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Production of Solid Sustainable Energy Carriers from Biomass by Means of Torrefaction

Supplement to Deliverable No. D3.3

Public summary of the scientific paper on torrefaction fundamentals

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PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Thermal decomposition of hemicelluloses

Public summary

Hemicellulose is a large component in wood and is the main component decomposed during torrefaction. The influence on torrefaction process operation and control of changed hemicellulose composition in biomass could be substantial both regarding mass yields and heat generated during torrefaction. The objective of this study was therefore to evaluate the thermal behavior of different commercially available hemicelluloses present in terrestrial biomass (xylan, arabinogalactan, arabinoxylan, galactomannan, glucomannan, xyloglucan and β-glucan).

All terrestrial biomass share the same basic cell wall architecture containing cellulose surrounded by polysaccharides (hemicellulose and pectin). In the secondary cell walls also lignin is present. It is important to consider that unlike cellulose, hemicellulose is a group of structurally diverse compounds. The building blocks of hemicelluloses are pentoses[1] (arabinose and xylose), hexoses[2] (galactose, glucose and mannose) and hexuronic acids[3] (glucuronic acid).

Thermal degradation of biomass, and in particular decomposition of hemicellulose, is a complex process and it includes many different reactions and decomposition pathways occurring simultaneously. The pyrolysis process results in a char residue and gaseous products. Hemicelluloses with different structure and sugar composition are expected to have different degradation pathways resulting in differences in thermal stability and product distribution.

The most thermally stable polysaccharide was cellulose, closely followed by the glucan-based hemicelluloses β-glucan and xyloglucan, and then arabinoxylan, arabinogalactan, galactomannan, glucomannan and finally xylan. The stable appearance of cellulose is explained by its partly crystalline structure. Moreover, the differences in stability among the hemicelluloses are probably caused by formation of more or less stable intermediates during decomposition. Xylan deviated compared to the other evaluated hemicelluloses by mass loss at lower temperature and in two stages.

[1] Pentose – five carbon sugar
[2] Hexose –six carbon sugar
[3] Hexuronic acid - an acid derived from a hexose

Arabinogalactan, arabinoxylan, β-glucan, galactomannan, glucomannan, xyloglucan and cellulose had overall endothermal[4] decomposition characteristics (not previously reported), whereas xylan displayed a clear exothermal[5] behavior.

The gaseous products formed during thermal decomposition of hemicelluloses were H_2O, CO, CO_2 and CH_4 together with a number of organic compounds e.g. different aldehydes, ketones and anhydrosugars, all fragments from the structure of the hemicelluloses. The concentration and composition of products differed between the hemicelluloses evaluated and were correlated to the original sugar composition.

[4] Endothermic - a process or reaction in which the system absorbs energy from its surroundings in the form of heat

[5] Exothermic - a process or reaction in which the system releases energy, usually in the form of heat.