R&D for Safe and Reliable Solvent-free Lithium-Ion Polymer Batteries

Background and Objective

Research and development of large size rechargeable battery for the main power source of advanced electric vehicles, stabilized power sources of photovoltaic and wind power systems are expected to contribute to a low-carbon society.

On this subject, CEIEPI is developing a solvent-free lithium-ion polymer battery (LIPB) which exhibits high energy efficiency and reliability. The target area of the battery is stationary use to correspond the highly diffused renewable energy in the system. In 2009FY, the improvement operation life of anode and rate properties of cathode characteristics was reported. In addition, energy density calculation procedure of the kWh-scale battery module was developed and validated the procedure to apply the conventional lithium-ion battery (LIB).

Main results

1. Trial production of flat-type LIPB using electrode coating system

Flat-type LIPB was fabricated using electrode coating system in the dry room (dew point of <-70 ºC) at the Akagi Testing Center (Fig.1).

2. Improvement of rate properties of cathode in LIPB

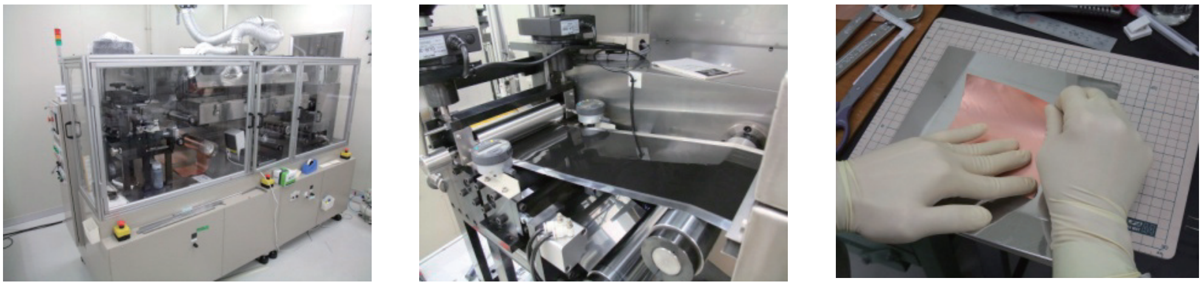
A cathode/solid polymer electrolyte (SPE) interface was optimized by adjusting the lithium salt concentration in the SPE (minimum region in Fig.2). Although the optimized salt concentration was inconsistent to that of ionic conductivity in the polymer electrolyte, we confirmed that the battery performance was ruled by the optimized condition of cathode/SPE interface (Fig.3) [Q09001].

3. Improvement of cycle properties of carbon anode by the modification of electrode components

Binder material in the anode electrode was changed from conventionally used PVDF to SBR. The carbon anode using SBR binder and SPE exhibited 700 cycles long cycle performance and it was twice as long as that using PVDF binder (Fig.4) [Q09010].

4. Energy density estimation of LIB

Energy density estimation procedure of LIB was proposed by integrating electrode and current collector material thickness, density, etc. The estimated maximum energy density of LIB using conventional electrode materials was 20% higher than that of commercially available LIB with the highest energy density, and 2-3 times higher than that of LIB for electric vehicles. Further higher energy density battery than LIB system was estimated using LIPB (Fig.5). Therefore, developing LIPB exhibited a potential for higher energy density than that of conventional LIB with reliability [Q09006].



[Electrode coating system] [Cathode coating step] [Electrode laminating step]

Fig. 1 LIPB preparation equipments in the dry room and schematic of prototype flat-cell preparation

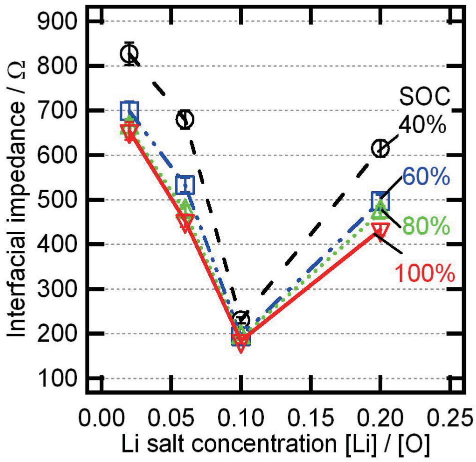
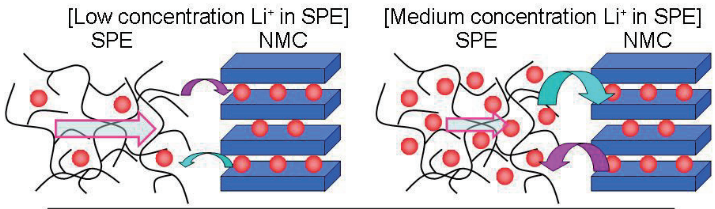


Fig. 2 Relationship between Li salt concentration in SPE and cathode / SPE interfacial impedance

Minimum interfacial impedance was found at a ratio of [Li] / [O]=0.1 at any state of charge (SOC).



Li+ conc. in SPE	Li⁺ mobility in SPE	Li+ mobility at SPE/NMC interface	Cell rate performance
Low	◎	△	△
Medium	○	◎	◎
High	△	○	○

Fig. 3 Main factor image of cell rate performance

Li+ mobility at cathode / SPE and rate performance showed maximum value at a ratio of medium concentration of Li+ in SPE.

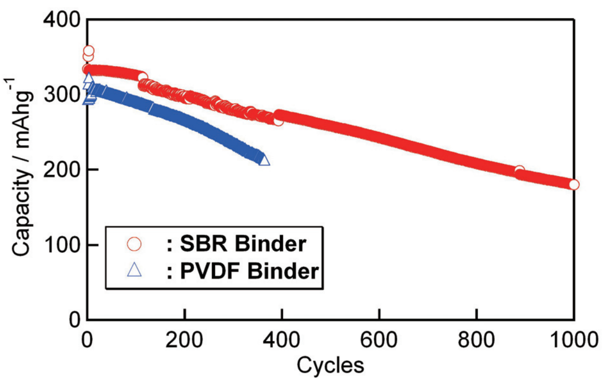


Fig. 4 Capacity retention versus operation cycles of carbon anode using different binders

PVDF: Polyvinylidene difluoride

SBR: Styrene-butadiene rubber

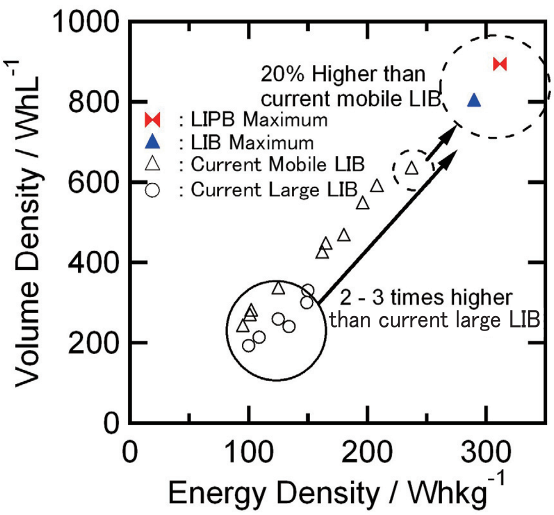


Fig. 5 Energy and volume densities of LIB and LIPB

Energy and volume densities of various LIB and LIPB were evaluated using developed cell energy density estimation procedure.