COTTON GIN TRASH BIOCHAR POROSITY ENHANCEMENT - A LITERATURE REVIEW

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Abstract

In evaluating cotton gin trash as a base material for biochar production from gasification, several parallels can be drawn from other biomass sources and techniques. For activated carbon, a measure of quality is the overall porosity, which is a direct measure of the absorption capabilities of the product. The quality of the biochar varies in several ways due to the differences in the operating parameters of the gasifier. Cotton gin trash itself is a material that, for the most part, is lignocellulosic and therefore provides the underlying carbon structure necessary to produce biochar with acceptable porosity and surface area.

In other research, activated carbon has been produced in different ways from physical and chemical activation. Overall, the best activation has been achieved through chemical activation yielding highly porous activated carbon products. Chemical activation works in helping to break apart linkages in the material yielding larger and deeper pores thereby increasing the absorptive capabilities of the carbon products produced (Viswanathan, 2009). In research conducted at Texas A&M University in gasifying cotton gin trash, the gasification process causes the biomass to undergo partial physical activation forming biochar. This physical activation has difficulty producing the same deep porosity as chemical processes of activation due to the inability for the heat treatment to penetrate deeply into the material. In future research, the hope is to improve the porosity of cotton gin trash biochar to increase overall marketability through testing the enhancement of additional activation, pretreatment, and/or increased gasification residence time.

Introduction

Biochar is an intermediate stage of carbon between fully activated carbon and the biomass base material undergoing a thermochemical change. Biochar has similar adsorptive capabilities to activated carbon just to a more limited extent. Activated carbon itself is a useful commodity used in many processes in water treatment and filtration, gas phase applications in industrial scrubbers, as well as uses in pharmaceutical and technology industries (Viswanathan, 2009). The minimum surface area needed for these different applications varies with gas phase applications requiring the greatest surface area (Cooper and Alley, 2011).

Currently the Biological and Agricultural Engineering Department at Texas A&M University (TAMU) is researching biomass gasification utilizing cotton gin trash. Gasification itself is partial combustion of a base material, in this case cotton gin trash, in a limited oxygen environment that produces a combustible gas and a biochar byproduct. Through this research, TAMU is looking into ways and means of improving the quality of the cotton gin trash biochar, safe handling of the biochar, and developing markets for biochar. By increasing the quality of the biochar, the goal of this research is to increase the porosity of the biochar which increases the surface area and thus the adsorptive qualities of the material.

Literature Review

Research review on the development of activated carbon from other biomass sources can shed light on the impact of different treatments on cotton gin trash biochar. Through the gasification of cotton gin trash synthesis gas, tars, and biochar are produced. Biochar is activated carbonaceous material with some porosity.

As shown in Table 1, using iodine number (a standardized measure of adsorption) for comparison, the cotton gin trash biochar exhibits limited adsorption capabilities compared to activated carbons. In order to increase overall marketability, the adsorptive qualities must be in the same range as other commercial activated carbons. In the production of activated carbon, there are two methods used to produce these materials, physical and chemical activation. Both have pros and cons addressed in the following paragraphs.

Table 1. Untreated Cotton Gin Trash Biochar compared to activated carbons.

Activated Carbon Source	Iodine Number
Cotton Gin Trash (a)	**300**
Corn Cobs (b)	**1360**
Apricot Stones (b)	**669**
Coconut (c)	**1350**
Wood (c)	**1230**

(a)- Capareda, 2010; (b)- Nowicki et al., 2014; (c)- Cooper and Alley, 2011

Chemical activation itself is a process that uses chemical application to a carbon rich base material and a thermal conversion in the absence of oxygen. The chemical applications to the materials help develop micropores due to the chemicals breaking apart the interconnections of the materials thus increasing porosity. In most cases, chemical activation of other biomass sources has been shown to produce high quality activated carbon (Nowicki et al, 2014). In addition to the improvement of quality, chemical pretreatment has been shown to inhibit tar formation which is very beneficial in biomass gasification (Viswanathan, 2009). However, chemical treatment causes issues in regards to material handling, and material processing due to the caustic chemicals used in this method of activation.

In physical activation, the carbon rich base material is exposed to high temperatures in an oxygen deficient atmosphere. The main process that forms pores is the harsh temperature conditions that physically break apart the base material forming a porous carbon structure. Physical activation does not have the extensive micropore development that would be typically found in materials that underwent chemical activation. In addition to the lack of micropore development, the physical activation process requires more energy due to the fact the action of activation is done though the physical conditions breaking apart the base material. However, the physical activation process does not require the use of additional, often hazardous, chemicals. Focusing on the gasification process, increasing the overall residence times in the gasification process can improve the quality of the char (Klinghoffer, 2013). In addition to increasing residence times, research conducted at Iowa State, wood biochar was activated through physical means after gasification and exhibited increased porosity (Del Campo, 2015). These two projects are pertinent to the work ongoing at TAMU in cotton gin trash biochar due to the relations to the gasification process used to produce the biochar.

Conclusions

Gasification of cotton gin trash creates biochar which is a moderately activated carbon material. Based on previous research, there are instances in which the porosity of different samples of biochar have been improved by chemical pretreatment, additional physical steam activation, in addition to other means. By improving cotton gin trash biochar to match or exceed currently available industrial activated carbons, a new market can be tapped for cotton industry byproducts. In future research, the goal is to test different methods of improving biochar porosity including additional activation, chemical pretreatment, and increased residence time in gasification.

References

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