Advanced Passivation Technique of Sulfide Minerals in Mine Wastes for Preventing Acid Mine Drainage Formation

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ABSTRACT

Mining and mineral processing industries often produce huge amounts of sulfide-rich mine wastes that cause the formation of acid mine drainage (AMD) due to their oxidation process under atmospheric conditions. AMD is considered as one of the most serious environmental problems encountered worldwide because of its extremely low pH and high concentrations of hazardous and toxic metals. Of all the remediation techniques, neutralization is most commonly used to mitigate the negative environmental impacts of AMD. This technique uses basic materials like limestone to raise the acidic pH of AMD, thereby precipitating most of the dissolved metals. Although effective, this technique is unsustainable because of following drawbacks: (1) continuous supply of reagents for decades–millennia until AMD formation stops, and (2) problems with the disposal of bulky sludge.

Because of these limitations, alternative methods aimed to directly prevent the formation of AMD by covering sulfide minerals with protective layers have gained attention as a promising technique. In this study, we review and introduce an advanced technique to passivate sulfide minerals for preventing AMD formation called carrier-microencapsulation (CME) developed by our laboratory. In CME, a redox-sensitive organic compound (catechol, 1,2-dihydroxybenzene) is used to transform insoluble metal(loid) ion into a soluble complex that can specifically target sulfide minerals where it is adsorbed and oxidatively decomposed. As a consequence of the complex decomposition, a relatively insoluble metal(loid) ion is released, and thus it is rapidly precipitated and forms a coating that protects sulfide mineral against further oxidation. The complex is decomposed via electrochemical reactions, so it occurs only on the surface of semi-conducting minerals like most of the sulfide minerals. Because of this apparent selectivity to sulfide minerals in complex systems like mine tailings, the amount of reagent used for CME can be dramatically reduced, which makes CME sustainable and cost-effective.

Keywords: Acid mine drainage, carrier-microencapsulation, passivation technique, sulfide-rich mine wastes