Mixed-Salt/Ester Electrolytes for Low-Temperature Li⁺ Cells

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Electrolytes comprising, variously, LiPF₆ or LiPF₄ plus LiBF₄ dissolved at various concentrations in mixtures of alkyl carbonates and alkyl esters have been found to afford improved low-temperature performance in rechargeable lithium-ion electrochemical cells. These and other electrolytes have been investigated in a continuing effort to extend the lower limit of operating temperatures of such cells. This research at earlier stages, and the underlying physical and chemical principles, were reported in numerous previous NASA Tech Briefs articles, the most recent being “Ester-Based Electrolytes for Low-Temperature Li-Ion Cells” (NPO-41097), NASA Tech Briefs, Vol. 29, No. 12 (December 2005), page 59. The ingredients of the solvent mixtures include ethylene carbonate (EC), ethyl methyl carbonate (EMC), methyl butyrate (MB), and methyl propionate (MP). The electrolytes were placed in Li-ion cells containing carbon anodes and LiNi₀.₅Co₀.₅O₂ cathodes, and the electrical performances of the cells were measured over a range of temperatures down to −60 °C. The electrolytes that yielded the best low-temperature performances were found to consist, variously, of 1.0 M LiPF₆ + 0.4 M LiBF₄ or 1.4 LiPF₆ in 1EC + 1EMC + 8MP or 1EC + 1EMC + 8MB, where the concentrations of the salts are given in molar units and the proportions of the solvents are by relative volume.

This work was done by Marshall Smart and ratnakumar Bugga of Caltech for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-42862

Miniature Free-Space Electrostatic Ion Thrusters

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A miniature electrostatic ion thruster is proposed for maneuvering small spacecraft. In a thruster based on this concept, one or more propellant gases would be introduced into an ionizer based on the same principles as those of the device described in the earlier article, "Miniature Bipolar Electrostatic Ion Thruster" (NPO-21057). On the front side, positive ions leaving an ionizer element would be accelerated to high momentum by an electric field between the ionizer and an accelerator grid around the periphery of the concave laminate structure. On the front side, electrons leaving an ionizer element would be ejected into free space by a smaller accelerating field. The equality of the ion and electron currents would eliminate the need for an additional electron- or ion-emitting device to keep the spacecraft charge-neutral. In a thruster design consisting of multiple membrane ionizers in a thin laminate structure with a peripheral accelerator grid, the direction of thrust could then be controlled (without need for moving parts in the thruster) by regulating the supply of gas to specific ionizer.

This work was done by Frank T. Hartley and James B. Stephens of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-21059