微生物外膜タンパク質内の多核ヘム電子移動鎖配向の差分円偏光二色性測定を用いた直接追跡

In situ whole-cell circular dichroisms difference spectroscopy for observation of multi-heme alignment in transmembrane electric conduit

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Recent advances of biochemical techniques enable the integration of biological molecules into fabricated electronic circuits. Ion channels and pumps have been the target biological molecules due to their ability to control signal transduction with high efficiency [1]. Given biological system utilizes electrons as well as ions to generate electric signal across membrane, transmembrane-electron transport proteins may have a chance to be applied to electric devices.

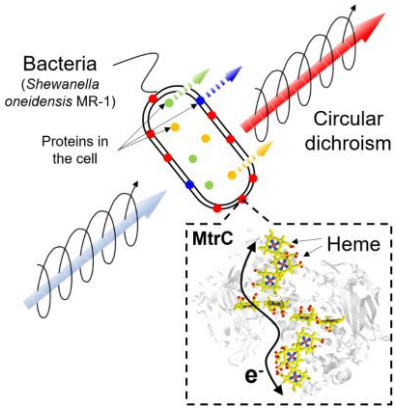

Figure. Schematic illustration of circular dichroism (CD) difference spectroscopy applied to bacteria reflecting the conformation of hemes in MtrC protein.

Outer membrane *c*-type cytochromes complex (OM *c*-Cyts) in an iron-reducing bacterium, *Shewanella oneidensis* MR-1, mediates efficient electron conduction with a rate constant of 10^4~10^5 electrons per second along a distance over 100 Å [2]. While the crystal structure of a unit of OM *c*-Cyts (e.g. MtrC protein in Figure) [2], has been well investigated, the OM *c*-Cyts requires membrane to act as electron conduits. Therefore, toward the use of membrane protein complex in bioelectronics, it is critical to establish a methodology to directly monitor the heme arrangement in OM *c*-Cyts complex associated with membrane.

In this study, we established whole-cell circular dichroism (CD) difference spectroscopy using bacteiral cells, wild-type bacteria and mutant strain lacking the gene for MtrC, to identify the inter-heme interaction in membrane-bound MtrC protein (Figure) [3]. Our data showed that the heme geometry of MtrC in reduced state changes specifically in membrane-bound protein complex conditions. Given the heme alignment strongly affects the rate of electron transport, conformational flexibility of electron conduit may have an essential role in promoting efficient biological electron conduction. In the presentation, we will discuss about the impact of electron flow rate on the heme geometry in MtrC by using whole-cell electrochemistry combined with CD spectroscopy.

References

[1] N. Misra *et al, Proc. Natl. Acad. Sci. U.S.A.* **2009**, 106(33), 13780 [2] M. J. Edwards *et al, Sci. Rep.* **2015**, 5, 11677 [3] (a) Y. Tokunou *et al., Chem. Commun.* **2018**, 54, 13933-13936 (b) Y. Tokunou and A. Okamoto, *Langmuir* in press (DOI: 10.1021/acs.langmuir.8b02977)