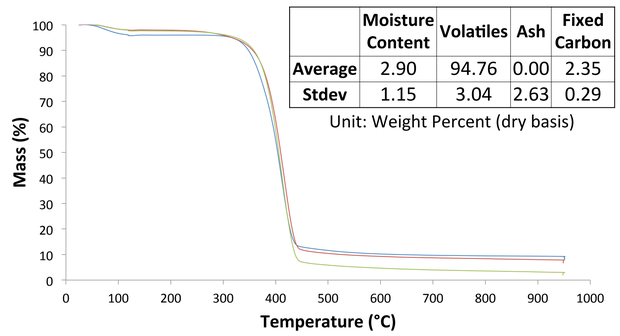


Figure 1: Step by step photo showing how torrefacted pellets are made .

- Pellets were characterized using elemental analysis, finding calorific value, and conducting TGA proximate analysis
- Best pellet was selected by team based on performance and characteristics to be produced in mass to be sent to an industry lab for further testing

Material Results



	Moisture Content	Volatiles	Ash	Fixed Carbon
Average	2.90	94.76	0.00	2.35
Stdev	1.15	3.04	2.63	0.29

Unit: Weight Percent (dry basis)

Figure 2: TGA results from running only the fabric, significant values shown in top right corner.

HHV = 16,046.33 J/g

Composition of Material:

Nitrogen %	Carbon %	Hydrogen %	Oxygen %
0.11	41.25	6.38	52.26

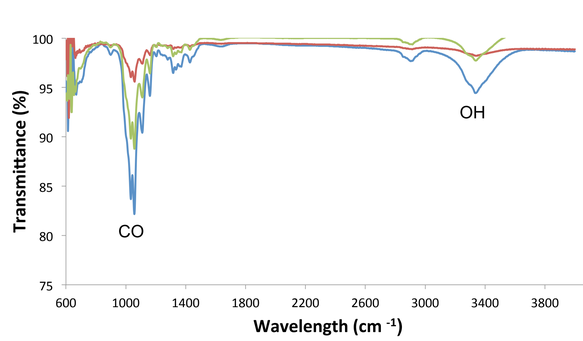
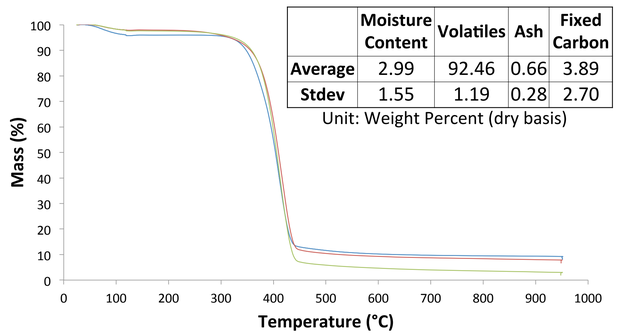


Figure 4: FTIR spectroscopy results, showing the functional groups of the raw material.

Selected Pellet Results



	Moisture Content	Volatiles	Ash	Fixed Carbon
Average	2.99	92.46	0.66	3.89
Stdev	1.55	1.19	0.28	2.70

Unit: Weight Percent (dry basis)

Figure 3: TGA results from the pellets we ultimately chose to produce in mass, these were torrefacted twice, first 300° C for 30 minutes and then 275° C for 30 minutes, significant values shown in top right corner

HHV = 17,247 J/g

Total Mass Loss = 71.60 wt.%

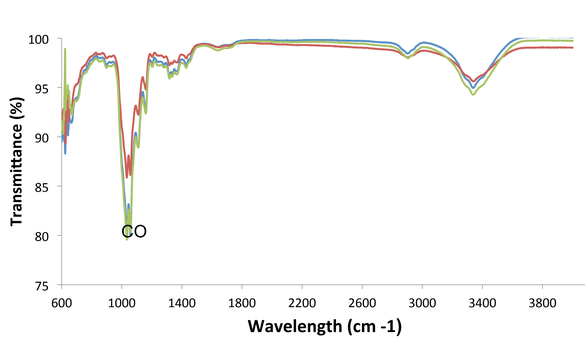


Figure 5: FTIR spectroscopy results, showing the functional groups of the selected pellet for mass production.

Conclusions

- By using the torrefaction method on the material prior to grinding a large amount of time and energy were saved.
- In the tests of the 3 binders, starch with the 1:4 starch to fabric ratio by mass proved to be the best.
- Further research on this topic would include testing the process in a small-scale industrial lab before scaling up to commercial production.
- Future tests could also include attempting to decrease the heat used in the primary and secondary torrefaction, as well as the amount of binder to make the product more economically feasible.
- It is believed that this product could serve as a sustainable and renewable drop in feedstock to current coal and pellet burning industrial settings.

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NARA

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Citations

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