【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Chemistry)

Title of Project : Quest for Fundamental Principles in Photoinduced Charge Separation and Their Application

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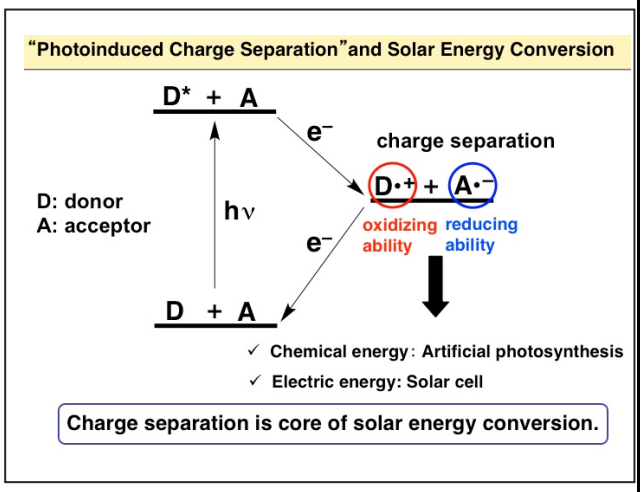
Research Area : Organic Chemistry, Photochemistry
Keyword : Photoinduced electron transfer, Porphyrin, Nanocarbon, Solar cell, Optogenetics

【Purpose and Background of the Research】

Photoinduced charge separation (CS) is core of solar energy conversion. For instance, photoinduced electron transfer (ET) occurs from donor (D) excited state to acceptor (A), generating a charge-separated state consisting of donor radical cation and acceptor radical anion. The donor radical cation has oxidizing ability, whereas the acceptor radical anion has reducing ability. Thus, they can be used for material conversion (artificial photosynthesis) as well as electric energy conversion (solar cell).



We have made outstanding contribution to photoinduced CS. Namely, We have proposed and demonstrated, for the first time, that the acceleration of photoinduced CS and the deceleration of charge recombination in donor-fullerene systems arise from intrinsic small reorganization energies of fullerenes. This finding allowed us to produce long-lived charge-separated state efficiently in donor-fullerene linked systems. The breakthrough has led us to a number of world records in photoinduced CS. We have further extended the concept to develop novel supramolecular photovoltaic cells as well as highly efficient porphyrin-sensitized solar cells.

Our comprehensive researches revealed that the linker structures in the porphyrin–nanocarbon covalent composites have a large impact on their optical and photophysical properties. Specifically, moderate length-spacers between donor and acceptor would be essential to produce a long-lived charge-separated state efficiently. As such fast decay of photoinduced charge-transfer (CT) states (i.e., exciplex state) to the ground state has been often observed in not only simple D-A linked systems, but also more complex dye-semiconducting electrode interface for dye-sensitized solar cells and D-A mixed interface for organic thin film solar cells, integrated views and interpretation on the undesirable unique phenomena should be developed to give us universal guideline on efficient photoinduced CS even without losing some fraction of the charge-separated state.

【Research Methods】

Our aim of this project is to establish basic principles in photoinduced CS to develop next-generation photoinduced CS. We will focus on systematic control of electronic coupling in D-A linked molecules as well as organic thin film solar cells, and control of living cell by photoinduced CS.

【Expected Research Achievements and Scientific Significance】

On the basis of obtained fundamental principles in photoinduced CS, we expect we will develop highly efficient organic solar cells as well as novel optogenetic method using charge-separated state.

【Publications Relevant to the Project】

1) T. Umeyama and H. Imahori, *J. Phys. Chem. C* (Feature Article) **2013**, *117*, 3195-3209.
2) Y. Mori, H. Imahori et al., *J. Am. Chem. Soc.* **2012**, *134*, 6092-6095.

【Term of Project】

FY2013-2017

【Budget Allocation】

167, 300 Thousand Yen

【Homepage Address and Other Contact Information】

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