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Customizable synthetic proxies for stable soil organic carbon

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Soil organic carbon (SOC) is the largest pool of terrestrial carbon and an essential component for the long-term management and sequestration of atmospheric CO_2. A fraction of this SOC is protected by association with soil minerals, thereby rendering this carbon sequestered for millenia. Understanding this preserved pool of SOC is fundamental to soil management practices and policy interventions. However, due to its chemical complexity and resistance to isolation, stable soil carbon has been challenging to study.

Here, we propose an alternative approach for synthesizing stable soil carbon in the laboratory to enable mechanistic studies of carbon preservation in the soil. We have designed bottom-up bacterial biopolymers that act as proxies for stable soil organic carbon. These biopolymers form complexes with short-range order iron oxides in laboratory timescales and can be produced with varying protein, carbohydrate, and C/N ratios. The tunable chemistry of these organomineral composites allows for robust, lab-scale incubation studies exploring the effects of organomineral associations on soil carbon and nitrogen cycling. By emulating the association between microbial necromass and soil minerals in a thoroughly characterized, closed system, we can dissect the mechanisms of carbon protection, determine microbial roles in soil carbon preservation, and inform models that predict soil feedback to climate change.