Proton motive force for the electrochemical CO_2 fixation toward the origin of life in deep sea hydrothermal vent

A. YAMAGUCHI[1], M. YAMAMOTO[2], K. TAKAI[2], T. ISHII[3], K. HASHIMOTO[3*], R. NAKAMURA[1*]

[1]RIKEN, Saitama 351-0198, Japan (correspondence: ryuhei.nakamura@riken.jp)
[2]Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokosuka, 273-0061, Japan
[3]The University of Tokyo, Tokyo, 113-8656, Japan (correspondence: hashimoto@light.t.u-tokyo.ac.jp)

"How did first carbon fixation occur and was it maintained?" is one of the key issues to understand the origin of life, and our group has proposed the electrochemical synthesis of the organic compounds from CO_2 in deep sea floors with the aid of the pH gradient (proton motive force: PMF) across the chimney wall [1-4]. At hydrothermal vents, the highly reductive (alkaline) hydrothermal fluid and acidic sea water are separated by the electron-conductive chimney wall composed of iron sulfide minerals, resulting in the electrical current generation through the wall and the current flow promoted the electrochemical CO_2 reduction on the surface of iron sulfide minerals.

To obtain the kinetic information of the organic synthesis on the surface of metal sulfides, we examined the electrochemical CO_2 reduction properties of iron sulfides [3,4]. Based on the obtained results, we proposed that 200 mV of PMF (pH difference of ~4) is necessary to promote the prebiotic organic synthesis. Furthermore, the pH-homeostasis mechanism required for sustainable organic sysnthesis was also proposed based on the hydrogen storing property of iron sulfides.

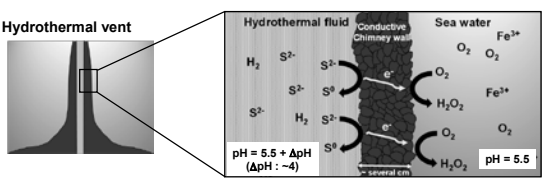

Figure 1: Proposed model for the deep sea electrical current generation system [1,2] and required pH difference [3,4].

[1]R. Nakamura *et al*. (2010) *Angew. Chem. Int. Ed.,* **49**, 7692-7694. [2]M. Yamamoto *et al*. (2013) *Angew. Chem. Int. Ed.,* **52**, 10758-10761. [3]A. Yamaguchi *et al*. (2014) *Electrochim. Acta* **141**, 311-318. [4]A. Yamaguchi *et al*. (2016) "CO_2 Reduction Using an Electrochemical Approach from Chemical, Biological, and Geological Aspects in the Ancient and Modern Earth", *Solar to energy conversion*, *Springer* **32**, 213-228