

Impact of torrefaction processes on Brazilian biomasses storage

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Context and objectives

Brazilian energy production differs from other countries since 44.0 % of the energetic matrix comes from renewable sources, 2.8 % higher than that obtained in 2016 (MMA, 2017). To avoid the use of non-renewable fuels limiting the environmental impact, the energy production from renewable sources would make it possible to use the residual biomass from the forest-based industry. However, biomass has some characteristics that hinder its direct use as fuel, such as high moisture content, low calorific value and low fixed carbon content, in addition to low density, especially when using residual biomass. In view of this, it is necessary to seek the most efficient use of this heterogeneous fuel in order to standardize and increase the biomass quality. In addition, the storage of these biomasses before, their energetic conversion, can cause several damages to the material properties.

Ligno-cellulosic biomasses, stored in humid environments for long periods, will absorb moisture and decompose, bringing about changes in physical properties, chemical composition and energy value. These changes reduce their potential to be processing and consequently decrease their market value. The higher moisture content (45-60%) of raw biomass has significant negative impact on the bioenergy production and its consumption chain and remains as one of the major obstacles for thermochemical conversion. A wet biomass, when stored could lose some solid mass due to the microbial decaying process.

This limitation can be reduced to some extent by pretreatment. Pretreatment alters the biomass chemicals and physical properties making it suitable for use in the existing energy conversion systems. Biomass pretreatment methods are classified into five categories: a) Chemical, b) Mechanical, c) thermal, (d) Hydrothermal (wet), and (e) Biological. The thermal pretreatment is a slow heating process in which biomass releases its volatiles. It is an emerging pretreatment method that has an ability to reduce the major limitations of biomass such as heterogeneity, lower bulk density, lower energy density, hygroscopic behavior, and fibrous nature. The utilization of torrefied biomass in existing handling and storage facilities and associated issues has been reported recently (Hermes, 2011; Zwart *et al.*, 2012; Kiel, 2014)

There is a great deal of interest in understanding the physical and chemical changes during storage of different biomass forms used for energy applications. The main purpose of this PhD work is to study the links between physical (calorific powers, elemental composition), biological (durability) and mechanical (friability) properties of torrefied biomasses and their

storage conditions according to the conditions of torrefaction processes compared to the raw biomass properties. On another hand, a basic environmental study will be addressed to open lines of thought about possible futures studies.

Materials and Methods

Biomass samples

The experiment used four types of biomass residues, being of national and international relevance: eucalyptus residues, pine residues, sugarcane bagasse and coffee bark. These biomasses were first dried outdoors in a drying yard until they reached hygroscopic equilibrium moisture. Afterwards, milling was done in a hammer mill and classification in 2 mm aperture sieves, to suit the desired granulometry for the heat treatment and storage.

Torrefaction process

Approximately 3 kg of dried (at 103 °C) particles were used for each heat treatment. The eucalyptus, pine sugarcane bagasse and the coffee husk biomasses were transformed into particles in a knife mill and classified in screen sieves with 2 mm openings.

The biomasses were torrefied using three reactor times for each biomass, including Eucalyptus (10, 15, 20 minutes), Pine (10, 15, 20 minutes), sugarcane bagasse (5, 7, 10 minutes) and coffee bark (5, 10, 15 minutes). The temperature of the reactor was set at 290 °C for all treatment. An endless screw type reactor, developed in the Laboratory of Panels and Energy of Wood (LAPEM - UFV - Brazil) was used (Fig. 1).

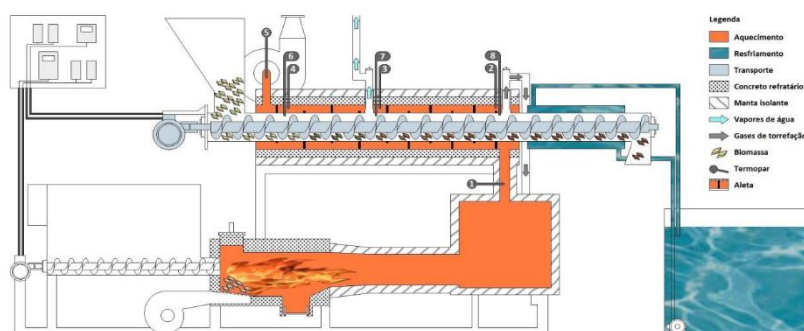


Fig. 1 : Layout in side view of the reactor for biomass torrefaction in semi-continuous flow (Magalhães, 2016).

Fungal decay exposure

All samples (native and heat treated) were firstly submitted to leaching process according to the NFX 41-569 (2014) standard (Fig. 2). Then, native and treated biomasses were place into plastic grid bags in order to expose themselves to wood destroying fungi. Before starting the fungus degradation experiment, the bags were oven dried 103 °C for 24 h and the dry mass (m_1) was determined for further determination of the mass loss in the experiment.

Decay resistance of native and torrefied biomasses was tested according to an adaptation of XP CEN/TS 15083-1 (2006) standard criteria, on both fungi species required by the standard: *Coriolus versicolor* (white rot) and *Coniophora puteana* (brown rot) (Fig. 3). The following fungal exposure duration were tested: 2, 4, 8, 12 and 16 weeks. After the decay exposure,

mycelia were removed and each sample was dried at 103 °C for 24 h and the final dried mass was determined (m_2). The Weight Loss was determined according to the formula: $WL (\%) = (m_1 - m_2) / m_1$.



Fig. 2 : Leaching process according to NFX 41-569 (2014) standard criteria.



Fig. 3 : Samples in contact with fungal decay.

Sample characterization

The impact of leaching and fungal degradation, according to the duration of fungal exposure will be evaluated on the following native and treated biomass properties: the High Heating Values (according to the BS EN ISO 18125 standard); the elemental composition (according to the NF EN ISO 16948) and the chemical composition (NIRS analysis).

First Results

Torrefaction process intensity (depending on the duration) undergoes mass loss to the lignocellulosic material. Figure 4 shows that wood species and their respective chemical compositions are directly correlated to thermal degradation reaction kinetic. The torrefaction duration has also an impact on treatment intensity as well as on mass loss kinetic. Whatever the sort of biomass, the higher the intensity of treatment is, the higher the carbon content and the more energetic properties of the material are significant.

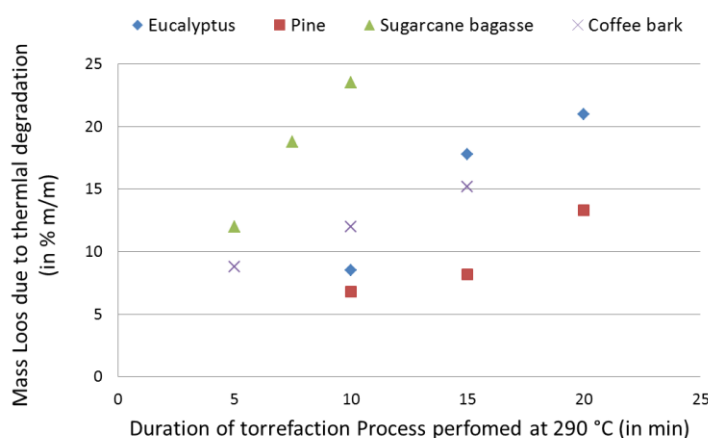


Fig. 4: Mass Loss due to the biomass thermal degradation according to the torrefaction duration.

The evolution of the raw and treated biomass energetically properties, after leaching and various fungal exposure durations are in course.

Conclusion and Perspectives

All results will be analyses in order to find indicators to predict torrefied sample degradation according to the torrefaction process and storage conditions in order to optimize the storage duration without lose torrefied biomass quality.

In parallel to the laboratory decay exposure test, field durability tests will be carried out on all samples, in France and Brazil. These outdoor exposed raw and treated biomasses will be regularly (every month, during one year) characterized in the same ways (HHV, Elemental and chemical compositions).

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