Battery Technology Award Address:
"Role Assigned Electrolytes"

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Introduction

The role of liquid electrolytes in lithium-ion cells is to act as an ionic conductor to transport lithium ions back and forth between positive and negative electrodes as the cells are charged and discharged. Since the electrodes in lithium-ion cells are the porous composite electrodes, consisting of an active material (carbon in the negative electrode and lithium transition metal oxide in the positive electrode, respectively), a conductive material, and a polymer binder, the liquid electrolyte must seep into the porous electrodes and transfer lithium ions smoothly at the interfaces between the liquid and solid phases. Most lithium-ion cells available in the market utilize nonaqueous electrolyte solutions, where lithium salts are dissolved in aprotic organic solvents. The gelled electrolytes used in lithium-ion polymer cells are also regarded as a liquid electrolyte immobilized with a high molecular weight polymer. Therefore, the same functions are required for the liquid and gelled electrolytes to greater or lesser degrees.

There are many books reviewing the liquid electrolytes for lithium or lithium-ion cells, where the various properties of aprotic solvents, lithium salts, and their mixtures are described [1-11]. The author also reviewed them mainly from the aspect of solution chemistry [12-16]. However, recent researches in the liquid electrolytes are mainly focused on the electrolyte additives, which add extra functions to the liquid electrolytes besides a fundamental function as an ionic conductor. The author attempted to outline the electrolyte additives by classifying them into several categories [17-20], although the fragmented information on the additives began to appear in the recent reviews [8,9,21]

Role Assigned Electrolytes

Most of the liquid electrolytes used in the commercial lithium-ion cells are the nonaqueous solutions, in which roughly 1 mol dm^{-3} of lithium hexafluorophosphate ($LiPF_6$) salt is dissolved in the mixture of carbonate solvents selected from cyclic carbonates (ethylene carbonate and propylene carbonate) and linear carbonates (dimethyl carbonate, ethyl methyl carbonate, and diethyl carbonate). Many other solvents and lithium salts have limited applications, although much effort has been made to develop new materials. Into the above base electrolyte solutions, a small amount of the additives are dissolved, which are so-called "functional electrolytes".

We have been developing various new additives by classifying them into the following several categories from their working mechanisms. A specific role is assigned to each additive. A set of specific functions are granted to the liquid electrolytes by formulating each additive at an optimum concentration. These can be called as "role assigned electrolytes".

(1) Anode passivation film forming agents
(2) Cathode protection agents
(3) Overcharge protection agents
(4) Wetting agents
(5) Flame retardant agents
(6) Others

In addition to the information in the literature, the author will explain the additive effects of every category by showing our experimental results.

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