Influence of steam explosion pretreatment on the thermal degradation of cellulose fibers

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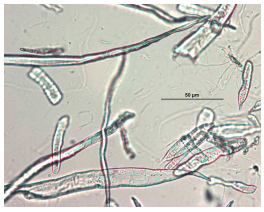
Background and Objectives

The aim of the present work is to compare the effect of different steam explosion pretreatments on the thermal degradation of a bleached cellulose where components like hemicelluloses and lignin have already been removed by acid and alkaline treatments.
The results of this study show that thermal degradation of cellulose fibres, studied by TGA, is still limited for a temperature process below 240 °C. However, derivative TGA show that thermal stability of cellulose obtained by these conditions decreases with the increase of temperature.
For temperatures above 250°C, char level is higher at the end of the pyrolysis. According to the literature, the increase of the char level is correlated to an increase of the degradation product[1]. Determination of the degradation products in the liquor obtained after the pretreatment show an important increase of furfural and 5-hydroxymethylfurfural concentration with the temperature in agreement with the increase of the char level. These results confirm the important degradation of the cellulose fibres.

Materials and Methods

Material

❖ *The material tested in the experiment is a microcrystalline cellulose (Alba-fibre C-200). This product is a bleached cellulose, purified from components like hemicelluloses and lignin (<1%). The average fiber size is around 200 µm length with a diameter of 30 µm. The density is between 120-150 g/dm³ with a moisture content of at least 8%.*

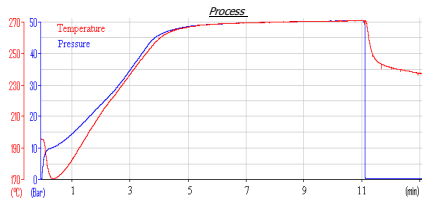


Steam explosion pretreatment

Parameters

Sample	Pressure (bar)	T°(°C)	Time (min)
SE 10 bar	10	184	2
SE 20 bar	20	214	2
SE 30 bar	30	235	2
SE 40 bar	40	251	2
SE 50 bar	50	265	2

Process



Drying

❖ Freeze Dryer : *Heto DW 8 ; T° plate 40°C; T° condenser –40°C; 48 h*

Centrifugation

❖ Centrifuge : *Allegra X-15R ; 10000 t/min ; 5 min*

Solid Phase

C200 SE 10 bar SE 20 bar SE 30 bar SE 40 bar SE 50 bar

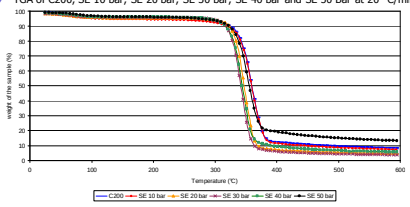
Liquor

C200 SE 10 bar SE 20 bar SE 30 bar SE 40 bar SE 50 bar

Results

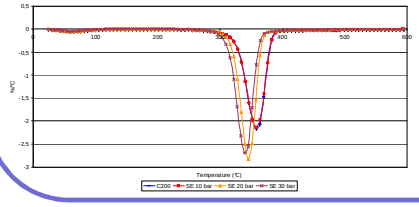
Thermogravimetric analysis

TGA of C200, SE 10 bar, SE 20 bar, SE 30 bar, SE 40 bar and SE 50 Bar at 20 °C/min.



Carbonaceous residues at the end of the pyrolysis (char) are more important for the SE 50 bar samples (14%) compared to the other samples (5 to 9 %)

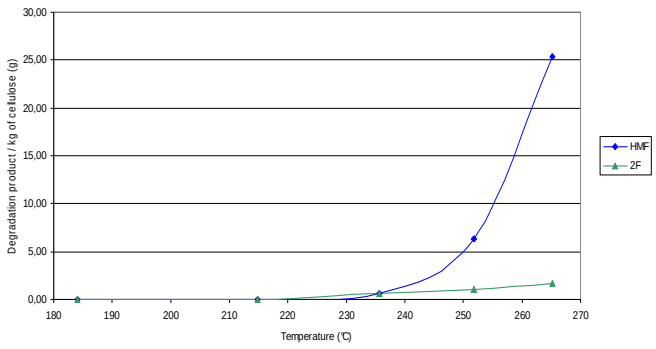
dTGA curves of C200, SE 10 bar, SE 20 bar, SE 30 bar and SE 40 bar at 20 °C/min.



Decrease of thermal stability of steam explosion samples obtained below 240°C. The main peak of the cellulose degradation is located around 370 °C for C200, 360 °C for SE 10 bar, 350 °C SE 20 bar and 340 °C for SE 30.

5-Hydroxymethyl Furfural and Fufural analysis

HMF and 2F concentration in steam explosion liquors



Quick increase of HMF and 2F concentration in the liquor obtained at a temperature higher than 240°C

Conclusions

❖ Strong thermal degradation of steam explosion cellulose fibers obtained at temperatures higher than 250°C

❖ Decreased of thermal stability of non-degraded steam explosion cellulose samples

❖ Important increase of degradation products in steam explosion liquors obtained at temperatures higher than 240°C

References

1. N. Quievy, N. Jacquet, M. Sclavons, C. Deroanne, M. Paquot, J. Devaux. 2010. Influence of homogenization and drying on the thermal stability of microfibrillated cellulose. Polymer degradation ant stability, 95, 306-314

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