Enhanced microbial corrosion by Acidithiobacillus ferrooxidans through the manipulation of substrate oxidation and genetic engineering

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Abstract

Acidithiobacillus ferrooxidans cells can oxidize iron and sulfur and are key members of the microbial biomining communities that are exploited in the large-scale bioleaching of metal sulfide ores. Some minerals are recalcitrant to bioleaching due to presence of other inhibitory materials in the ore bodies. Additives are intentionally included in processed metals to reduce environmental and microbially influenced corrosion. We have previously reported a new aerobic corrosion mechanism where A. ferrooxidans cells combined with pyrite and chloride can oxidize low grade stainless steel (SS304) with a thiosulfate-mediated mechanism. Here we explore process conditions and genetic engineering of the cells to enable corrosion of a higher grade steel (SS316). The addition of elemental sulfur and an increase in the cell loading resulted in a 74% increase in the corrosion of SS316 as compared to sulfur- and cell-free control experiments. The overexpression of the endogenous rus gene, which is involved in the cellular iron oxidation pathway, led to further 85% increase in the corrosion of the steel. Thus, the modification of the culturing conditions and cell line, led to a more than 3-fold increase in the corrosion of SS316 stainless steel, such that 15% of the metal coupons was dissolved in just 2 weeks. This work demonstrates how the engineering of cells and the optimization of their cultivation conditions can be used to discover conditions that lead to the corrosion of a complex metal target.

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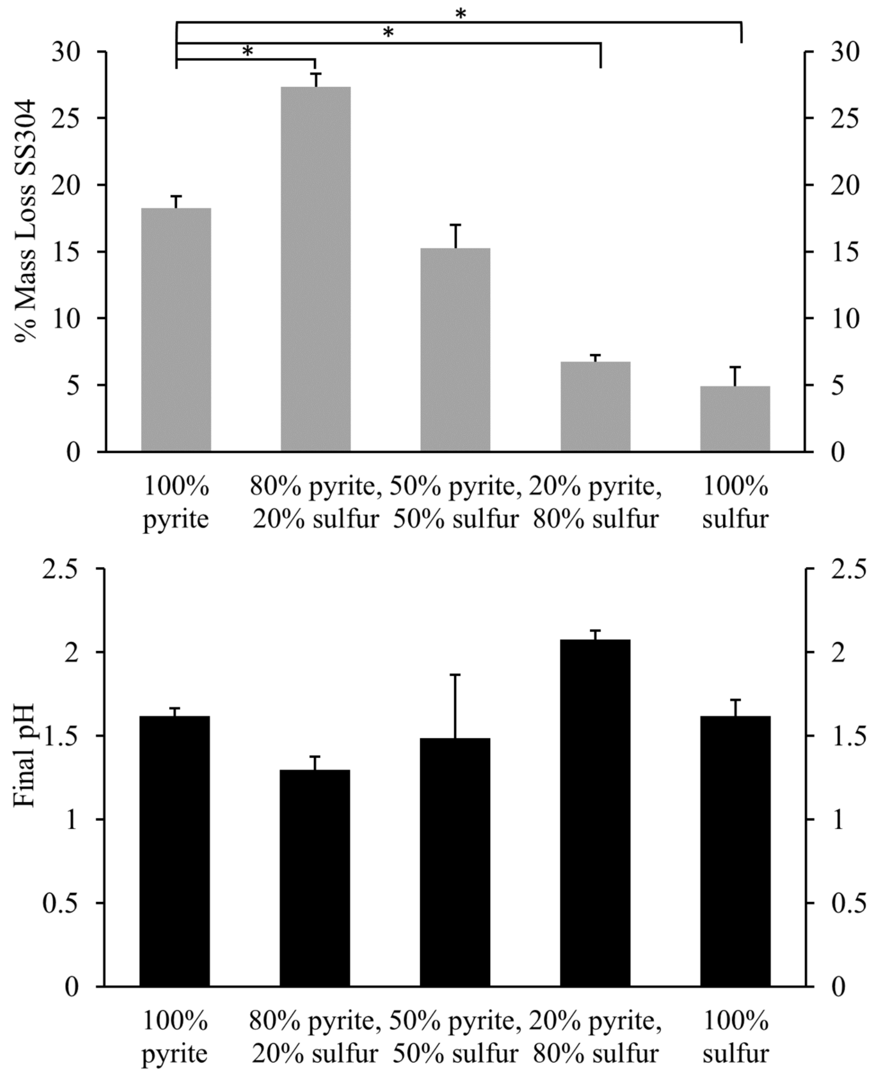
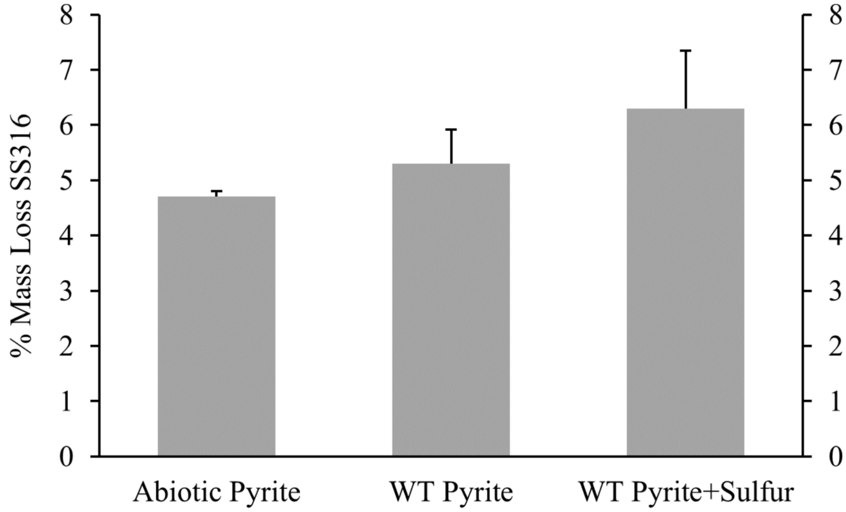
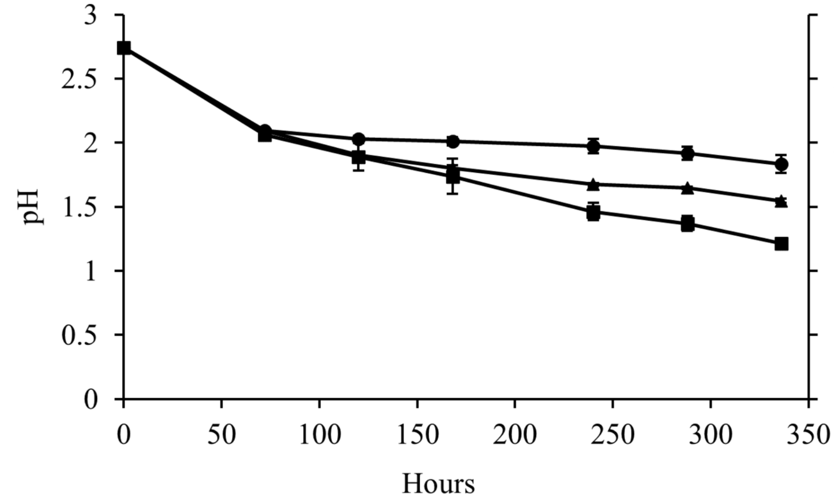
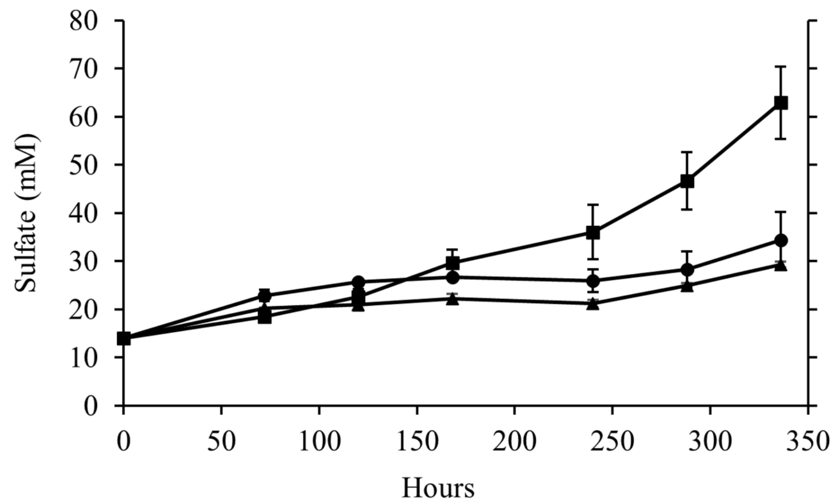
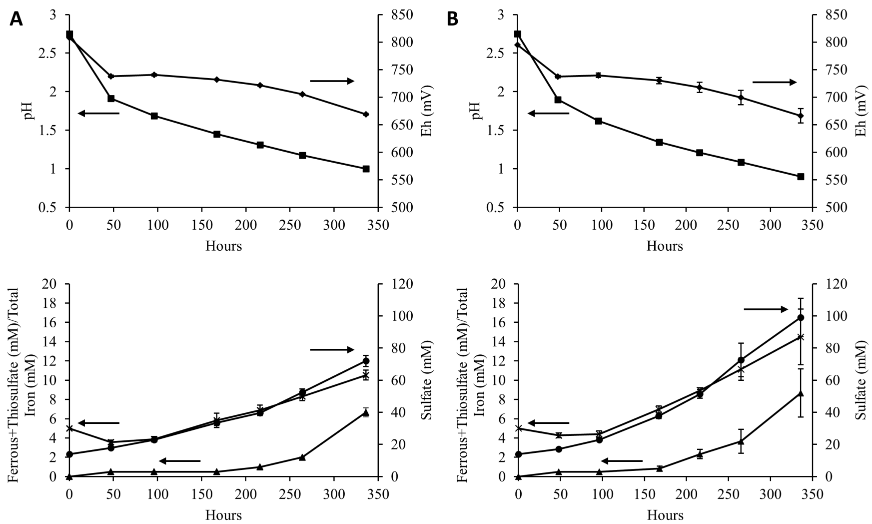
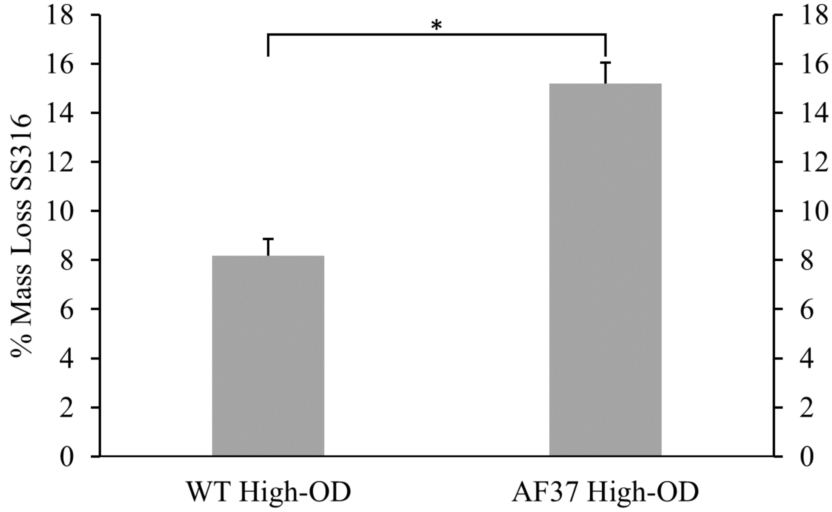

*
*
*
30
25
20
15
10
5
0
% Mass Loss SS304
100% pyrite
80% pyrite, 20% sulfur
50% pyrite, 50% sulfur
20% pyrite, 80% sulfur
100% sulfur
2.5
2
1.5
1
0.5
0
Final pH
100% pyrite
80% pyrite, 20% sulfur
50% pyrite, 50% sulfur
20% pyrite, 80% sulfur
100% sulfur


8
7
6
5
4
3
2
1
0
% Mass Loss SS316
Abiotic Pyrite
WT Pyrite
WT Pyrite+Sulfur


pH
Hours
0
50
100
150
200
250
300
350
0.5
1
1.5
2
2.5
3


Sulfate (mM)
Hours
0
50
100
150
200
250
300
350
10
20
30
40
50
60
70
80


A
B
pH
Eh (mV)
Hours
Ferrous+Thiosulfate (mM)/Total Iron (mM)
Sulfate (mM)


% Mass Loss SS316
*
WT High-OD
AF37 High-OD