

Hunting the Green Lion



One of the economically most important chemicals in Tudor England (after the disastrous reign of Henry the Eighth) was **green vitriol**. It was used in so many other processes that importing it from Europe was bankrupting English industry. Monopolies in this era (16th century) were granted by the Pope in Rome (and you thought he was primarily a religious leader!). After Henry ditched the Pope, the English king could rake in the monopoly fees, but there was still the problem of expertise. England hired European chemists with a knowledge of vitriol manufacturing to get things started. The next problem was finding suitable **raw materials**. In order to be a financially rewarding process, the starting materials must be cheap. England had lots of **pyrites**. (Pyrites are sulfide minerals of the form MS_2 such as FeS_2 (fool's gold) and chalcopyrite ($CuFeS_2$) or Peacock Ore.)



Chalcopyrite

The desired product is $FeSO_4 \cdot 7H_2O(s)$. This means that a source of iron, sulfur, oxygen and water are required. The first transformation is to produce a solution of pyrites in water. Grind the chalcopyrite fine; mix with fresh “rain water;” spread out in large shallow troughs in good sunlight. The next process is the oxidation of the disulfide ion to sulfate. It was once thought that merely allowing atmospheric oxygen and sunlight to produce the oxidation was enough, but it is now known that what really made it happen in real time was a bacterium that had been latent in the mineral for perhaps millions of years. The solution now contains copper ions, iron ions (both iron(II) and iron(III), disulfide ions (S_2^{-2}), sulfate ions (SO_4^{-2}), hydrogen sulfate ions (HSO_4^-), dissolved sulfuric acid ($H_2SO_4(aq)$), and any other constituents of rain water and raw chalcopyrite. This is not suitable to crystallize out pure green vitriol. The secret was to concentrate the solution and suspend pure iron bars above the vats and heat the vat to drive off the sulfuric acid as fumes. The sulfuric acid reacts with the iron bars and the water vapor to produce green vitriol and hydrogen gas. The beautiful crystals of green vitriol are then harvested from the bars. The hydrogen gas produced by this reaction was invisible to the early alchemists.



Green Vitriol