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Harnessing Energy from Stellar Radiation to Build Chemical Complexity for Life

V. Vaida[1], R. J. Rapf[1], and R. J. Perkins[1]
[1]University of Colorado Boulder, Boulder CO 80309-0215
*Vaida@colorado.edu

Identification of cosmic bodies that maintain environments suitable for the evolution of life necessitate understanding the key characteristics of habitable environments and the chemical mechanisms involved in the generation of biomolecules that are signatures of life. Taking the known example of life on Earth, we assume that the presence of liquid water is a necessary condition for a habitable environment, and focus on the development of carbon-based life on a body illuminated by light from a near-by star. Conversion of energy or energy transduction to form high-energy chemical compounds able to drive metabolic cycles is critical in the synthesis and regulation of the chemical components required for an organism to survive. This presentation will use as input of energy an external nearby star as shown in Figure 1 [1]. The existence of this type of high-energy molecule inherently implies a system that is chemically out of thermodynamic equilibrium, and requires an energy input from an external, non-molecular source.

This presentation discusses results of our laboratory experiments modeling the use of sunlight to generate abiotically the chemical complexity needed for the synthesis of biopolymers necessary for life. Specifically, the reactivity of high-energy molecules that are precursors to metabolism as it has evolved in life on Earth will be discussed. The photochemical synthesis and reactivity of complex organic systems under conditions representative of early Earth will be presented.

The photochemistry of pyruvic acid under a variety of terrestrial conditions was investigated observing that product yields vary considerably with reaction environment and that, under some conditions, in the presence of water, an increase in chemical complexity is observed. Pyruvic acid will be discussed as a critical molecule in the development of protometabolic pathways, capable of abiotic energy transduction and central to current metabolism.

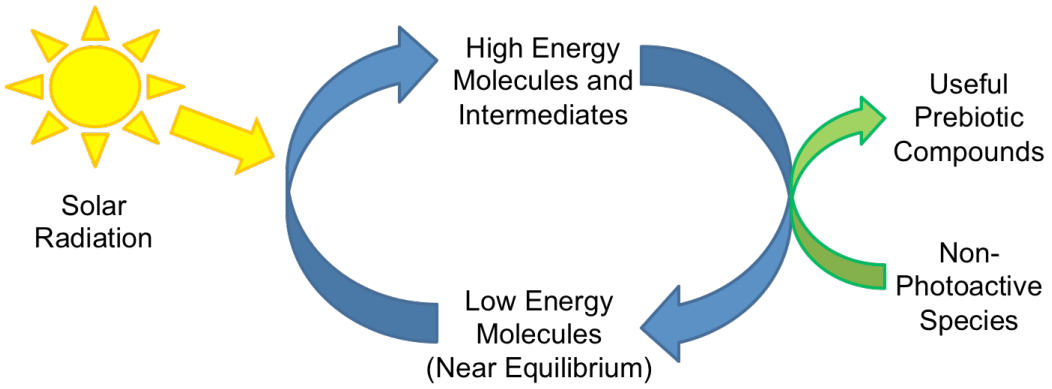

Figure 1 – Schematic of the transduction of energy by photochemistry to sustain metabolism.[1]

References:

[1] Rapf, RJ and Vaida V (2016) *Physical Chemistry and Chemical Physics* 18:20067-20084.