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Biogeochemical Fate and Stability of Iron Oxide Organic Carbon Complexes

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Associations between organic carbon (OC) and iron (Fe) minerals play an important role in regulating OC stability in the soil environment. However, Fe minerals in soil systems are subjected to redox reactions, which can compromise the stability of Fe-bound OC. Thus, understanding the process of Fe-bound OC during Fe reduction and roles of different OC functional groups is crucial for accurately predicting the C biogeochemical cycle and its response to climate change. We have systematically studied the biogeochemical fate and stability of Fe oxide-OC complexes during the abiotic and biotic reduction.

During the abiotic reduction of Fe in hematite-OC complexes, we found that the release rate for Fe bound-OC was faster than the rate of Fe reduction.¹ In addition, the aromatic OC was released during the early phase while the aliphatic OC was enriched in the residual fraction.^{1,2} The higher resistance of aliphatic OC to the reductive release provided a new mechanism for the stability of Fe-bound OC and partially explained the widely observed accumulation of aliphatic OC.

During the microbial reduction of ferrihydrite (Fh) in Fh-OC co-precipitates by *Shewanella putrefaciens* strain CN32, we found that higher C/Fe ratio of the co-precipitates facilitated Fe reduction and release of Fe-bound OC.³ The aromatic and carboxylic OC was preferentially retained in the complex during the reduction. We also investigated the fate and stability of Fh co-precipitated with model organic compounds, including glucose (GL), glucosamine (GN), tyrosine (TN), benzoquinone (BQ), amylose (AM), and alginate (AL), under anaerobic reaction.⁴ During 25-d anaerobic incubation with *Shewanella putrefaciens* CN32, Fe reduction followed the order Fh-BQ > Fh-GL > Fh-GN > Fh-TN > Fh-AL > Fh-AM. For OC release, highest OC was released from Fh-GN, and lowest OC was released from Fh-AM. OC regulated Fe reduction and consequent release of OC, through acting as an electron shuttle and regulating the bacterial activity. Effects of OC on Fe reduction were also controlled by the association and interactions of OC with Fh. These findings provided insights into the complex role of different organic functional groups in regulating the Fe reduction and stability of Fe-bound OC under anaerobic conditions.

Our results highlight that the stability of Fe oxide-OC complexes during the reduction was regulated by Fe mineral phase, the C/Fe ratio, and OC chemical composition. Such information is of great value for the development of a process-based model for prediction of biogeochemical cycles of OC.

References

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