



Hawai'i Natural Energy Institute Research Highlights

Alternative Fuels

PHA Bioplastics and Hydrochar from Cellulosic Biomass

OBJECTIVE AND SIGNIFICANCE: This project aims to develop a biorefinery technology for producing biochar-like solid fuel and bioplastics from cellulosic biomass. The bioplastics have a much higher monetary value than solid fuel and hence, reduce the cost of solid fuel for power generation. The carbon-neutral solid fuel can supplement the intermittent solar and wind powers.

BACKGROUND: Cellulosic biomass from agriculture and forest management is an under-utilized renewable resource. The major components of raw biomass are cellulose (30-50% wt), hemicellulose (15-25% wt) and lignin (20-35% wt). Compared to lignite coal (~\$20/ton), raw biomass is expensive (~\$60/ton) and has a relatively low heating value (HHV 17-19 MJ/kg) because of the high atomic O/C ratio of cellulose and hemicellulose. However, cellulose and hemicellulose could be a potential feedstock for high value products, such as bioplastics.

PROJECT STATUS/RESULTS: The research investigated chemical and biological conversions of woody biomass. Under thermal catalytic hydrolysis conditions, sawdust was converted into hydrochar, a biochar like solid (Figure 1). The cellulose and hemicellulose in raw biomass were completely converted into organic acids, primarily levulinic and formic acids. Accounting for ~45% wt of raw biomass, the hydrochar has a heating value of lignite coal (HHV 25 MJ/kg), which is higher than the heating values of raw or torrefied biomass. Since the cellulose, hemicellulose, organic extractives, and minerals have been removed, the hydrochar has a lower atomic O/C ratio and is cleaner than raw biomass. The lignite-grade hydrochar performs better than raw biomass for power generation. In addition to the major organic acids, the hydrolysates solution

contained minor byproducts including furfurals and phenolic compounds that were inhibitive to microbes. The research investigated the microbial yields on individual hydrolysates and determined the inhibitive concentration levels for detoxification operation and fermentation control. After proprietary treatment, the biomass hydrolysates could be utilized by microbes to form polyhydroxyalkanoate (PHA) (Figure 1). The biopolymer content in microbial cells reached about 60% dry mass. The PHA bioplastics exhibit the material properties of conventional plastics such as polypropylene and can be completely degraded into water and carbon dioxide by microorganisms in the environment, including marine waters.

According to the experimental results, 100 lbs. of raw woody biomass (dry base) can be converted into ~48 lbs. of hydrochar (~\$0.04/lb.) and ~11 lbs. of bioplastics (~\$2/lb.). The technology can increase the value of raw biomass by more than ten folds. As a result, the hydrochar could be used as a carbon neutral solid fuel for power generation at a competitive price of lignite-grade coal.

The project has generated four technical reports, six research articles in peer-reviewed scientific journals, and three presentations in national and international conferences. Recent progress is described in the following publication:

- 2021, G. Mohan, et al., [Conversion of Pine Sawdust into Polyhydroxyalkanoate Bioplastics](#), ACS Sustainable Chemistry & Engineering, Vol. 9, Issue 25, pp. 8383-8392.

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Figure 1. Conversion of wood sawdust into hydrochar and bioplastics.