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Thermogravimetric and online gas analysis on various biomass fuels

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Abstract

In this work, the biomass property is evaluated based on pyrolysis behavior of biomass fuels by means of TGA and online gas analysis. Wood, sawdust, pine bark, peat, straw, black liquor and microalgae are chosen as the biomass feedstocks for the pyrolysis study. The measurement results show high volatile content for algae and black liquor (around 85%) and low volatile content for pine bark and peat (around 69%). Differently from woody biomass, the DTG curve of straw has a single dominant peak at much lower temperature, which suggests a dominant component of hemicellulose in biomass, while algae and peat have a broader temperature specturm of devolatilization but much lower peak temperature. CO2 is released first and H2 later in the pyrolysis process for all biomass feedstocks, whileas the peak of CO formation follows CO2 formation trend for most feedstocks used, except for peat and pine bark which give a peak later at high temperature. This indicates secondary reactions of tar cracking, steam reforming and char gasification.

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Keywords: TGA; pyrolysis; biomass feedstock; fuel lexibility

1. Introduction

Fuel availability and flexibility are important issues for biomass-based heat and power generation, and advanced biofuel production plants. The physical and chemical properties of biomass fuels may vary greatly from one to others, which must be taken into account for the reactor design and operation, system optimization and blend feedstock application. The basic fuel characterization approaches for a solid fuel are proximate and ultimate analyses, by which different standard methods are used to evaluate the fuel

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quality. The proximate analysis includes the measurement of moisture, ash and combustible (volatile and fixed carbon) contents. The ultimate or elementary analysis refers to the determination of the content of the most important elements of a solid fuel, such as C, H, O, N and S. Since biomass solid fuels normally have much higher volatile content than coals, the behavior of biomass fuels during thermochemical conversion is characterized by the devolatilization process. The devolatilization rate and kinetic data in chemical reaction expression is commonly determined by thermogravimetric analysis (TGA). Further detail analysis of different components of volatile gas released from biomass pyrolysis at certain temperature can be made online, which may provide valuable clues and insight into the complex reaction scheme [1, 2, 3].

In this work, the devolatilization behavior and the chemical composition of gases released during the devolatilization of various biomass fuels are simultaneously studied by means of a thermogravimetric analysis machine and an online gas analyzer. Wood, pine bark, peat, straw, black liquor and microalgae (scenedesmus quadricauda) are chosen as feedstocks for the study.

2. Experimental

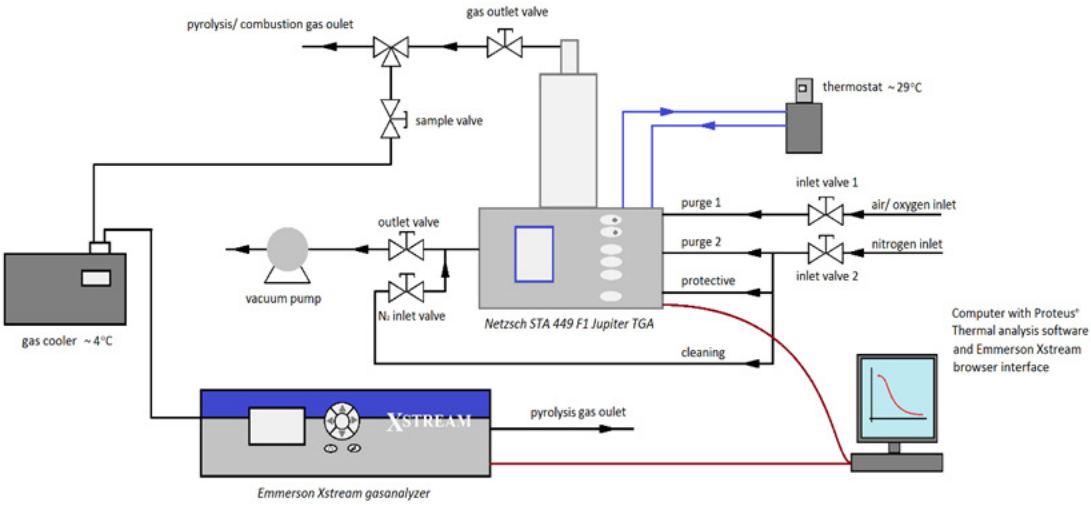

Figure 1 Experimental setup for TGA+online gas analyzer

Fig. 1 presents the experimental setup with the purge gas number 2 (Nitrogen inlet) active for this study. As shown in the figure, the heart of the setup is a Netzsch STA 449 F1 Jupiter® thermogravimetric analyser, where the devolatilization experiment was carried out. The chemical composition (CO, CO_2, H_2, CH_4 and O_2) of the gas released during devolatilization was monitored and acquired by means of an online *X-STREAM Enhanced XEGP – General Purpose Gas Analyzer* as well as an offline parallel TCD FID gas chromatography detection system.

The biomass feedstocks including wood, sawdust, pine bark, peat, black liquor, straw and microalgae (*scenedesmus quadricauda*) were provided by SCA Ortviken, SCA Östrand, SCA Bionorr, HEMAB, Laga Bioenergy AB and Algkraft. The biomass samples was placed inside the TGA furnace made of silicate material. N_2 gas was used to purge the system to guarantee oxygen free condition before and during the pyrolysis experiment. First, the sample was heated to 110^{o}C and kept for 10 minutes to ensure that all moisture has left the sample. Afterwards the temperature is increased again to 950 ^{0}C at a speed of