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论文

氧化锰矿物的生物成因及其性质的研究进展

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摘要:

土壤中的氧化锰矿物是原生矿物风化和成土过程的产物,是最具反应活性的一类矿物,决定着环境中许多物质的形态、迁移和转化,在元素生物地球化学循环中起着重要的作用,其形成机制和环境效应备受关注。已有的研究表明,环境中氧化锰的形成与微生物作用紧密相关,微生物作用可使自然环境中的Mn(II)氧化速率提高105倍。参与Mn(II)氧化的微生物在环境中广泛存在,已知的典型锰氧化细菌分布在变形菌门、放线菌门或厚壁菌门,它们均通过胞外聚合物中的多铜氧化酶来催化氧化Mn(II)。细菌氧化Mn(II)成Mn(Ⅳ)是酶催化的两个连续的快速单电子传递过程,Mn(III)在溶液中以与酶结合的瞬时中间态出现。生物形成氧化锰的最初形态为层状锰矿物,与δ MnO2或酸性水钠锰矿很类似,且结晶弱,粒径小,锰氧化度高,结构中的八面体空穴多,因而比化学形成的氧化锰具有更强的吸附、氧化等表面活性。环境中Mn(II)微生物氧化及形成的Mn(Ⅲ)中间体与碳、氮、硫等生命元素的地球化学循环的关系令人关注。

关键词: 氧化锰矿物; Mn(II)微生物氧化; 锰细菌; 生物成因; 多铜氧化酶; 环境效应; 表面化学性质; 吸附; 氧化还原

Advances in the study of biological genesis of manganese oxide minerals and their characteristics.

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Abstract:

Manganese oxide minerals in soils are the products of the weathering of primary mineral and the process of soil formation As one family of most active minerals in reactions, they play a crucial role in the biological geochemical cycling of many elements through impacting these elements speciation, transport and conversion in natural environments Consequently, the formation mechanism and environmental behaviors of manganese oxide minerals are one of the hot topics in the fields of soil science, sedimentology, oceanography and material science It has been indicated in literatures that the genesis of manganese oxide in the environment is closely related to the microbiological process, and microbial mediated oxidation of aqueous Mn(II) can greatly accelerate the rate of oxidation up to five orders of magnitude faster than surface catalyzed reactions Microorganisms, including bacteria and fungi, that participate in oxidation of Mn(II) are widespread in nature All of the known typical Mn(II) oxidizing bacteria belong to the Firmicutes, Actinobacteria and Proteobacteria branches of the Domain Bacteria They enzymatically catalyze the oxidation of Mn(II) by a kind of putative multicopper oxidase in extracellular polymeric substances The bacterial oxidation of Mn(II) to Mn(IV) proceeds as two sequential quick one electron transfer processes with the occurrence of an intermediate of soluble transient Mn(III) The initial biogenic manganese oxide is a kind of phyllomanganate mineral, similar to δ MnO2 or acid birnessite, with low degree of crystallanity, small particle size, high oxidation state of Mn and high proportion of octahedral vacancy sites Therefore, it exhibits a more active surface reactivity such as adsorption and redox reactions The relationship of microbially mediated oxidation of Mn(II) and the formed Mn(III) intermediates to the global geochemical cycling of life related elements such as C, N and S is needed of us to pay attention to in the future.

Keywords:

manganese oxide mineral; microbial Mn(II) oxidation; Mn bacteria; biological genesis; multicopper oxidase; environmental behavior; surface chemical properties; adsorption; redox

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