Bioresource Technology 125 (2012) 348–352

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Short Communication

Physicochemical properties of bio-oil and biochar produced by fast pyrolysis of stored single-pass corn stover and cobs

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ARTICLE INFO

Article history:
Received 14 June 2012
Received in revised form 14 September 2012
Accepted 15 September 2012
Available online 24 September 2012

Keywords:
Fast pyrolysis
Bio-oil
Biochar
Corn stover and cobs
Biomass storage

ABSTRACT

Short harvest window of corn (*Zea mays*) stover necessitates its storage before utilization; however, there is not enough work towards exploring the fast pyrolysis behavior of stored biomass. This study investigated the yields and the physicochemical properties (proximate and ultimate analyses, higher heating values and acidity) of the fast pyrolysis products obtained from single-pass stover and cobs stored either inside a metal building or anaerobically within plastic wraps. Biomass samples were pyrolyzed in a 183 cm long and 2.1 cm inner diameter free-fall fast pyrolysis reactor. Yields of bio-oil, biochar and non-condensable gases from different biomass samples were in the ranges of 45–55, 25–37 and 11–17 wt.%, respectively, with the highest bio-oil yield from the ensiled single-pass stover. Bio-oils generated from ensiled single-pass cobs and ensiled single-pass stover were, respectively, the most and the least acidic with the modified acid numbers of 95.0 and 65.2 mg g^{-1}, respectively.

1. Introduction

Corn (*Zea mays*) stover is the most abundant agricultural residue in the Midwestern United States, but for it to be the primary feedstock for cellulosic biofuels production in this region, the fact that this feedstock has a short annual harvest window (typically around 1–3 months) and, thus, requires storage for durations ranging from few days to more than an year to secure year-round continual operation of biorefineries should be realized. Additionally, corn stover has low bulk density and bulk flowability; thus, it would be advantageous to convert this feedstock to the liquid form before transportation, and one of the techniques to do so, which is also the subject of this study, is fast pyrolysis. Fast pyrolysis is the rapid thermal decomposition of organic compounds in the absence of oxygen and at moderate temperatures (400–600 °C) to produce liquids (bio-oil), solids (biochar) and non-condensable gases. Residence times for fast pyrolysis of biomass is shorter (0.5–2 s) which is followed by rapid cooling and condensation of the formed pyrolysis vapors (Bridgwater et al., 1999; Brown, 2003; Venderbosch and Prins, 2011). Detailed discussions on the fundamentals and the state-of-the-art of fast pyrolysis, pyrolysis reactor types, properties of pyrolysis products and their potential end-uses are explained elsewhere (Bridgwater, 2012; Laird et al., 2009; Mohan et al., 2006; Oasmaa and Czernik, 1999). Additionally, several researchers have investigated the characteristics and physicochemical properties of the fast pyrolysis products of different biomass types.

This study focuses on the fast pyrolysis of stored corn stover and cobs with the vision that pyrolyzing stover early in the supply chain would be advantageous in that each pyrolysis product can be separately delivered to their potential end-use sites. For instance, bio-oil can be transported to biorefineries for further processing and upgrading whereas biochar can be transported to the fields for their potential soil-application and carbon sequestration. It can be argued that corn stover can be pyrolyzed before storage; however, the issues like phase separation and aging of bio-oil during storage (Bridgwater et al., 1999; Mohan et al., 2006; Oasmaa and Czernik, 1999; Yu et al., 2007) as well as the need of higher throughput pyrolyzer to pyrolyze all biomass upon receipt at the storage site, thus, increasing the unit conversion price due to the increased capital and operating cost of the pyrolyzer would make it advantageous to store the biomass first, followed by pyrolyzing before transportation of different pyrolysis products to their respective end-use locations. Additionally, this opens option for pipeline transportation of the bio-oil to the biorefineries.

As per authors best knowledge, only Agblevor et al. (1995) have investigated the properties of the pyrolysis products from stored biomass feedstocks. They pyrolyzed fresh, and 26 and 52 weeks outside stored corn stover feedstock and found the increase in

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http://dx.doi.org/10.1016/j.biortech.2012.09.061