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AN EXPERIMENTAL INVESTIGATION OF THE IRON-SULFUR WORLD

Anthony D. Keefe*†, Stanley L. Miller*, Gene McDonald‡§ and Jeffrey Bada‡

* Department of Chemistry and Biochemistry, University of California, San Diego, La Jolla, CA 92093, FAX: +(619)-534-6128, email: slm@ucsd.edu

‡ Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92093, FAX: +(619)-534-2674, email: jbada@ucsd.edu

† Present address: NASA Ames Research Center Moffett Field, CA 94035 FAX: +(415)-604-1088, email: tony_keefe@qmgate.arc.nasa.gov

§ Present Address: Laboratory for Planetary Studies, Space Sciences Building, Cornell University, Ithaca, NY 14853, FAX: +(607)-255-9888, email: mcdonald@astrosun.tn.cornell.edu

An autotrophic theory of the origin of metabolism and life has been proposed by Wächtershäuser (1988, 1990). In this theory carbon dioxide is reduced by ferrous sulfide and hydrogen sulfide by means of a reversed citric acid cycle, leading to the production of amino acids. Similar processes have been proposed for purine synthesis. The balanced equations and their free energies are shown below.

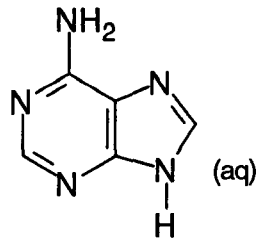
$$2\,CO_2(aq) + NH_3(aq) + 3\,FeS + 3\,H_2S(g)$$

$$\downarrow \quad \Delta G = -38.8 \text{ kcal/mol}$$

$$H_3N^{+}\text{–}CH_2\text{–}COO^{-}(aq) + 2\,H_2O(l) + 3\,FeS_2$$

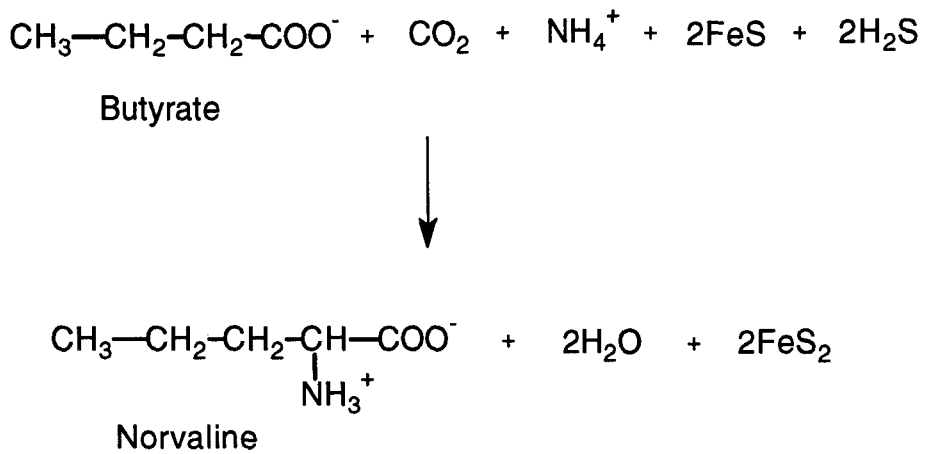
$$5\,CO_2(aq) + 5\,NH_3(aq) + 5\,FeS + 5\,H_2S(g)$$

$$\downarrow \quad \Delta G = -45.3 \text{ kcal/mol}$$



(aq) + 10 $H_2O(l)$ + 5 FeS_2

Ferrous sulfide is a strong reducing agent in the presence of hydrogen sulfide (Garrels and Christ, 1965) and can produce hydrogen (Drobner et al., 1990) as well as reduce alkenes, alkynes, and thiols to saturated hydrocarbons (Blochl et al., 1992) and ketones to thiols (Kaschke et al., 1994). However, the reduction of carbon dioxide has not been demonstrated. We show here that no amino acids, purines or pyrimidines are produced ($<10^{-4}\%$) from carbon dioxide or carbon monoxide with the ferrous sulfide and hydrogen sulfide system despite the fact that the free energies for these transformations are favorable. Furthermore, this system does not produce amino acids from carboxylic acids by reductive amination and carboxylation ($<10^{-6}\%$).



Thus the proposed autotrophic theory, using carbon dioxide, ferrous sulfide and hydrogen sulfide, lacks the robustness needed to be a geological process, and is therefore unlikely to have played a role in the origin of metabolism or the origin of life.

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