PRODUCTION OF MACADAMIA NUT SHELL AND COCONUT SHELL ACTIVATED CARBONS BY AIR ACTIVATION

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Introduction

The focus of this paper is the synthesis of activated carbons by a controlled, low temperature, air gasification of macadamia nut shell ("macshell") and coconut shell charcoals. This work builds upon earlier publications in which we described a novel three-step process that produced high-yield activated carbons with moderate surface areas from biomass charcoal. [1-2]. Here we show how the process can be employed to produce high quality, high surface area, activated carbons. Our main goals are to demonstrate the possibility of producing activated carbons from biomass charcoals by air gasification, and to provide insights into the development of the surface area of the activated carbon during activation.

Experimental

A three-step procedure: carbonization, oxygenation (or air gasification), and activation is used in this work to synthesize activated carbons from macshell and coconut shell charcoal feeds [3]. The charcoal feed is ground to 1.0 - 1.4 mm particles prior to carbonization. Both the carbonization and activation steps are conducted in a closed crucible inside a furnace (Thermolyne Furnace 1300) at 1173K for 15 minutes. The third step, oxygenation, is accomplished in a semi-batch, fixed-bed flow reactor described elsewhere [2-3]. Carbon characterization is done using a Quantachrome Autosorb-1 apparatus.

Results and Discussion

The overall yields and BET surface areas of the activated carbons produced in this work are displayed on Figures 1 and 2. As displayed in these figures, the overall yield of activated carbon from each shell feedstock begins at about 0.3 (carbonization only). Similar to conventional steam and CO_2 activation processes, the BET surface area of both activated carbons increases with BO. BET surface areas near 1000 m^2/g are realized from both feedstocks when the BO reaches 50 to 60%. The overall yields of these high surface area activated carbons are substantially higher (> 50%) than commercially available activated carbons manufactured from coconut shells by conventional physical activation. This increase in overall yield is largely due to our use of high-yield charcoal feeds.

Recently, Conesa et al. [1] proposed the use of a cost index $M_{bio,IN}$ to clarify the impacts of overall yield and the adsorptive properties of an activated carbon on the cost of water cleanup. Observing that feedstock costs often dominate the cost of products manufactured from biomass, the authors posed the following important question: "How much biomass $M_{bio,IN}$ is required to manufacture an activated carbon that can remove 1000 mg of iodine from water according to the standard test procedure (ASTM D4607-86)?" It is easy to see that $M_{bio,IN}$ is given by the formula $M_{bio,IN} = 1000 / (Y4*IN)$, where Y4 is the overall yield of the activated carbon from the biomass feed on a dry weight basis, and IN is the iodine number. Recognizing the close relationship that exists between IN and SA, Dai and Antal [2] introduced the related cost index $M_{bio,SA} = 1000 / (Y4*SA)$, where SA is the BET surface area. Typically, $M_{bio,IN} \approx M_{bio,SA} \approx 12$ g for commercial coconut shell activated carbons. In other words, about 12 g of dry, raw coconut shells are required to produce enough commercial activated carbon to remove 1000 mg of iodine from water according to the standard test procedure. Figure 2 shows that the air activation process lowers the cost index by almost 50% when macshells are used as a feedstock. The improvement (a 40% decrease in the cost index) is nearly as good for coconut shells.

Conclusions

By use of a three step process involving (i) carbonization, (ii) controlled low-temperature air oxidation, and (iii) a second carbonization (activation); high surface area (> 1000 m^2/g) activated carbons can be produced from macadamia nut shell and coconut shell charcoals. Activated carbon yields as high as 15 wt% of the dry, raw biomass feedstock can be achieved when high-yield charcoal is used as a substrate for activation by air gasification. This yield is almost double the reported commercial yield for coconut shell activated carbon. Likewise, the cost index $M_{bio,SA}$ for the activated carbons produced in this work is 40% lower than the comparable cost index of commercial coconut shell activated carbons.

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References

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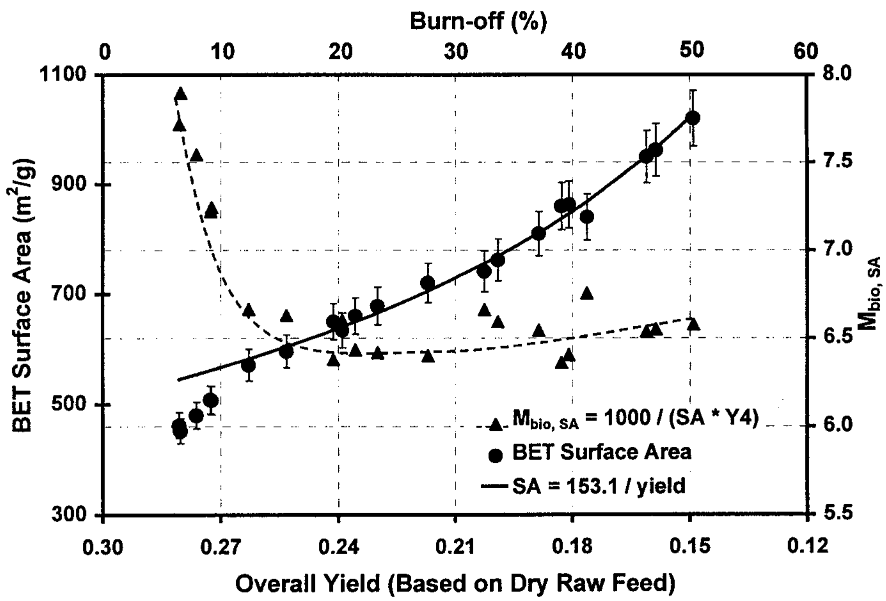

Figure 1. Surface Area and Cost Index vs. Yield of Macadamia Nut Shell Activated Carbons

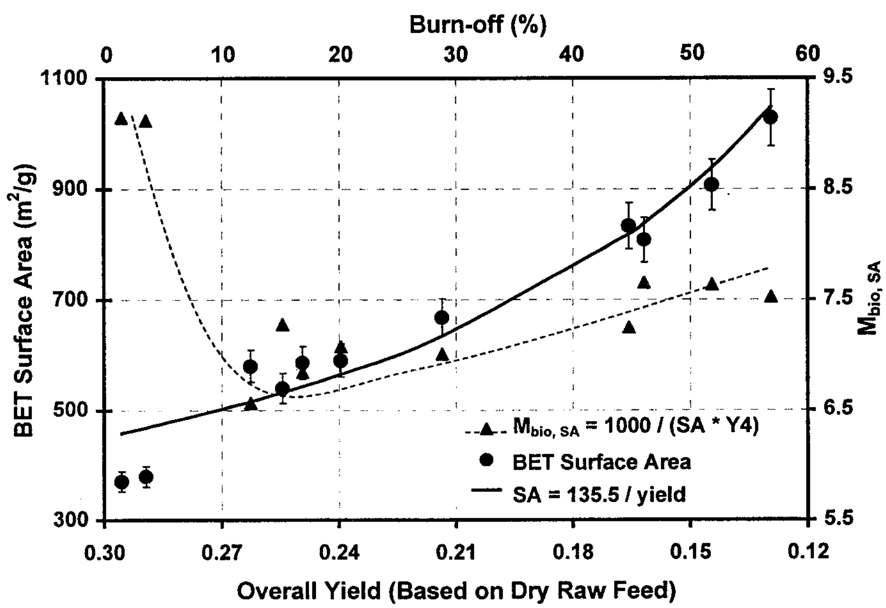

Figure 2. Surface Area and Cost Index vs. Yield of Coconut Shell Activated Carbons