Bioreduction of Cr(VI) over the composites of montmorillonite, humic acid, and *Shewanella oneidensis* MR-1

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Bioreduction of toxic Cr(VI) into less toxic Cr(III) has been recognized as a promising way to remove Cr contaminants. The interaction among soil montmorillonite, organic matter, and microorganisms will inevitability affect the process of bioreduction of Cr(VI). In this study, montmorillonite, *Shewanella oneidensis* MR-1 and humic acid were used as experimental materials. Cr(VI) reduction kinetics experiment, surface site analysis, ATR-FTIR, SEM, AFM and XPS studies were used to investigate the mechanism of Cr(VI) reduction on the individual components, binary composites, and ternary composites. The roles of clay mineral, humic acid on the Cr(VI) bioreduction over *Shewanella oneidensis* MR-1 were also investigated.

Addition of montmorillonite increased the negative charge on the surfaces of composites and decreased the surface sites of composites. However, humic acid has no obvious effect on the surface charge and site concentration of the composites. Pseudo first-order kinetic model provided good fit to the reduction kinetics data of Cr(VI) by *Shewanella oneidensis* MR-1, montmorillonite, humic acid and their composites. Both montmorillonite and humic acid had an inhibition effect on Cr(VI) reduction by *Shewanella oneidensis* MR-1. The adsorption of chromium on montmorillonite or humic acid was neglectable, implying that the decrease in Cr(VI) concentration was not due to the adsorption but mainly to the biological reduction process (pH 7). The introduction of montmorillonite and humic acid have no significant impact on the surface function groups, roughness, or morphology of *Shewanella oneidensis* MR-1; After the reduction of Cr(VI) by pure *Shewanella oneidensis* MR-1 or the composites, both surface roughness and deformation degree of cells increased. Cr(VI) has an apparent toxic effect on bacteria. However, the introduction of clay montmorillonite and humic acid could reduce the toxic effect on the bacteria.