Influence of the heating rate on energy consumption of the biomass torrefaction process

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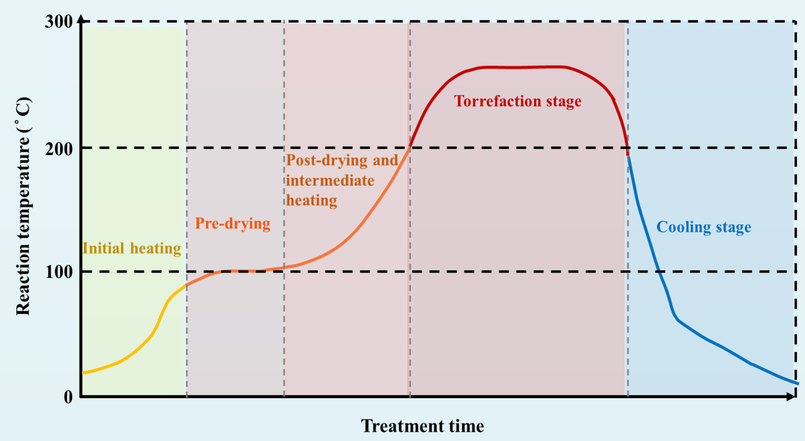
INTRODUCTION

Wood constitutes a renewable and sustainable material usable in construction and energy production. Torrefaction (200-300°C in oxygen free atmosphere) is a thermo- modification process to upgrade wood properties.

Many torrefaction technologies have been developed since the 1980's, but processes are still lead in an empirical manner. A significant lack of knowledge persists in the initial stages, where temperature is raised from the ambient to the treatment one. Low heating rates (0.2 to 1 °C min^{-1}) are practiced to produce fungi resistant construction material and induce longer immobilization time of the production unit. High heating rate (20 to several hundred °C min-1) applied to pretreat biomass for energy production, require powerful heaters. In order to elaborate an optimal business plan, companies need to evaluate the compromise between investment and process duration.

Stages in the heating of most biomass.



Keywords: Biomass; degradation pathway; energy consumption; heating rate; kinetics; torrefaction; sustainable material.

AIMS

The purpose of this study is to investigate the influence of the heating rate on the biomass thermo-degradation pathway and the final properties of the material. the investigation of the total energy consumption of the torrefaction process could be an important key for industrial process control.

Poplar

EXPERIMENTAL PROGRESS

Sampling and drying

- Wood species: Poplar
- Particle of 0.5-1 mm.
- Drying temperature: 105°C

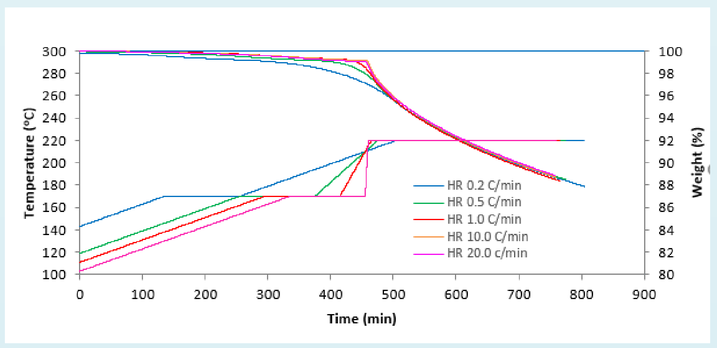
Heat treatment of wood

- TGA Mettler Toledo, under N_2
- Treatment temperature: 220°C
- Heating rate : 0.2 to 20°C min^{-1}
- Isothermal plate: 300 min

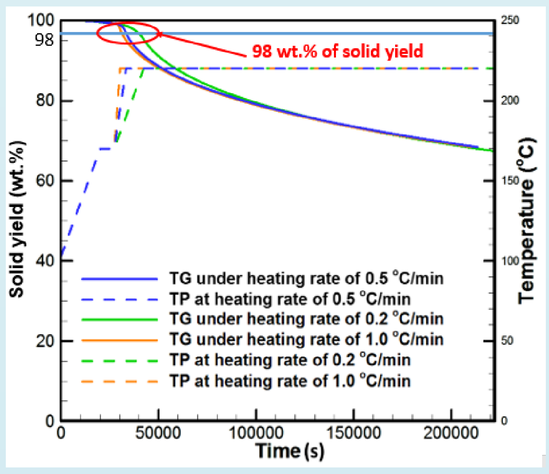
TG and DTG analysis

- Samples treated to 98wt% of solid yield
- Temperature: 100-800 °C
- Heating rate: 20 °C min^{-1}
- Condition: Nitrogen

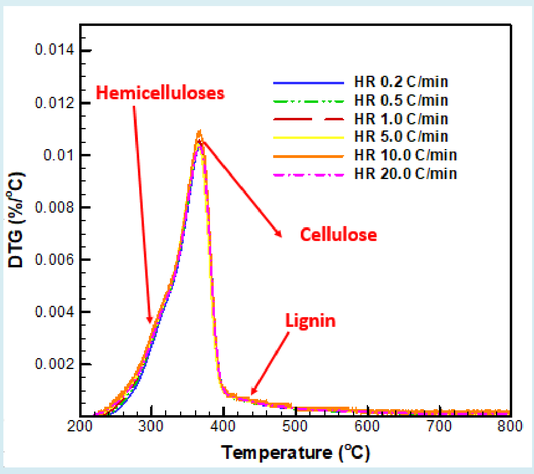
TGA and DTG OF HEAT TREATED WOOD



Dynamic weight and temperature profiles for 6 different heating rates (0.2; 0.5; 1.0; 5.0; 10.0 and 20.0 °C min^{-1}) followed by 5 hours isothermal plate



Strategy of investigation.



Derivative thermodegradation analysis.

DISCUSSION

Chemical aspect: The DTG curves derived from pyrolysis of heat-treated products (2 % Mass Loss) overlap. It is indicating that the heating rate has no effect on the thermal degradation of the poplar when they achieve the same weight loss.

Energy aspect: Among cases with 2 % Mass Loss, using heating rate of 0.2 °Cmin-1 is much energy-saving or cost-saving, since it can reach the 2 %Mass Loss at lower temperature. This may be due to the low heating rate having enough time to transfer heat homogeneously, and thus enhancing the thermal degradation.

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