FUEL DRYING METHODS COMPARISON AND THEIR EFFECT ON IGNITION AND COMBUSTION PROPERTIES OF *PINUS HALEPENSIS*

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ABSTRACT

Fuel moisture content is known as the most important parameter influencing fire behaviour. Organic gas emission during the exposition of the fuel to a heat flux source depends to its moisture content [1]. Three decades ago, Trabaud found experimentally a maximum moisture content above which the fuel cannot ignite [2]. This led fire managers and operational to discuss the existence of a critical moisture for ignition. However, all the experiments were realized on dead fuels, whereas most of wildland fires (such as crown fires) concern live fuels. Fuel flammability depends strongly on its live or dead nature as well as on its age [3].

Recently, Terrah et al. [4] studied the ignition dependence on the moisture content for live fuels. The fuels were harvested, partially dried and ignited within the same day. They found no critical moisture for ignition. The partial drying process was realized by using two different devices: a microwave household and a radiation desiccator. Assuming that the total drying process occurs during a maximum time t_{max}, where the completely dried mass is m_s, a drying time $t < t_{max}$ yields a mass $m(t)$. The corresponding moisture content is defined on the wet basis as:

$$h(t) = \frac{m(t)-m_s}{m(t)} \qquad (1)$$

Terrah et al. [4] found much larger ignition time fluctuations for the desiccator that the microwave device. This is due to the time of the drying process which is much larger. Obviously the Organic Volatile Components (VOC) emission is much smaller for the microwave drying process, where the holding time is much smaller.

The aim of this communication is to study the effect of the fuel moisture content on the flammability and combustibility of *pinus halepensis* needles. The experimental tests were performed during September 2018 on mature pine needles, which were collected each morning between 8 and 8:30 am from the same tree located next to the location of the drying and ignition tests, i.e. the laboratory LEPM of "Université des Sciences et de la Technologie d'Oran" in Algeria.

Pine needles were subjected to two different drying processes using two devices: a radiative SAMSUNG M181 DN domestic microwave (at 800W) and a convective climatic chamber - Weiss 100 (at a temperature of 60°C with a relative humidity of 0%). The results of these two methods are compared. After the partial drying process, the samples were subjected to a ignition tests, using a cone calorimeter which provides a radiation incident heat flux of 17kW/m². The time to ignition, the residence time and the total time of combustion were recorded.

We noticed a loss of VOC during the drying process for both methods. This loss is one of the causes of the observed fluctuations of ignition and residence times. However, as the drying process is much shorter for the microwave, the loss is significantly reduced for this device. Due to the fact that each method involve a specific drying process, the mass loss behavior with time exposure is different for each process. For the microwave oven, the received heat flux P remains constant through time, and the temperature increases as:

$$P = m\, c_p\, \frac{dT}{dt} \tag{2}$$

Here, c_p is the specific heat. If c_p is constant, the temperature increases linearly with time, and the mass lost by the evaporation of water increases linearly with time. Concerning the climatic chamber, the temperature is constant and the heat flux is used for evaporating water. The decrease is exponential and its rate follows an Arrhenius law with temperature [5].

Figure 1 illustrates the variation of moisture content h(t) during the drying time of the fine fuel elements in the microwave device. The moisture content of the pine needles decreases linearly with the drying time. From (2), the loss is proportional to the exposition times, the microwave heat flux being constant. The best linear fit is obtained when the exposure time is less or equal than 60s yielding a rate of drying of 0.75%/s. Above this time, the fluctuations correspond to the re-hydration when the sample is outside the device. Besides, for climatic chamber, the samples were dryed at a constant temperature (T=60°C). However, it increases with exposure time for the microwave drying. As the loss of mass has an arrenhius dependence on temperature, the constant drying temperature yields an exponential decrease of the mass and then the moisture content.

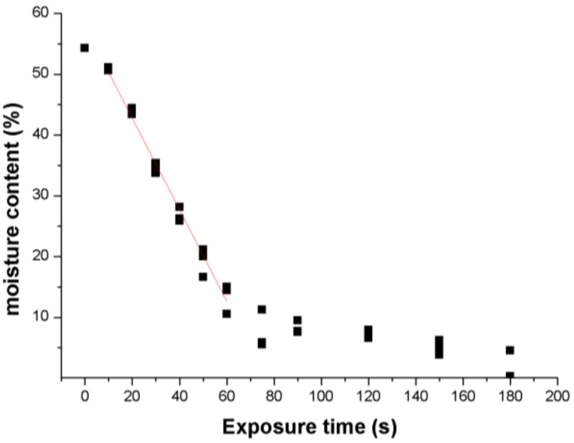

Figure 1: Time of partial drying dependence on moisture content for a microwave device.

The dependence of ignition time on the moisture content is found to follow an exponential increase for both drying processes , confirming the existence of a characteristic moisture for ignition of 18.87% for the used samples of moisture (the moisture of the fresh samples is h=54%). Larger fluctuations are observed for the climatic chamber.

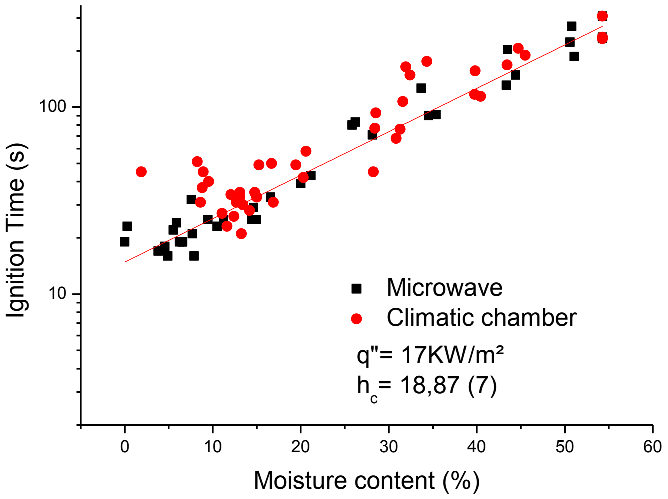

Figure 2 Ignition time vs Moisture content with microwave and climatic chamber.

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