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

Title of Project：Development of Ionic Liquids for Bioscience

Hiroyuki Ohno
(Tokyo University of Agriculture and Technology,
Institute of Symbiotic Science and Technology, Professor)

Research Area：Chemistry

Keyword：Biofunctional Devices

【Purpose and Background of the Research】

The salts, consist of designed ions, realize an extremely low melting point. They become liquid at room temperature known as ionic liquids (ILs). Since ILs possess very different characteristics from those of molecular liquid, they are extensively studied as new reaction solvents, functional liquids, and so on. Based on the structural diversity of organic ions, we aim to design ILs to contribute to the biosciences. For example, biochemistry in non-aqueous system should be developed instead of water-based one. Especially, the final goal is to establish basic science for the non-aqueous biomass fuel cells to overcome the energy crisis in the future and that for the cell device that can be operated stably under air.

Followings are concrete aims of this study.
(1) to develop ILs to extract useful substances such as cellulose from biomass without heating
(2) to convert the cellulosic materials into glucose or cellobiose by using enzymes that were designed to work in the IL
(3) to construct non-aqueous biofuel cells using a wide variety of biomass as energy sources
(4) to design ILs that can maintain cell activity under air to establish the basis for cell device technology under air

【Research Methods】

We will clarify the correlation between structure and properties of the salts or their component ions, to design some functional ILs. Highly polar ILs will be used to extract cellulose from biomass. Our original IL database should be effective for this process. Similarly, we will design ILs as solvent for many natural polymers.

We will investigate the methodology to solubilize enzymes in the IL or fix them on the electrode. The required factors should be clarified to keep higher-ordered structure of the enzymes in the IL. Not only the direct solubilization, chemical modification of amphiphiles to the enzymes should also be examined to improve the solubility in many IL.

We will also develop a novel methodology to keep functions of insect cells or myocardial cells in ILs and to investigate the array patterned cells for cell actuator under air. This is very challenging subject and this might be impossible with pure ILs, and we will use mixtures of ILs and molecular liquids.

【Expected Research Achievements and Scientific Significance】

We aim to establish "the science based on ILs" which was impossible with the molecular liquids in the past. For example, generation of energy from biomass generally needs three steps, i.e., to extract cellulose from biomass, to decompose it into glucose, and to generate energy directly with the aid of enzymatic reactions. It can be carried out with one-pot in the designed ILs. It should be an energy saving process and large quantities of biomass wastes should be used as new energy sources.

Additionally, to maintain the cell function is long believed to be possible in aqueous phase, but that in non-water system should lead to build a biomicro-actuator driven under air.

As described above, our proposal would change the blindly believed idea of “water is essential for proteins and other biological systems”. To apply ILs for a wide variety of biomaterials should open and to establish the new science based on both biotechnology and ionic liquids.

【Publications Relevant to the Project】

・H. Ohno and K. Fukumoto, “Amino acid ionic liquids” *Accounts of Chemical Research*, **40**, 1122-1129 (2007).
・H. Ohno Ed., ”Electrochemical Aspects of Ionic Liquids” Wiley Interscience, New York (2005).

【Term of Project】 FY2009-2013

【Budget Allocation】 145,600 Thousand Yen

【Homepage Address and Other Contact Information】

http:// www.tuat.ac.jp/~ohno/index.html