Influence of natural potassium content on the thermal treatment of woody biomass

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Introduction

One of the main issues for the industrial use of woody biomass is the lack of property consistency of the feedstock. Torrefaction can enhance biomass properties, but key mechanism steps aren't fully understood. Potassium naturally present in ligno-cellulosic biomass can catalyze its thermal degradation. The elucidation of the role of potassium during biomass thermal degradation enables the design of ideal heat treatment conditions for different biomass based on their natural potassium content. Tailored thermal treatment allows the strategic use of locally abundant, low cost biomass, adding value to natural resources for potential applications in energy, construction, and outdoor furniture.

Methods and Materials

Thermogravimetric analysis were performed on two hardwood species (oak, Quercus petraea and beech, Fagus sylvatica) in N_2 and air atmospheres. The natural potassium content of all species had been previously determined. The thermodegradation behavior of all samples were analyzed by a thermogravimetric analyzer (TGA 2 (LF), Mettler Toledo). Prior to the experiments, the powdered woody samples were dried at 103 °C until mass stabilization. The samples were heated from 50 °C to 800 °C with a heating rate of 20 °C min^{-1}. The reaction gas flow was fixed at 100 mL min^{-1}.

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Results

It has been observed that potassium catalyzes the thermal-oxidation of cellulose above 300˚C. A decrease in the cellulose degradation temperature can be seen for oak samples with increasing potassium concentrations treated under air (Fig 1).

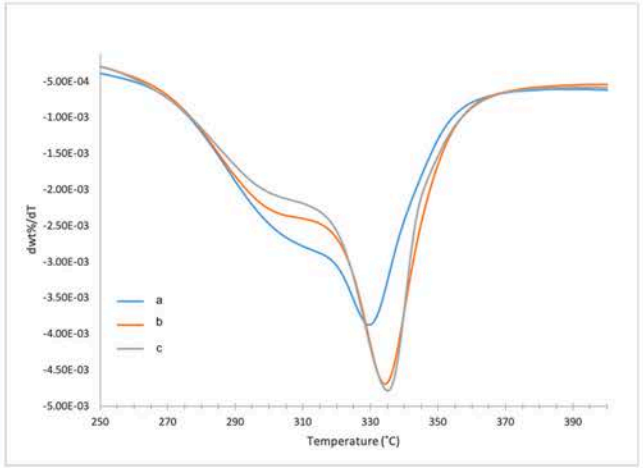

Fig 1. DTG curves of oak samples heated from 50 ˚C to 800 ˚C at 20 ˚C/min under air. The concentration of natural potassium in the samples is (a) [K] = 0.1657%, (b) [K] = 0.1039%, and (c) [K] = 0.0707%.

An equivalent correlation was also established using beech under the same conditions, but was impossible to be established when the treatment was conducted under inert atmosphere.

It was shown that treatment time decreases with increases in potassium concentration during the isothermal torrefaction of beech at 300 ˚C, under inert atmosphere (Fig 2).

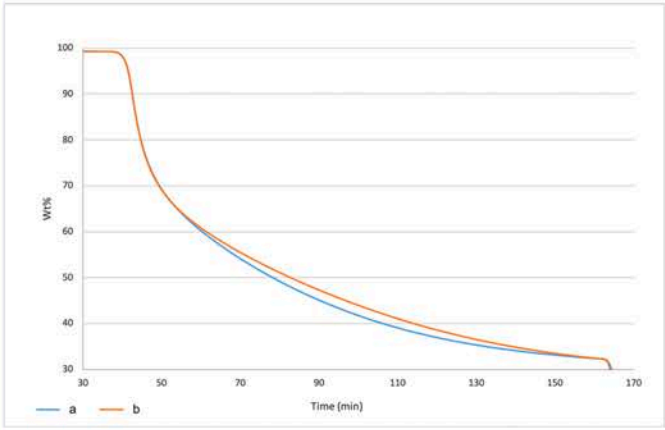

Fig 2. TGA curves of beech samples treated at 300 ˚C under N_2. The potassium concentration in the samples is (a) [K] = 0.2047% and (b) [K] = 0.1274%.

Conclusions

The results presented herein allow for better control of torrefaction duration, quality and homogeneity of thermally treated biomass. Such control is achieved by:

- taking into account the natural potassium content of the biomass when determining treatment time;
- developing a selection method for the wood species with a high and consistent potassium content to decrease treatment time.

Future Work

Further investigations include a detailed analysis of a broader selection of wood samples impregnated with specific amounts of potassium to complement and validate the data generated so far. Additionally, the contribution of other metals will be considered and evaluated.