【Grant-in-Aid for Transformative Research Areas（B）】

Science of Active Ion-Rich Liquids（Active Ion-Rich Liquids）

Head Investigator	Osaka University, SANKEN, Professor YAMADA Yuki　　Researcher Number:30598488
Research Area Information	Number of Research Area : 23B207　Project Period (FY) : 2023-2025 Keywords : Active ion-rich liquids, interface, electrochemistry, liquid science

Purpose and Background of the Research

●Outline of the Research

Functional liquids containing reactive ions (active ions) are used as electrolytes for Li-ion batteries and solvents/catalysts for organic and inorganic chemical reactions. Recently, “active ion-rich liquids”, which contain super-dense active ions, have revolutionized Li-ion batteries. In Li-ion batteries, an active ion-rich liquid is defined as a concentrated electrolyte solution containing dense active Li ions that are involved in the battery reaction (Figure 1). The active ion-rich liquids, being in the boundary between typical solutions and ionic liquids, have both high reaction activity and high chemical stability, thus not only enhancing the battery performance and safety but also realizing new battery concepts. Besides, this liquid materials concept is being applied to solvents/catalysts in organic/inorganic chemistry to realize unprecedented “dissolution processes” and “chemical reactions”. Despite such high social and industrial value, it is still unclear why active ion-rich liquids exhibit unique functions.

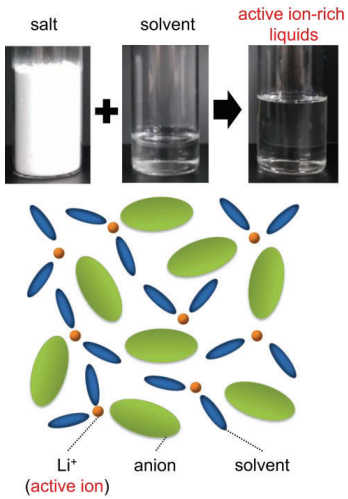

Figure 1. Active ion-rich liquids as a Li-ion battery electrolyte.

We aim to establish an integrated concept of active ion-rich liquids (Figure 2). We will design and synthesize new active ion-rich liquids with novel liquid functions for diverse applications. In addition, we will scrutinize the structure and behavior of active ion-rich liquids and interfaces based on physical/electro/organic/inorganic chemistry. Our final goal is to create a new academic field “Science of Active Ion-Rich Liquids” that will enable us to control liquid functions for various applications.

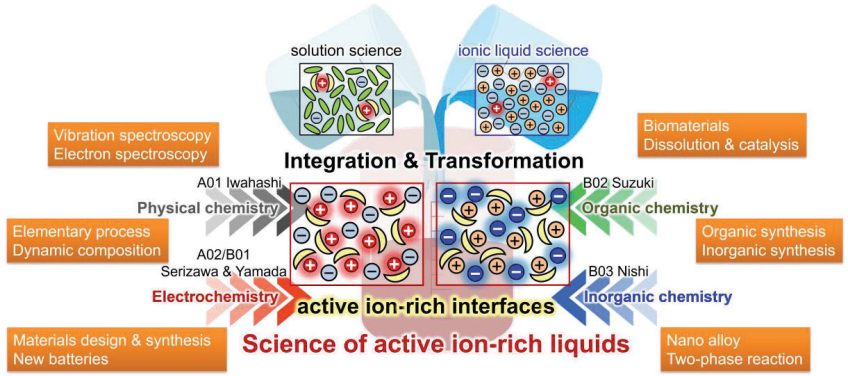

Figure 2. Outline of the research.

Expected Research Achievements

We commit to establishing the broad and deep knowledge of “active ion-rich liquids” with a focus on the “active ion-rich interfaces (Figure 3)” that give rise to their unique properties. The goal of this research is to create “Science of Active Ion-Rich Liquids” that enables us to develop new functions of liquid materials for a wide range of applications. Group A [Fundamentals] pursues the unique functions of active ion-rich liquids and interfaces at a molecular scale from the viewpoints of physical chemistry and electrochemistry. Group B [Applications] explores new functions and applications of active ion-rich liquids in electrochemistry, organic chemistry, and inorganic chemistry.

A1: IWAHASHI Takashi (Tokyo Tech)
Physical chemistry of active ion-rich liquids based on surface scientific approach
The dissolution processes and chemical reactions at the active ion-rich interfaces will be investigated at a molecular scale via interface-sensitive vibrational and electronic spectroscopies to establish fundamental physical chemistry of active ion-rich liquids.

A2: SERIZAWA Nobuyuki (Keio Univ.)
Tracing active ion-rich interfaces using fundamental electrochemistry approach
The origin of unique functions and properties of active ion-rich liquids will be unveiled by analyzing the local and dynamic liquid structure at the active ion-rich interfaces and scrutinizing its impact on interfacial ion transfer and crystal growth/dissolution.

B1: YAMADA Yuki (Osaka Univ.) and OKA Kouki (Osaka Univ.)
Design and synthesis of active ion-rich liquids for applied electrochemistry
New functional active ion-rich liquids will be designed and synthesized, and the origin of their unique electrochemical functions will be elucidated to establish a scientific basis for novel rechargeable batteries (Figure 4) and energy conversion devices.

B2: SUZUKI Shiori (Hokkaido Univ.) and KURODA Kosuke (Kanazawa Univ.)
Creating organic reaction fields based on an essential understanding on the dissolution and catalytic abilities of active ion-rich liquids
Fundamental science on the multifunctional active ion-rich liquids in organic reactions will be established to develop active ion-rich organic reaction fields that can dissolve poorly soluble organic compounds and induce highly selective catalytic reactions.

B3: NISHI Naoya (Kyoto Univ.)
Pioneering inorganic reactions in active ion-rich liquids: creation of nanostructured base metals
An active ion-rich liquid | oil interface will be designed and developed, and its basic science will be established to achieve unprecedented inorganic chemical synthesis of base metal nanomaterials.

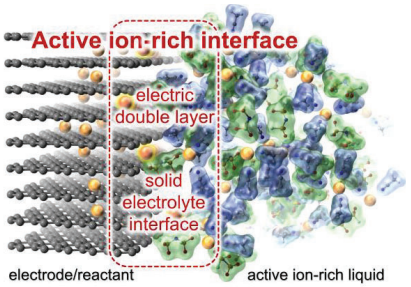

Figure 3. Active ion-rich interface (reaction field).

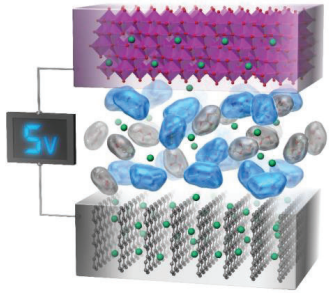

Figure 4. High-voltage rechargeable battery realized by active ion-rich liquids.

Homepage Address, etc.	https://active-ions.jp