Determination of composition of cashew (Anacardium occidentale) nut shell by thermogravimetry

INTRODUCTION

The global energy demand is still very dependent on fossil fuels nowadays. According to the International Energy Agency (IEA, 2019), the use of fossil fuels (primary sources of energy) represented 80.8 % of the total energy matrix in 2017, while the use of renewable and sustainable energy represented only 14.2 %, with 69.5 % stemming from bioenergy sources.

In this scenario, the most important bioenergy source is biomass, such as lignocellulosic compounds (sawdust, sugarcane bagasse, corncobs), solid waste, landfill gas and biogas, and alcohol fuels (like bioethanol or biodiesel). Lignocellulosic biomass can be converted into useful compounds by chemical, biological and physical processes. A commonly-used chemical process is pyrolysis, a thermochemical reaction which takes place in absence of oxygen and transforms lignocellulosic biomass into three main compounds: biochar, bio-oil and biogas.

This study aims to characterize the lignocellulosic composition of a very important lignocellulosic biomass – the cashew nut shell (CNS) – by high-resolution thermogravimetric analysis, a technique that calculates the mass loss rate from the thermal decomposition of a material as temperature increases.

DEFINITION ASSIGNMENT

In order to measure the lignocellulosic composition of the raw cashew nut shell (rCNS) kindly provided by Privim B.V company, a few thermogravimetric experiments were performed beforehand with standards, such as white granular powder of microcrystalline cellulose (*CAS* 9004-34-6) purchased from Acros Organics™, off-white xylan (4-O-methylglucuronoxylan) isolated from beechwood (*CAS* 9014-63-5) purchased from Megazyme™ and reddish-brown cashew nut shell liquid extracted with *n*-heptane at 100 °C for 24 hr in an agitated flask. The employed equipment (TGA *Q500* Series) was provided by TA Instruments®. For all experiments, it has been selected an initial heating rate of 30°C/min from room temperature up to 600°C at resolution 5 (sensitivity 1.0).

DTG curves from the analyses of standards are presented in Fig. 1. The parameters (***A***, ***w*** and ***x****c*) from the Gaussian equation (Eq. 1) were calculated for each curve and used as reference values during the multiple peak fitting of the Gaussian deconvolution for the DTG curve of thermal decomposition of CNS (Fig. 2).

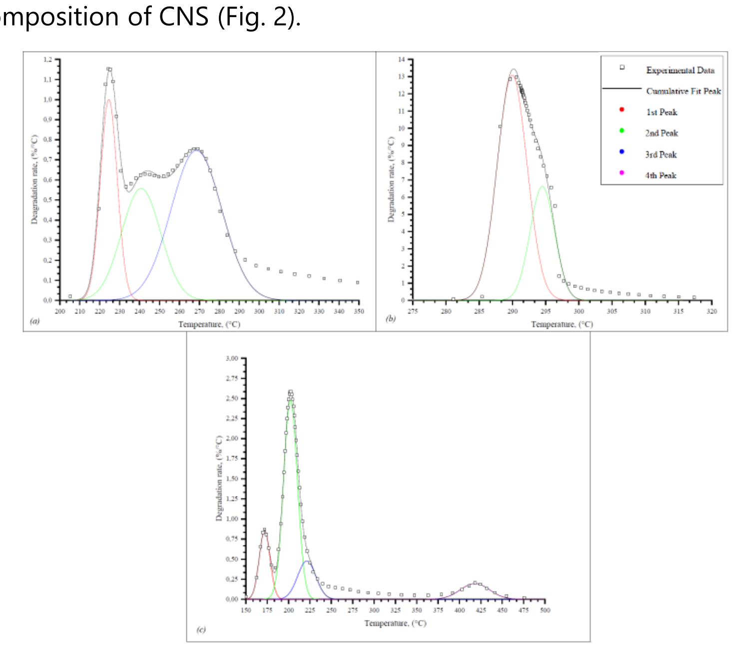

Figure 1. Gaussian deconvolution of DTG curves from thermogravimetric analyses performed under high resolution approach (initial heating rate of 30 °C/min; sensitivity 1.0; and resolution 5.0) for **(a)** xylan, **(b)** microcrystalline cellulose (MCC) and **(c)** cashew nut shell liquid (CNSL). Coefficient of determination (r^2): **a)** 0.961, **b)** 0.994 and **c)** 0.997.

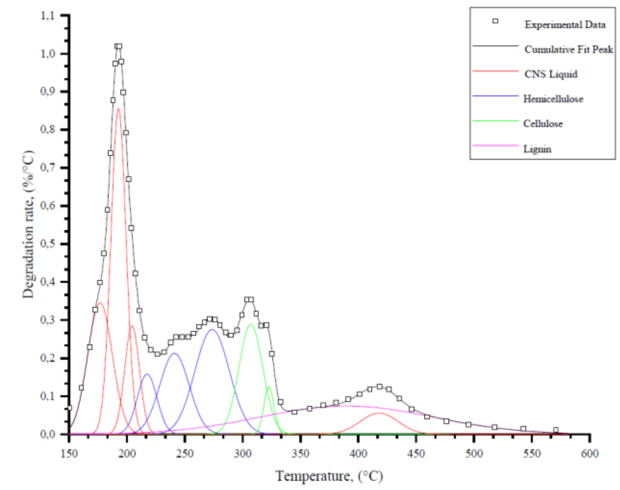

Figure 2. Gaussian deconvolution of DTG curve from thermogravimetric analyses performed under high-resolution approach (initial heating rate: 30 °C/min; resolution: 5; sensitivity: 1.0) for raw cashew nut shell. The graph shows the deconvoluted peaks for hemicellulose (blue), cellulose (green), lignin (pink) and cashew nut shell liquid (red). Temperature range selected from 150 to 600 °C. Coefficient of determination (r^2): 0.9994.

$$y = \frac{A}{w\sqrt{\frac{\pi}{4\ln(2)}}} e^{-4\ln(2)\frac{(x-x_c)^2}{w^2}} \qquad \textbf{(Eq. 1)}$$

RESULTS

From the area values in Fig. 2 and considering the amount of volatiles produced by each species in Fig. 1, it follows that the lignocellulosic composition of the raw cashew nut shell on a dry and ashes-free basis is: 28.3 ± 0.2 % hemicellulose, 9.6 ± 1.3 % cellulose, 28.8 ± 2.3 % lignin and 33.2 ± 1.9 % CNSL. It is noteworthy that the total cellulose content is very low compared to the total hemicellulose and lignin contents, which is in disagreement with the literature.

Ocheja *et al.* (2015) carried out analytical experiments in order to evaluate the fibre composition of CNS. They found 7.35, 11.50 and 7.45 % of hemicellulose, cellulose and lignin, respectively, in 26.30 % of neutral detergent fibre. In this case, it is either possible that the feedstock has been contaminated with cellulolytic bacteria or fungi or maybe there should be another peak for the cellulose decomposition apart from those obtained from the microcrystalline cellulose standard. In other words, either the feedstock is not good to evaluate the lignocellulosic composition of CNS or the method cannot be applied by considering that each component decomposes independently. Despite this, the ratios between total hemicellulose and total lignin reported by this paper and by Ocheja *et al.* (2015) are approximately the same (0.981 and 0.987, respectively).

REFERENCES

IEA, International Energy Agency. **World Energy Outlook**: The gold standard of energy analysis, 2019.

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