

Characterization of the Volatile Fraction of Used Wind Turbine Blade Pyrolysis Oil by Two-Dimensional Gas Chromatography

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With the global expansion of wind energy sector, finding sustainable solutions for the disposal of wind turbine blades (WTBs) has become increasingly critical. Indeed, most parts of the wind turbines are made of concrete and steel, which are easily recyclable. However, the blades are a complex assembly of different materials (wood, resins, coatings, glass fiber and unsaturated polyester matrix). It is therefore necessary to develop a recycling process to divert the blades from landfill and recover valuable materials.

This study investigates the volatile fraction produced through one of the most promising recycling methods (pyrolysis) using comprehensive two-dimensional gas chromatography (GC × GC) coupled with time-of-flight mass spectrometry (TOFMS) and a flame ionization detector (FID). Two column configurations, normal (non-polar × mid-polar) and reverse (mid-polar × non-polar), were compared to enhance the separation and semi-quantification of chemical families with a particular emphasis on oxygenated compounds. Indeed, oxygenated molecules can significantly impact the macromolecular properties of the recovered materials and act as a catalyst inhibitor therefore a focus has been made to have a clear understanding of oxygen-bearing compounds present in the WTB pyrolysis oil.

Both column configurations revealed a dominance of aromatic compounds, alongside smaller amounts of normal and iso-paraffins, naphthenes and olefins. Over 800 compounds were detected including 80 oxygenated species such as ketones, aldehydes, esters, alcohols and carboxylic acid. The findings highlight the complementary strengths of both chromatographic configurations. This approach not only allows for the semi-quantification of various chemical classes with a focus on oxygenated molecules but also successfully links these identified oxygenated species to their origin within the unsaturated polyester resin. This molecular-level insight into WTB pyrolysis oil supports the development of more effective recycling strategies for composite materials.