Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.15662

Autotrophic Growth of Purple Sulfur Bacteria Enabled by Solid-Phase Metal Sulfide as Sole Electron Donors

JIE XU[1], HUGO ALARCON[2], JONATHAN MOHL[2], YI WANG[3] AND JASON WHITE[3]

[1]Arizona State University
[2]the University of Texas at El Paso
[3]The Connecticut Agricultural Experiment Station
Presenting Author: jiexu10@asu.edu

Purple sulfur bacteria (PSB), which are capable of anoxygenic photosynthesis via oxidizing reduced sulfur compounds, have been around for billions of years. While being recognized as key drivers of the sulfur cycle in a range of anoxic environments, PSB may be underestimated for their full metabolic capability and flexibility. Here we report successful autotrophic growth of *Allochromatium vinosum* using solid-phase pyrite (FeS_2) as the sole sulfur and electron-donor source. We confirmed different growth patterns of the pyrite cell cultures ("py") compared to their positive controls (containing $Na_2S{\cdot}H_2O$) in terms of doubling time and concentration profiles of dissolved sulfide, sulfate, and iron species through the experiments. Comparative analysis of transcriptomic sequencing data revealed major and extensive upregulation in genes related to cytochromes that are likely key constituents of electron transport chains in "py". By contrast, almost all genes encoding light-harvesting complex subunits (i.e., *puf* and *puc* clusters) and bacteriochlorophylls were significantly downregulated although those related to carotenoid biosynthesis were not. In terms of sulfur metabolism, genes encoding the periplasmic flavocytochrome c sulfide dehydrogenase and membrane-bound sulfide: quinone oxidoreductases are dramatically upregulated, whereas expression of most genes in the *sox* cluster were slightly upregulated and those related to cytoplasmic proteins (i.e., *dsr* and *apr* clusters) are extensively suppressed. Other top differentially expressed genes include those encoding flagellar/pilin proteins (+), metal efflux proteins (+), outer membrane receptors for ferrienterochelin (-), ribulose-bisphosphate carboxylase (-), and most [NiFe] hydrogenases (+). In "py", we also observed upregulation of key genes related to ferredoxins, iron trafficking proteins, and 4Fe-4S binding proteins but overall downregulation related to FeS assembly proteins. Transmission electron microscopic and X-ray photoelectron spectroscopic analyses of the pyrite substrate in the cell cultures confirmed presence of S^0 and polysulfide. All results combined strongly point to altered pathways in both photosynthesis and sulfur metabolism for the pyrite-supported cell cultures. The findings of this work directly impact our understanding of PSB's metabolic capability, especially their extracellular electron transfer mechanisms, and further, may provide new insight into the early-Earth biological-geological coevolution and artificial photosynthesis as well as bioelectronics designs.