SO2-catalyzed steam pretreatment enhances the strength and stability of softwood pellets

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HIGHLIGHTS

► The grinding step can be replaced by a SO2-catalyzed steam treatment for pelleting.
► The treated pellets were denser and twice stronger than the untreated ones.
► The energy input decreased for production of SO2-catalyzed steam treated pellets.
► Having higher water affinity, treated pellets did not disintegrate at high humidity.

ABSTRACT

Densification can partially resolve the logistical challenges encountered when large volumes of biomass are required for biocconversion processes to benefit from economies-of-scale. Despite the higher bulk density of pellets, their lower mechanical strength and sensitivity to moisture are still recurring issues hindering long-term transportation and storage. In this study, we have evaluated the potential benefits of SO2-catalyzed steam treatment to achieve both the needed size reduction prior to pelletization while improving the stability of the produced pellets. This pretreatment substantially reduced the particle size of the woodchips eliminating any further grinding. The treated pellets had a higher density and exhibited a two-time higher mechanical strength compared to untreated pellets. Despite a higher moisture adsorption capacity, treated pellets remained intact even under highly humid conditions. The high heating values, low ash content and good overall carbohydrate recovery of treated pellets indicated their potential suitability for both biochemical and thermochemical applications.

1. Introduction

Escalating greenhouse gas emissions and concerns over climate change due to an extensive use of fossil fuels have motivated industrialized economies to seek clean energy solutions for their sustainable development. In this context, lignocellulosic-based biofuels are currently being developed as a sustainable alternative to the use of fossil fuels for transport (Solomon and Johnson, 2009). One of the challenges with any future biomass-to-fuels/chemicals process will be achieving access to the substantial amounts of biomass that will be required to benefit from the economics of scale that are inherent in the traditional oil based refinery process.

Raw cellulosic feedstocks are typically bulky (75–200 kg/m³) and have a high moisture content (~50%) (Mani et al., 2006). These two undesirable characteristics alone make raw biomass costly and difficult to be stored, transported and fed into a reactor. Earlier work (Mani et al., 2006) has shown that one way to improve the economics of transporting biomass over long distances is to pelletize the material. Their higher bulk density (600–800 kg/m³), lower moisture content (5–8%) and ease of handling should make wood pellets an attractive commodity for the biofuel/bioenergy processes. Due to these benefits, wood pellet production and export have experienced a rapid growth, as demonstrated by the ever increasing global production and trade in wood pellets (Bradley et al., 2011). In 2010, 37 Canadian pellet plants operated at about 65% of their capacity, producing about 1.3 million metric tons (t) per year. Pellet production increased in 2011 when almost 1.9 million t of pellets were produced and exported to Europe, USA