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A method comparison to infer charring temperature, aromaticity and the degree of condensation of pyrogenic carbon

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Fire-derived, pyrogenic carbon (PyC) is a persistent organic carbon fraction with a slow turnover in the environment because it is relatively resistant against chemical and biological degradation. It thus represents an important carbon fraction with a sequestration potential in the global carbon cycle. PyC is naturally produced on a large scale during wildfires and anthropogenically in the form of biochar, when organic waste is pyrolyzed.

Aromaticity and the degree of condensation are the two main quality properties of PyC that probably largely determine its persistence against degradation. The two parameters should theoretically be dependent on pyrolysis conditions, such as charring temperature, pyrolysis time or feedstock.

In this study, we used four different feedstocks and two different pyrolysis procedures to produce a thermosequence of 40 chars, ranging from 100 – 1000° C. The chars were then analyzed with six different state-of-the-art methods: solid state 13C nuclear magnetic resonance (13C NMR), diffuse infrared Fourier transform spectroscopy (DRIFT), X-ray diffraction (XRD), synchrotron-based near-edge X-ray absorption fine structure analysis (NEXAFS), benzene polycarboxylic acid analysis (BPCA) and pycnometry. They allowed to infer the aromaticity and the degree of condensation of the material.

Using multivariate statistical methods, aromaticity and the degree of condensation could successfully be linked to charring temperature because characteristic patterns of the two properties could be observed by different methods throughout the whole thermosequence. Moreover, we show, which methods are most suitable for a quality assessment of PyC and discuss their advantages and limitations.