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# Microbial effects in promoting the smectite to illite reaction: Role of organic matter intercalated in the interlayer

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## ABSTRACT

Cysteine and toluene as model organic molecules were intercalated into Fe-rich smectite (nontronite, NAu-2). The illitization of these intercalated smectites as induced by microbial reduction of structural $Fe^{3+}$ was investigated. Iron-reducing bacterium *Shewanella putrefaciens* CN32 was incubated with lactate as the sole electron donor and structural $Fe^{3+}$ in cysteine- and toluene-intercalated NAu-2 (referred to as cysteine-NAu-2 and toluene-NAu-2 hereafter) as the sole electron acceptor. Anthraquinone-2, 6-disulfonate (AQDS) was used as an electron shuttle in bicarbonate buffer. The extent of $Fe^{3+}$ reduction in cysteine-NAu-2 and toluene-NAu-2 was 15.7 and 5.4%, respectively, compared to 20.5% in NAu-2 without organic matter intercalation. In the bioreduced NAu-2, X-ray diffraction, and scanning and transmission electron microscopy did not detect any discrete illite, although illite/smectite mixed layer or high charge smectite phases were observed. In bioreduced cysteine-NAu-2, discrete illite and siderite formed. In contrast, bioreduction of toluene-NAu-2 did not result in any mineralogical changes. The contrasting bioreduction results between cysteine- and toluene-intercalated nontronite may be ascribed to the nature of organic matter-bacteria interactions. Whereas cysteine is an essential amino acid for bacteria and can also serve as an electron shuttle, thus enhancing the extent of $Fe^{3+}$ bioreduction and illitization, toluene is toxic and inhibits $Fe^{3+}$-reducing activity. This study, therefore, highlights the significant role of organic matter in promoting the smectite to illite reaction under conditions typical of natural environments (i.e., non-growth condition for bacteria).

**Keywords:** Cysteine, illite, microbial $Fe^{3+}$ reduction, nontronite NAu-2, toluene, *Shewanella putrefaciens* CN32