WOODY AND AGRICULTURAL BIOMASS DIVERSITY IN TORREFACTION:
A COMPLETE STUDY IN SOLID CONVERSION AND VOLATILES FORMATION ON TGA-GCMS

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Nowadays, there is an increasing awareness on the importance of biomass waste as a renewable source of energy, materials and chemicals. In this context, the European project MOBILE FLIP aims at developing and demonstrating mobile conversion processes suitable with various underexploited agro- and forest based biomass resources in order to produce energy carriers, materials and chemicals. One of these processes is torrefaction, which consists in a mild thermal treatment, occurring typically between 200 and 300°C during a few tens of minutes in a default-oxygen atmosphere. The solid product obtained has properties closer to coal in terms of heating value, carbon content, hydrophobicity, grindability as well as flowability, and thus is suitable as fuel for combustion, co-combustion or gasification. During torrefaction, condensable coproducts are released, that can damage the installation but that may also be source of “green” chemicals.

Biomass is a highly diverse resource, whose properties are very different from a coniferous to a deciduous wood, or from an agricultural by-product to an herbaceous crop. As a result, the behaviour of biomass in thermochemical conversion may differ from a type of biomass to another. The upscaling of biomass torrefaction to industrial units requires therefore the modelling of both solid conversion and gases released versus feedstock type.

However, up to now, only a small number of biomasses has been compared in torrefaction studies under identical conditions and only few works have been focused on characterizing and modelling both solid and condensable species during torrefaction versus feedstock type [1].

Based on this background, our objective is to propose the first lab-scale extensive study of biomass torrefaction, including ten main biomasses selected as representative of the European diversity. For each biomass, a complete and simultaneous study of solid degradation and of volatiles release was carried out through non-isothermal torrefaction tests between 200 to 300°C. The experimental set-up was composed of a thermogravimetric analyser (TGA) coupled with a gas chromatography mass spectrometer device (GCMS). An original system of 16 heated loops allowed volatile species sampling at different temperatures and then samples storage before analysis in GCMS. Thanks to this device, kinetics of formation of condensable species could be derived through one single experiment, together with kinetics of mass loss. Specific attention was paid to perform tests under conditions ensuring chemical regime [2].

Biomass composition was shown to have a major influence on torrefaction. Thus different kinetic profiles of solid degradation and volatiles release could be observed among coniferous and deciduous woody, as well as regarding to agricultural biomasses, in relation with their composition in sugars and lignin. Moreover volatiles yields could also be correlated with macromolecular composition. For instance, as expected, furans were produced in higher amount by biomasses with higher hemicelluloses and cellulose content (Figure 1), while phenols production was favoured by lignin-rich biomasses. In a process viewpoint, this implies that torrefaction operating conditions as well as volatiles cleaning or recovery steps must be feedstock specific.