Discovery and Characterization of an Undocumented Ferric Sulfate Compound Formed by the Reaction of Gold Ore with Sulfuric Acid

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This research project aimed to identify the colored substance produced by the reaction of sulfuric acid with a specific type of gold ore that I discovered in Boulder, Colorado. The collected ore reacted with different concentrations of sulfuric acid to produce deep red and purple solutions. No reference to this reaction was found in the literature. I performed a variety of chemical analyses to characterize solutions of the unknown substance, and then developed a method to purify the solutions by refluxing the ore with sulfuric acid to leach out impurities. Repeated fractional crystallizations of the purified solutions yielded crystals of the unknown substance. The structure of the substance was then solved using single crystal X-ray diffraction, which classified it as a new ferric sulfate compound with the formula H5O2Fe(SO4)2(H2O)2. Inductively coupled plasma mass spectrometry revealed that manganese(III) was causing disordering in the lattice, which explains the strong oxidizing properties of the compound. A possible application of this new compound is that it is structurally similar to Li2M(SO4)2 (M = Co, Fe, Mn), which is a class of high potential cathode materials for lithium-ion batteries. Additionally, the compound crystallizes with repeating layers of cations and anions; this is similar to the layered structure of lithium cobalt oxide---a material used in high energy density batteries for portable electronics. Thus, the hydrogen ferric sulfate discovered may have applications in creating more efficient lithium-ion batteries. This makes the new compound a valuable candidate for future research.

Awards Won:

Intel ISEF Best of Category Award of $5,000

Air Force Research Laboratory on behalf of the United States Air Force: First Award of $750 in each Intel ISEF Category

American Chemical Society: First Award of $4,000