

# Cellulose pyrolysis investigation by thermogravimetry coupled with FTIR spectrometry

## Introduction

Cellulose is a polysaccharide (Figure 1) consisting of a linear chain of several hundred to over ten thousand  $\beta(1\rightarrow4)$  linked D-glucose units. Cellulose, located in the cytoplasmic membrane of plant cells, is the principal component and therefore the most abundant matter in the nature.

According to the Broido-Shafizadeh model [1] (Figure 2), during cellulose pyrolysis, there is a formation of an activated cellulose with a lower polymerization degree. The thermal degradation of this activated cellulose produce in one hand, volatiles and in other hand, char and gases. Proportions of each pyrolysis product depend of experimental conditions (heating rate, sample mass, gas flow...)

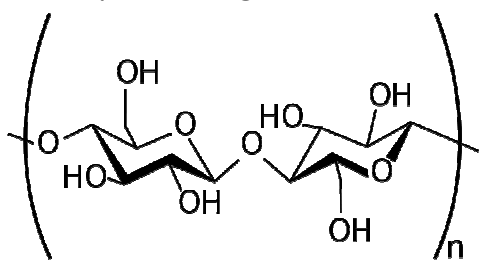


Figure 1 – Cellulose  
(source : kachelinfo.net)

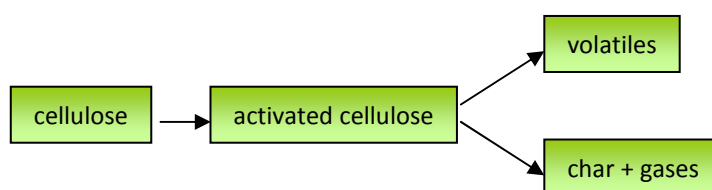


Figure 2 – Broido-Shafizadeh model [1]

## Experiment

About 200mg of cellulose were introduced in a platinum container and heated from 25°C to 700°C at 10°C/min under a helium gas flow (60mL/min). The gases released in the TGA were immediately directed towards the FTIR spectrometer. The transfer line was heated to an internal temperature of 200°C. Each IR spectrum was obtained with a resolution of 4 cm<sup>-1</sup> and the IR scanning range was from 4000 to 400 cm<sup>-1</sup>.

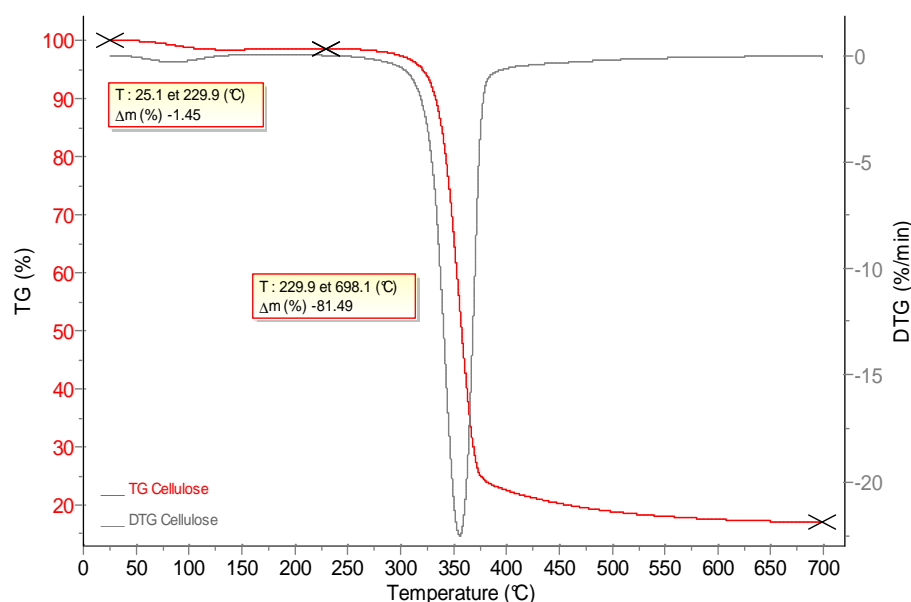


Figure 3 – Weight loss curve (%) vs. temperature of cellulose.

Setsys Evolution TGA  
(ambient to 1600°C)



www.setaram.com  
sales@setaram.com



## Results and conclusion of thermogravimetric analysis

Between 25.1°C and 230°C (Figure 3) moisture contain in cellulose is eliminated, it represent 1.45% of the initial mass. Cellulose pyrolysis is mainly carried out between 230°C and 400°C with the maximum weight loss rate of 22.57%/min attained at 356°C. This weight loss correspond to the cellulose depolymerization. When temperature is higher than 500°C, almost all cellulose is pyrolyzed with a low solid residue (19%).

## Results of evolved gases analysis by Fourier Transform InfraRed spectroscopy (FTIR).

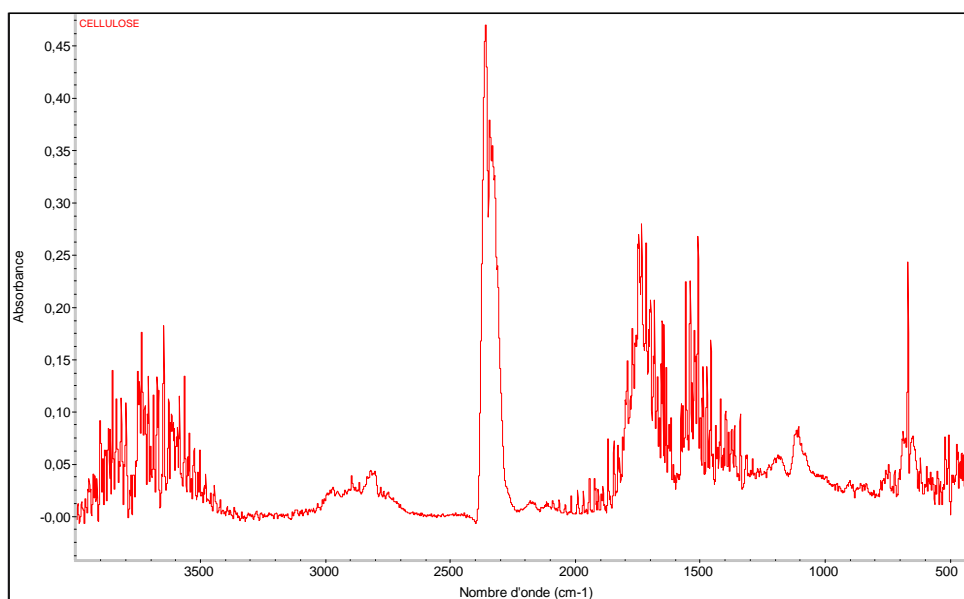


Figure 4 – FTIR spectra of gases product from cellulose pyrolysis at 364°C

| Wavenb (cm <sup>-1</sup> ) | Assignement (Bond) | Vibration        | Compound         | T <sub>max</sub> (°C) |
|----------------------------|--------------------|------------------|------------------|-----------------------|
| 2143-2223                  | C-O                | Stretching       | CO               | 364                   |
| 2020-2138                  | C-O                | Stretching       |                  |                       |
| 2237-2397                  | C=O                | Stretching       | CO <sub>2</sub>  | 360                   |
| 671                        | C=O                | Bending          |                  |                       |
| 3425-3991                  | O-H                | Stretching       | H <sub>2</sub> O | 364                   |
| 1282-2010                  | O-H                | In-plane rocking |                  |                       |
| 1712                       | C=O                | Stretching       | Furfural         | 350                   |
| 754                        | C-H                | Bending          |                  |                       |
| 1651-1834                  | C=O                | Stretching       | Formaldehyde     | 360                   |
| 2590-3132                  | C-H                | Bending          |                  |                       |
| 1680-1751                  | C=O                | Stretching       | R-CHO            | 364                   |
| 2665-3049                  | C-H                | Bending          |                  |                       |
| 1700-1800                  | C=O                | Stretching       | R-COOH           | 364                   |
| 1215-1301                  | C-O                | Stretching       |                  |                       |
| 2897-3300                  | O-H                | Stretching       |                  |                       |

Table 1 – The main products of cellulose pyrolysis characterized by FTIR and the temperature corresponding to their maximum evolution

[1] Shafizadeh F. Chemistry of pyrolysis and combustion of wood . Proc. –Int. Conf. Resid. Solid Fuels: Environ. Impacts Solutions 1982.

Setsys Evolution TGA  
(ambient to 1600°C)



www.setaram.com  
sales@setaram.com

