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NMR-based estimates of the molecular dimensions in wildfire charcoal: Implications for predictions of biochar residence time

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The thermochemical conversion of biomass to energy and fuels generates charcoal as a co-product. Charcoals derived from sustainable biomass sources—biochars—are an inherently stable form of carbon, relatively long residence times in the environment. Biochars can have potentially beneficial properties as soil fertility amendments, which has further stimulated research on the use of biochars for soil carbon sequestration as a climate change mitigation strategy. However, it is challenging to assess the long-term stability of biochar carbon using laboratory or field incubations because these are comprised of short-term observations. In this study, we make use of ancient charcoals from the boreal forests of Alaska and Scandanavia. We have deliberately selected charcoals from organic soil horizons, as to investigate the inherent biological and chemical stability of charcoal C without the protective influence of soil minerals. We use 14C radiocarbon dating to determine the age of the charcoals, differential scanning calorimetry to assess thermal stability, and solid-state 13C NMR to assess the chemical structure. Specifically, we employ C-H dipolar-dephasing NMR experiments to estimate the relative abundance and molecular dimensions of condensed aromatic domains and aliphatic structures. We test the hypothesis that the environmental stability, as determined by apparent 14C age and thermal stability, is related to the extent of ring condensation in the charcoal structure. Preliminary results suggest that the dimension of the condensed aromatic ring clusters may be an important molecular parameter to include in algorithms used to model/predict the residence time of charcoal and biochar C in soil.