Biocarbons

Soon after joining the University of Hawai‘i (UH), a Thai colleague (Dr. Woraphat Arthayukti) asked Professor Antal to deliver a lecture in Bangkok on improving the yields of charcoal from biomass. Dr. Arthayukti explained that the forests of Thailand were being clear-cut to manufacture charcoal because the efficiency of charcoal production was very poor. This request led us to a 3 decade search for a thermochemical process that can realize high yields of charcoal without noxious emissions of smoke or other pollutants. Prior work of the R3Lab at Princeton had revealed the beneficial effects of elevated pressure on the yields of biocarbons. This prior work caused us to emphasize elevated pressure throughout our search for an efficient carbonization process.

During the 1990s we invented and patented the “high-yield” process for biomass carbonization. This process employed electrical heating of biomass in a pressure vessel to produce charcoal efficiently at pressures below 100 psig. Because of its use of electricity to generate the needed heat for carbonization, the “high-yield” process was not economical.

During the first decade of the 21st century, we invented and patented the Flash-Carbonization™ process, which consumes very little electric power, and both quickly and efficiently produces biocarbon from biomass. The Flash-Carbonization™ process involves the ignition of a flash fire at elevated pressure in a packed bed of biomass. Because of the elevated pressure, the fire quickly spreads through the bed, triggering the transformation of biomass to biocarbon. Fixed-carbon yields above 80% of the theoretical limit have been achieved in as little as 20 or 30 minutes. Feedstocks have included woods (e.g., leucaena, eucalyptus, and oak), agricultural byproducts (e.g., macadamia nutshells, corncobs, and pineapple chop), moist green wastes (e.g., wood sawdust and Christmas tree chips), various invasive species (e.g., strawberry guava), and synthetic materials (e.g., shredded automobile tires). Our early work employed a lab-scale reactor that provided data for scaleup.

Beginning in 2005, scaleup resulted in the fabrication of a commercial-scale, stand-alone (off-the-grid) Flash Carbonization™ Demonstration Reactor ("Demo Reactor") -- see the photo to the right. The first successful test of the Demo Reactor occurred on 24 November 2006. A canister full of corn cobs was carbonized in less than 30 min. This test proved that the Flash-Carbonization™ process can be scaled-up to commercial size.

The UH Flash-Carbonization™ technology is protected by U.S. Patent No. 6,790,317 and U.S. Serial No. 12/679,635. UH has applied for patents on the Flash-Carbonization™ process in many other countries. Some of these patents have been granted, and others are pending. The first license was signed in 2003. Kingsford obtained a limited license in 2007. Licenses to practice the Flash Carbonization™ process in the State of Hawai‘i and many other states are available. All
patent licensing activity is handled by the UH Office of Technology Transfer and Economic Development (OTTED).

Our experience with the Demo Reactor caused us to realize that a practical biomass carbonization technology must control emissions. In this regard we are excited to announce the successful operation of the thermal afterburner that we designed and fabricated to remediate emissions from the Flash Carbonization™ Demo Reactor. Consequently, we are now operating the Demo Reactor on a regular basis and are currently in the process of carbonizing 1000 lb of macadamia nutshells for market studies.

In an effort to greatly reduce emissions while improving the speed, efficiency, and economics of the carbonization process, we have initiated studies of the pyrolysis of biomass in pure oxygen at elevated pressure in sealed vessels. Some of our findings, which are promising, were presented at the 20th International Symposium on Analytical & Applied Pyrolysis in Birmingham, UK (19-23 May 2014). The powerpoint presentation is available.

Based on prior experience, a potential licensee of UH carbonization processes should take the following steps to develop a relationship with the UH, HNEI, and OTTED.

1. Contact Professor Michael J. Antal, Jr. and provide information on the proposed region for practice of the technology, the proposed feedstock, etc. The potential licensee should have the ambition, ability and experience to produce and market at least 10,000 tons per year of charcoal (not necessarily at a single location). Also, the potential licensee should have significant engineering expertise.

2. Test the proposed feedstock's carbonization behavior. This test may involve the lab-scale Flash-Carbonization reactor, or one of our new reactors that employ pure oxygen. The fee for this test will be determined on an individual basis, but will not be less than $2000. The charcoal will be returned to the client for evaluation. Based on our experience, we will also provide the client a rough estimate of the capital and operating costs associated with the client's business plan. HNEI does not take any license inquiry seriously until after this test has been completed.

3. Visit Professor Antal and OTTED personnel to discuss license terms. In general these terms include a license agreement with UH to practice the patented technology, a separate know-how license agreement with Prof. Antal, and a research agreement with UH that provides for training in UH facilities.