



## **Molecular characterization of soil organic matter: a historic overview**

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The characterization of individual molecular components of soil organic matter started in the early 19th century, but proceeded slowly. The major focus at this time was on the isolation and differentiation of different humic and fulvic acid fractions, which were considered to have a defined chemical composition and structure. The isolation and structural analysis of specific individual soil organic matter components became more popular in the early 20th century. In 1936 40 different individual compounds had been isolated and a specific chemical structure had been attributed. These structural attributions were confirmed later for some, but not all of these individual compounds. In the 1950s much more individual compounds could be isolated and characterized, using complicated and time-consuming chromatography. It became obvious that soil also contains a number of compounds of microbial origin, such as e.g., amino sugars and lipids. With the improvement of chromatographic separation techniques and the use of gas chromatography in combination with thin layer chromatography in the 1960s hundreds of individual compounds have been isolated and identified, most of them after chemical degradation of humic or fulvic acids. The chemical degradative techniques were amended with analytical pyrolysis in the 1970s. More and more, bulk soil organic matter was analyzed with these techniques and the advent of solid-state  $^{13}\text{C}$  NMR spectroscopy around the 1980s allowed for the characterization of the composition of bulk soil organic matter. The gas chromatographic separation of organic matter can nowadays be combined with specific detectors, such that specific attributes of individual molecules can be analyzed, e.g. the radiocarbon content or the stable isotope composition.