【Grant-in-Aid for Specially Promoted Research】

Science and Engineering (Chemistry)

Title of Project : Pioneer the Physical Chemistry of Biological Electron Transfer based on Bacterial Extracellular Electron Transport

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Research Area : Physical Chemistry
Keyword : Extracellular ET, Metabolic Control, Energy Conversion with Microbes

【Purpose and Background of the Research】

Biological processes consist of intricate chains of various redox proteins that mediate highly efficient and functionalized intracellular energy conversion and production. Thus, one of the central goals of this proposed research project is to clarify the nature of these reactions from a physical chemistry perspective to better understand biological electron transfer (ET) in living systems.

Up to now, physical chemistry studies on biological ET were strictly limited to the available model systems, such as bi- and tri-molecular redox compounds, or purified proteins. However, using the metal-reducing bacterium, *Shewanella*, as a model species to study *in-vivo* ET, we have demonstrated that synthetic compounds and purified proteins behave differently than *in-vivo* protein complexes, as proteins embedded in a lipid membrane function together as a whole and their properties are largely influenced by equilibrium shifts in the whole-cell system. Building on our previous achievements, herein we investigate biological ET, with emphasis being placed on the physicochemical understanding of the flexible, reversible, and dynamic responses of living organisms to external stimuli, which are the important characteristics of living systems.

【Research Methods】

We utilize the *in-vivo* spectroscopic and electrochemical techniques recently developed in our laboratory for the study of microbial extracellular electron transfer (EET). The following three techniques are employed to deepen our understanding of the ET process in living organisms

(1) Whole-microorganism electrochemistry with a three-electrode system to examine EET pathways and dynamics under physiological conditions.

(2) UV-vis evanescent wave spectroscopy for monitoring the electronic state of cytochromes (*c*-Cyts) located at the cellular membrane/electrode interface in the course of microbial current generation.

(3) To photochemically control photo-inactive proteins, such as the *c*-Cyts of *Shewanella*, we will employ the coordination of CO to hemes, as the iron-bound CO ligand dissociates from hemes upon visible-light irradiation.

(4) In-frame deletion mutants of OM and periplasmic *c*-Cyts to determine the specific location of proteins responsible for the respiratory EET chain.

【Expected Research Achievements and Scientific Significance】

The molecular spectroscopic and whole-cell electrochemical techniques developed in our group will aid physical chemists to investigate ET in living organisms. We speculate that the study in this direction is an important precondition to cultivate and advance the emerging research field of "Bacterial EET", and will serve as an important first step in pioneering a new field of ET in living systems.

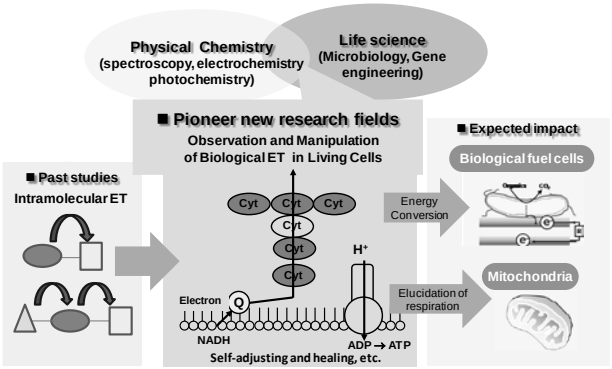

Figure 1. An overview of the direction of our proposed research project

【Publications Relevant to the Project】

・Angew.Chem.Int.Ed, 2011, 50, 9137.
・Chem.Commun. 2011, 47, 3870.
・Angew.Chem.Int.Ed, 2010, 49, 6596.
・Angew.Chem.Int.Ed, 2010, 49, 7692.
・ChemBioChem. 2010, 11, 643.
・Angew.Chem.Int.Ed, 2009, 48, 1606.
・Angew.Chem.Int.Ed, 2009, 48, 508.

【Term of Project】 FY2012-2016

【Budget Allocation】 394, 500 Thousand Yen