【Grant-in-Aid for Specially Promoted Research】
Science and Engineering (Chemistry)

Title of Project : Synthesis and Nano-organization of Organic Semiconductors for Efficient Photoelectronic Conversion

Eiichi Nakamura
(The University of Tokyo, School of Science, Professor)

Research Area : Physical Organic Chemistry, Organic Synthesis, Organic Electronics
Keyword : π-Electronic System, Fullerene, Organic Semiconductor, Thin-film Structure, Organic Thin-film Photovoltaic Cells

【Purpose and Background of the Research】

Because of the infinite diversity of organic semiconductor molecules and the structures they form, the design of efficient organic thin-film solar cells consisting of various organic compounds with different functions is an exciting new challenge for the chemist. Because the efficient use of solar energy has an intimate connection with the survival of human beings, this is an important research topic in which chemists should play a positive role. Unlike the pharmaceutical and agricultural applications of organic chemistry, which have existed for a long time, its full-scale application to electronic technology is only just beginning.

Based on the new guideline in organic electronics, "finding functional molecules with new reactions," this project aims to design and synthesize planar π-conjugated molecules with semiconductor properties and spherical fullerene derivatives to develop methods of controlling the structure of these molecular entities at the nanosize level, and successfully to achieve the production of efficient organic thin-film solar cells.

【Research Methods】

The "small molecule-based solution processable organic thin-film solar cells" in this research have many superior features compared with conventional organic thin-film solar cells in regard to various factors such as durability and diversity of material design. The following topics are addressed in this project: (1) finding organic semiconductor molecules and undertaking their molecular design and synthesis; (2) fabricating layered nanostructure devices; and (3) analyzing the nanostructure of these semiconductor materials (molecular-level analysis of aperiodic structures). By combining these topics, we hope to develop highly efficient, highly durable, new organic thin-film solar cells at low cost.

【Expected Research Achievements and Scientific Significance】

The "design of highly functional semiconductor molecules," "full layering of molecular structures from nanoscale to macroscale," and "molecular-level analysis of aperiodic structures," which has never been seriously attempted in chemistry research until now, are key to this research, and are expected to lead to the opening up of new fields of basic science. If the organic solar cells developed in this research reach the level of practical utilization, they would make an invaluable contribution towards solution of the energy crisis.

【Publications Relevant to the Project】

・"Columnar Structure in Bulk Heterojunction in Solution-Processable Three-Layered p-i-n Organic Photovoltaic Devices Using Tetrabenzoporphyrin Precursor and Silylmethyl[60]fullerene", Y. Matsuo, Y. Sato, T. Niinomi, I. Soga, H. Tanaka, E. Nakamura, *J. Am. Chem. Soc.*, **131**, 16048-16050 (2009).
・"Bis(carbazolyl)benzodifuran: A High-mobility Ambipolar Material for Homojunction Organic Light-emitting Diode Devices", H. Tsuji, C. Mitsui, Y. Sato, and E. Nakamura, *Adv. Mater.*, **21**, 3776-3779 (2009).
・"Imaging Single Molecules in Motion", M. Koshino, T. Tanaka, N. Solin, K. Suenaga, H. Isobe, and E. Nakamura, *Science*, **316**, 853 (2007).

【Term of Project】 FY2010-2014

【Budget Allocation】 458,700 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.chem.s.u-tokyo.ac.jp/users/common/NakamuraLab.html