Elucidation of Gram-positive bacterial iron (III) reduction for kaolinite clay refinement

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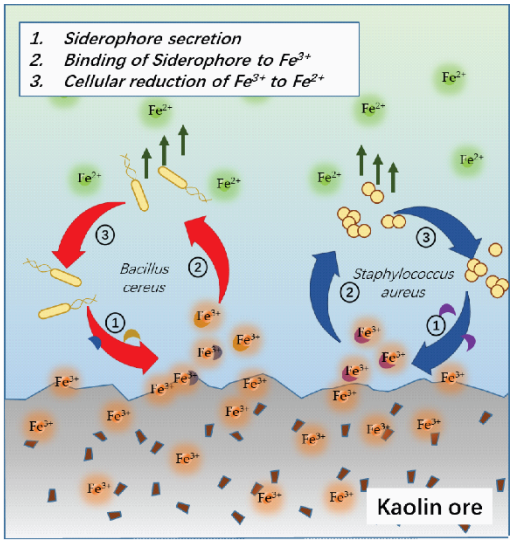
Abstract: Microbial-based iron reduction recently is considered as a viable alternative to typical chemical-based treatments. The iron reduction is an important process in the kaolin refining, where iron-bearing impurities in kaolin clay affects the whiteness, refractory properties, and its commercial value. In recent years, Gram-negative bacteria is the center stage for iron reduction research, whereas little is known about the potential use of Gram-positive bacteria to refine kaolin clay. In this study, we investigated the ferric reducing capabilities of five microbes by manipulating the microbial growth conditions. Out of the five, we discovered that *Bacillus cereus* and *Staphylococcus aureus* outperformed the other microbes under nitrogen-rich media. When using ferric (III)oxide as reducing reagent, *Bacillus cereus* could reduce 40.3% of the total weight, while the other two Gram-negative bacteria *Burkholderia thailandeensis* and *Escherichia coli*, which had reducing ability, could only reduce 32.3% and 33.3% respectively. In the reduction of ferric contaminants in kaolin, *Staphylococcus aureus* could remove 76.2% of the total ferric (III)oxide contaminants, while *Bacillus cereus* and *Burkholderia thailandeensis* removed a total of 38.7% and 31.4% ferric (III)oxide contaminants, respectively. Through the biochemical changes and the microbial behavior, we mapped the hypothetical pathway leading to the iron reduction cellular properties and found that the iron reduction properties of these Gram-positive bacteria rely heavily on the media composition. We discovered that the use of diluted lysogeny broth resulted in the best reduction of ferric (III)oxide salt, showing a total amassed value of 3.0 mg/L of ferrous ion in the medium. The media composition results in increased basification of the media that is a prerequisite for cellular reduction of ferric ions. Further, these changes impact the formation of biofilm, suggesting that the cellular interaction for the iron (III)oxide reduction is not solely reliant on the formation of biofilms. This article reveals the potential development of Gram-positive microbes in facilitating microbial-based removal of metal contaminants from clays or ores to which further studies to elucidate the corresponding pathways would be crucial for the further development of the field.

Graphical abstract:



Keywords: kaolin; iron (III) oxide; reduction; medium; secondary metabolites.

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