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# Alkaline hydrothermal vents as electrochemical reactors driving an autotrophic origin of life

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**Introduction:** Hadean alkaline hydrothermal vents have been proposed as electrochemical reactors driving an autotrophic origin of life [1, 2]. Theoretical thermodynamics show that the abiotic synthesis of biomass from $H_2$ and $CO_2$ is indeed favoured under these conditions [3]. But $CO_2$ reduction is kinetically extremely tardy, casting doubt on the feasibility of this mechanism. Given that almost all extant life grows by hydrogenating $CO_2$, this question is of central importance to the autotrophic origins hypothesis. We are examining the possibility that geochemical proton gradients across inorganic Fe(Ni)S barriers, analogous to autotrophic cells, could have driven $CO_2$ reduction at the origin of life in alkaline hydrothermal vents.

Here we report the successful reduction of $CO_2$ to formaldehyde ($CH_2O$) under simulated alkaline hydrothermal conditions without the aid of organic catalysts, by tapping the free energy of a pH gradient across Fe(Ni)S barriers. We confirm that $CH_2O$ can be transformed under these conditions into biotically relevant sugars via the formose reaction, discovered by Butlerow in 1861. Acetyl phosphate can be synthesised from inorganic phosphate and thioacetic acid, and will phosphorylate organic molecules such as sugars and amino acids, making it a plausible primordial energy currency equivalent to ATP [4]. Following Mellersh & Smith [5], we show that acetyl phosphate can redirect the formose reaction towards biotically relevant sugars such as ribose at high yield. Overall, our results show that alkaline hydrothermal conditions could drive the synthesis of biologically relevant sugars such as ribose from $H_2$ and $CO_2$.

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