New Gel-type Polymer Electrolyte for Rechargeable Lithium Batteries

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Polymer electrolytes have been actively studied for use in rechargeable lithium batteries, because the use of a polymer electrolyte makes the fabrication of safe and thin batteries possible. Much research has been devoted to the development of solid polymer electrolytes of poly(ethylene oxide) (PEO) with high conductivity. However, the conductivity of the solid polymer electrolyte of PEO type is still too low for practical battery operating at room temperature. Therefore so-called polymer gel electrolytes (pge) that contain considerable amounts of solution within the polymer matrices have been examined as more promising materials for the practical usage. Recently the pges based on polyethylene oxide (PEO), polyacrylonitrile (PAN), polymethyl methacrylate (PMMA) and polyvinylidene fluoride (PVDF) with ionic conductivities of 1mS/cm at room temperature have been prepared and applied for lithium batteries. Among them the PVDF has been the most commonly studied and the lithium batteries using PVDF pge have already been mass-produced since 1999. As for the fluorine-contained polymer materials that have now been widely used, there remains a problem concerning the treatment after the cells are used, since fluorine is a component constituting the polymer matrix. It is therefore desired to provide a nonhalogen-type polymer electrolyte to batteries, superior to those of the fluorine-contained pge. PAN, PEO and PMMA polymer materials are candidates of the nonhalogen- type pge. However, these self-supported films are not capable of absorbing and holding large amounts of the electrolytic solution unlike the film of PVDF- type, and cannot be used by being simply sandwiched as a self-supported film electrolyte between the anode and the cathode when fabricating the cell. In order to solve the above-mentioned problems, we pay attention to polyolefin materials which are chief components of the separator materials, but those were not so far regarded as an pge one, because those are originally not capable of absorbing and holding organic solvents used for the lithium batteries. Oyamafs group has previously discovered that a diacrylate compound having oligo (oxyethylene) groups at both terminals thereof and grafted with PMMA, exhibits a property of transporting lithium ions, and that compatibility is markedly enhanced between the polymer chain thereof and the electrolytic solution. The present paper has paid attention to a carboxylic acid-containing polyethylene copolymer as a polyolefin and succeeded in making ester it with a polyethylene oxide having hydroxyl group at one terminal thereof to introduce the polyethylene oxide like a comb into the polyethylene side chains. Electrolytic properties of the resulting polymer (Abbreviated as OMD polymer) have been examined. As a result, it was found that the polymer can be easily formed into a self-supported film and exhibits properties for absorbing and holding large amounts of the electrolytic solution used in the lithium batteries. For example, the electrolyte absorbing 1.0M LiPF6 solution of ethylene carbonate and dimethyl carbonate mixture has a high ionic conductivity of 1.5-4.3 mS/cm at 20C, even if 1.1mS/cm at 0, and makes it possible to provide a cell which has excellent charge/discharge characteristics at low temperature as well as at high temperature.