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Note

Thermal decomposition of a Moroccan wood under a nitrogen atmosphere

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Abstract

Weight losses in the thermal decomposition of a Moroccan wood have been studied by means of dynamic and isothermal experiments, carried out under a nitrogen atmosphere. At low heating rates, weight loss measurements on pyrolysis samples of *Acacia mearncii* wood indicate that decomposition occurs in discrete stages of hemicellulose evolution, cellulose decomposition and lignine degradation.

Keywords: Acacia; Pyrolysis; Wood

1. Introduction

Large parts of Morocco are covered by forests, which are worked to make charcoal, and to produce heat, paper and wood. For all these reasons, we are trying to valorize the wood and, more specifically, we are interested in its thermal decomposition. The literature does not contain any data on the pyrolysis of Moroccan *Acacia mearncii* wood, in spite of the efforts made all over the world to develop processes on the valorization of the biomass by its thermal decomposition under different atmospheres such as nitrogen [1–4], oxygen [5, 6], steam [7] and in vacuum [8].

A major concern today is the rate at which global deforestation is occurring. It is therefore almost paradoxical that at the same time as forests are receding there should

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be a growing interest worldwide in obtaining fuels and chemicals from wood. One wood-derived product of particular interest is charcoal, which is used as a fuel both domestically and industrially. Domestically, charcoal is preferred to wood as fuel because it is clean burning and has a higher energy density; demand for charcoal is consequently increasing, particularly in urban areas in developing countries [9].

The pyrolysis of wood, and other lignocellulosic materials is extremely complex. It is the result of hundreds of concurrent and consecutive reactions which vary according to pyrolysis conditions [10]. Each component in a lignocellulosic material behaves differently during thermal treatment [1, 11]. The rate of weight loss of wood by thermal decomposition is strongly influenced by the experimental conditions such as heating rate, flow gas [12], and the physical and chemical characteristics of the material in question.

The aim of the study is to attempt to predict the overall behaviour of each component (hemicellulose, cellulose and lignine).

2. Experimental

Thermogravimetric measurements were performed using a MacBain and Baker thermobalance made in this laboratory by Professor L. Belkbir. The principal components of the balance (Fig. 1) are a spring and a reaction tube of quartz inside of which is the sample holder which is suspended from the bottom of the spring. The change in sample weight causes stretching and contraction of the spring. These variations in spring length are followed by a micrometric telescope. The experiment temperature is provided by a tubular furnace. The thermocouple head is located in the reaction tube to reduce the temperature gap between the sample and the tube [13]. This affects greatly the isothermal and non-isothermal kinetics results of the decomposition of the biomass.

Two different types of experiments have been carried out: dynamic experiments, carried out with different heating rates (5, 15 and 30°C min^{-1}) which were kept constant throughout each dynamic experiment; and isothermal experiments in which the weight loss was studied stage by stage at the desired temperature between 200 and 350°C.

3. Dynamic experiments

The reactivity of *Acacia mearncii* to volatile matter via physico-chemical transformations, was studied by thermogravimetric analysis under an inert atmosphere.

The results of the carbonization process indicate that the pyrolysis takes place in several stages related to the chemical composition.

The weight loss measurements can best be understood by considering the rate of transformation ($d\alpha/dt$) curves (Fig. 2), where $\alpha = (w_o - w_t)/(w_o - w_f)$, and w_o, w_t and w_f

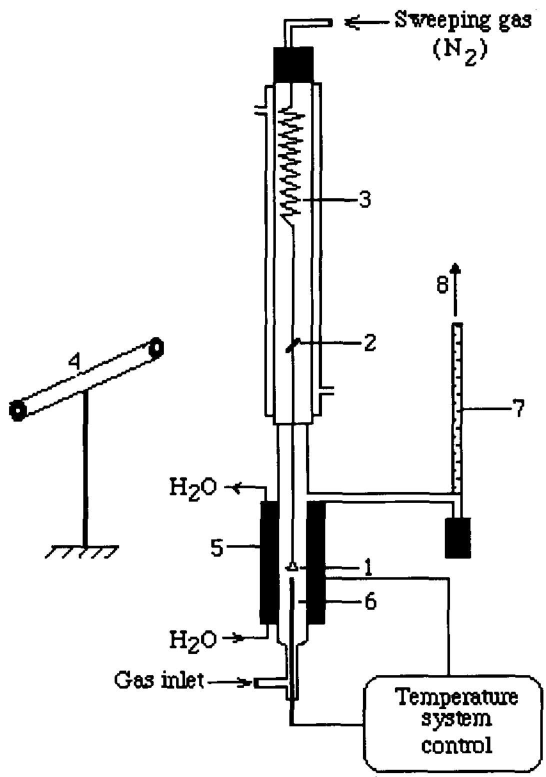

Fig. 1. Thermogravimetric apparatus: 1, skiff; 2, stamper; 3, spring; 4, field glass; 5, oven; 6, thermocouple; 7, flowmeter; 8, gas outlet.

are respectively the initial weight of solid (dry basis), weight of solid after time t, and final weight of solid at the end of the pyrolysis process.

The rate of transformation curves shows three zones. Analysis of the results in the light of information provided by Bilbao and coworkers [1, 11] and Connor [14], led to the conclusion that the first stage in the rate of transformation curve corresponded to the evolution of hemicellulose. The second zone was concluded to correspond to decomposition of the cellulose while the third zone was concluded to represent degradation of lignine and secondary reactions.

Table 1 shows the temperature regions related to the decomposition of each component of *Acacia mearncii* at different heating rates.

The results from Table 1 indicate that the decomposition temperature regions of each component vary with heating rate. The regions overlap when the heating rate is relatively high. Therefore, it was important to use a low heating rate so as to distinguish separately the evolution of each component in the same thermal decomposition.

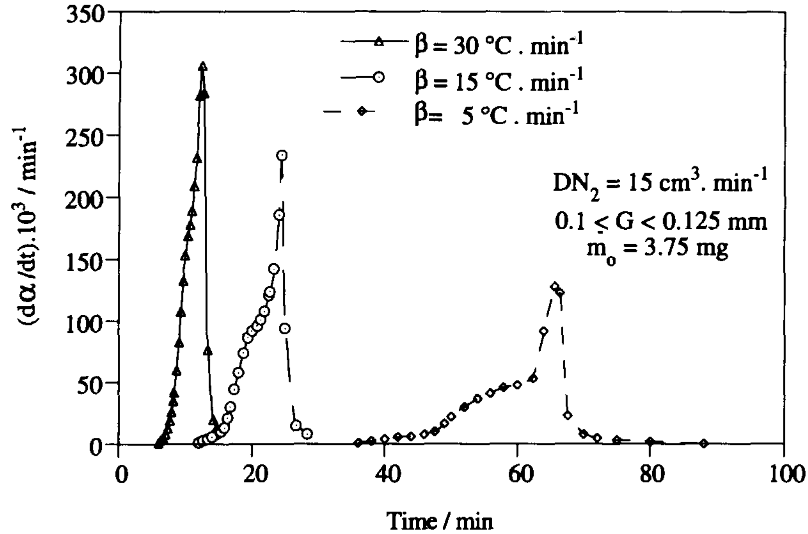

Fig. 2. Transformation rate $d\alpha/dt = f(t)$ of pyrolysis of organic matter.

Table 1
Effects of heating rate on temperature regions for the decomposition of each component

Components decomposition regions in °C	Heating rate in °C min^{-1}		
	30	15	5
Hemicellulose	180–240	180–240	170–240
Cellulose	230–310	240–310	240–310
Lignine	300–400	310–400	320–400

4. Isothermal experiments

In order to understand the dynamic thermogravimetric studies, it was necessary to be familiar with the thermal behaviour of each component of *Acacia mearncii*. We decided to apply isothermal thermogravimetry in several stages. The procedure allows the sample to pyrolyse at the desired temperature until the rate of conversion is very low; the temperature is then raised to a new isothermal plateau. A typical multistage isothermal thermogram is shown in Fig. 3, the thermogram presents three zones of weight loss: the first is related to hemicellulose decomposition; the second shows decomposition of cellulose; and the last zone corresponds to the evolution of lignine and secondary reactions [9].

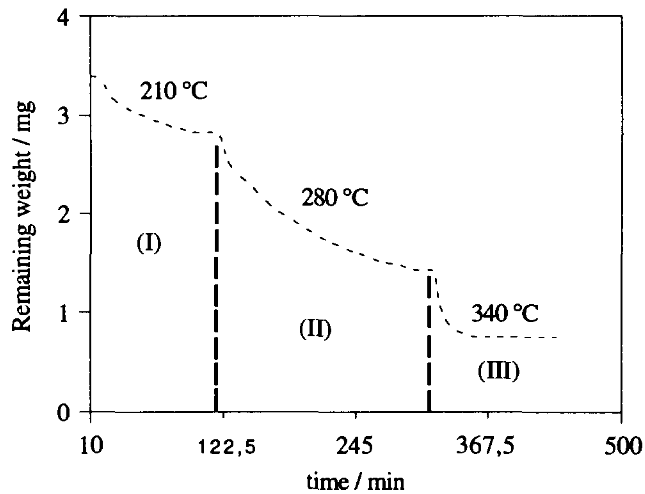

Fig. 3. Weight loss of *Acacia mearncii*.

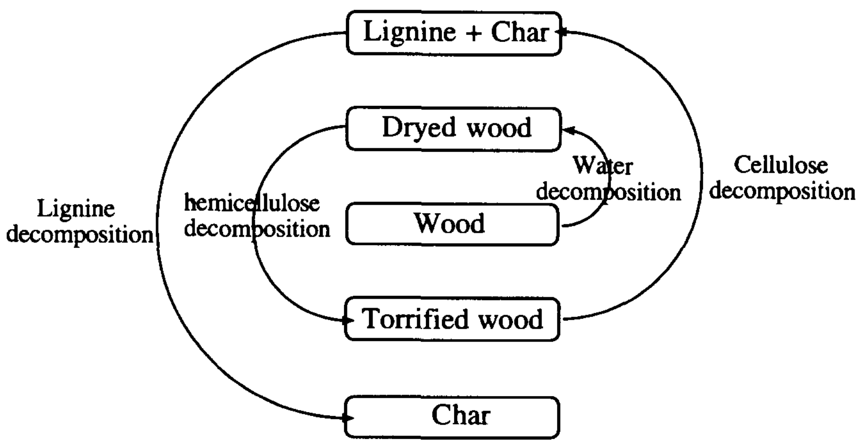

Fig. 4. The thermal decomposition of *Acacia mearncii*.

5. Conclusions

The general conclusions regarding the thermal degradation of *Acacia mearncii* wood are summarized in Fig. 4.

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