

PYRITE MICROENCAPSULATION: A POTENTIAL FUTURE APPROACH FOR CONTROLLING PYRITE OXIDATION

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Oxidation of pyrite in mining waste or overburden is the main source of acid mine drainage (AMD) production which causes major environmental pollution. Presently, the most common method of controlling AMD problems is through the application of limestone and rock phosphate. However, the effectiveness of this method is still questionable because of iron armoring potential.

Recently, three new microencapsulation (coating) methodologies for preventing pyrite oxidation and acid production in pyritic waste have been developed in our laboratory using small leaching columns. The first coating methodology is that of *Iron-oxide-phosphate coating*. This was done by leaching coal waste with a solution composed of low but critical concentrations of H_2O , KH_2PO_4 , and a pH buffer. During the leaching process, H_2O_2 oxidizes pyrite producing iron (Fe^{3+}). When Fe^{3+} reacts; with PO_4^{3-} forms iron phosphate precipitates as a coating on pyrite surfaces. The purpose of pH buffer in the coating solution is to eliminate the inhibitory effect of the protons, produced during pyrite oxidation, on the precipitation of iron phosphate. Laboratory tests showed that this phosphate coating was effective in inhibiting pyrite oxidation (Fig. 1 A). The technology has been patented by the University of Kentucky.

It is important to note that the technology of coating pyrite as we described above, is not to be confused with the field application of rock phosphate. Rock phosphate complexes dissolved iron and thus reduces the potential of $\text{Fe}(\text{III})$ production, reducing the potential for pyrite oxidation as well. Rock phosphate does *not* coat pyrite; rather, it complexes released $\text{Fe}(\text{II})$ from the oxidizing pyrite. Instead, a rock phosphate surface coating with $\text{Fe}(\text{II})$ forms, reducing rock phosphate dissolution. Therefore, the effectiveness of rock phosphate in controlling pyrite oxidation is short lived.

A second coating methodology is that of *iron-oxide coating*. This was done by leaching pyritic waste with a solution composed of low but critical concentrations of H_2O_2 and a pH buffer. During the leaching process, H_2O_2 oxidizes pyrite and produces an iron oxide coating on the surface, of pyrite. The purpose of a pH-buffer in this case is to buffer the solution during coating formation at a pH between 5 and 7 where iron oxide formation is promoted. This technology has also been proved very effective in preventing pyrite oxidation although not as

effective as the phosphate coating (Fig. 1 B).

A third coating methodology is that of an *iron-oxide coating*. This was done by leaching pyritic waste with a solution composed of H_2O_2 and silica (Si) at pH 5 adjusted with a sodium acetate (NaOAc) pH buffer. It was demonstrated that the presence of silica coating significantly suppressed the oxidation potential of pyrite by H_2O_2 compared to that of uncoated pyrite (Fig. 2). The explanation for this behavior is that oxidation of pyrite by H_2O_2 in presence of Si and NaOAc lead to the formation of an iron-oxide silica coating Compared to iron phosphate or oxide coatings, silica coating is more resistant to the acid environment. The technology has been patented by the University of Kentucky.

In order to test the coating technology under natural environment for possible field application, an outdoor leaching column experiment is currently under observation. This experiment consists of control, phosphate, and silica coating treatments on the mine tailing samples which were constructed in a plexiglass tubing (18" high and 6" in diameter and set up in the field. Preliminary result indicated that, after a 9-month exposure to the natural environment, pH of the leachate samples collected from the control treatment continue to be stable at 2.0 while those from phosphate and silica treatments are stable at about 7.0 (Fig.3). Introduction of phosphate and/or silicate to the mine tailing significantly reduced Fe and SO_4 -S production to the level below the maximum standard for drinking water. Moreover, introduction of pyrite oxidizing bacteria (*Thiobacillus ferrooxidans*) after a 3 month period has not affected the Fe and SO_4 -S production from the treated mine tailing suggesting that, up to now, **pyrite coating is limiting** microbial pyrite oxidation. The results of this outdoor column leaching experiments show that application of the coating technology seems to offer a new solution in the abatement of acid mine drainage. However, long term meticulous monitoring and evaluation are still needed. We will be monitoring these columns for several years.

Successful application of such coating methodologies in the field scale could mean long term solution (perhaps even permanent solution) to certain types of acid mine drainage problems, These coating methodologies are expected to be cost effective since they involve readily available materials and only cover the surface of pyrite particles. Furthermore, the coating solution could be applied to any permeable coal mine waste thus, little or no physical disturbance of coal mine waste during treatment would be necessary. However, future study to scale up the coating technology demonstrated in columns to actual sites in the field is necessary.

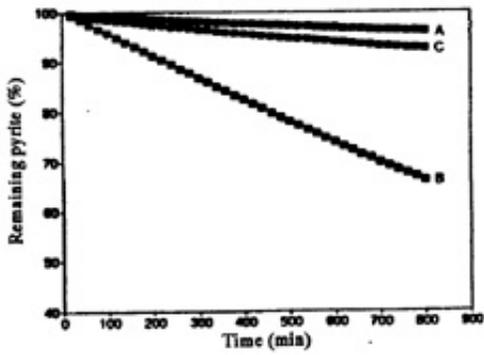


Fig. 1. Oxidation kinetics of pyrite leached with the following three pH 6 solutions: A) NaAC plus H_2O_2 and KH_2PO_4 ; B) NaAC plus H_2O_2 and EDTA; C) NaAC plus H_2O_2 .

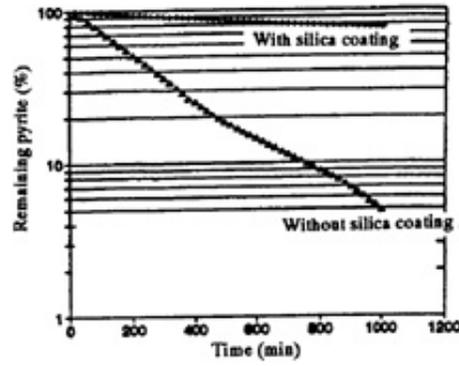


Fig. 2. Pyrite leached with H_2O_2 with and without silica (Si) at pH 5 buffered with sodium acetate at room temperature.

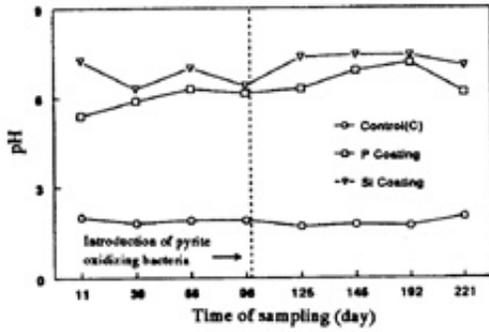


Fig. 3. Preliminary leachate pH from the outdoor leaching column experiment.

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