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Laboratory Production of Mineral-Associated Organic Matter using Synthetic Biology

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Soil organic carbon is the largest terrestrial reservoir of carbon and is one target for the sequestration and management of atmospheric CO_2. While some of this carbon pool is easily remineralized to CO_2, a fraction is stored in stable organomineral associates that persist for centennia to millenia, termed mineral-associated organic matter (MAOM). MAOM can act as stable, long-term storage for fixed atmospheric carbon. However, our understanding of the inherent controls on MAOM stability is limited due to its chemical complexity, small size, and diverse mechanisms of formation. It has also been hypothesized that changing environmental conditions could increase or decrease MAOM remineralization, but we currently lack a model MAOM material to use in controlled laboratory experiments.

Here we report the design of microbes for the production of synthetic MAOM, which can be used as a proxy for natural MAOM. We characterize biopolymers secreted by a native soil organism, *Bacillus subtilis*, and present a scalable organic matrix with tunable C:N ratios and chemistry. We discuss modifications that facilitate the formation of synthetic MAOM and explore methods of testing persistence. Synthetic MAOM can be used to better understand soil carbon protection mechanisms, determine microbial roles in soil carbon preservation, and inform models that predict soil feedbacks to climate change.