

The redesign of the optical system has included the formulation of a modular optical-system design that integrates lenses, mirrors, the lamp and its radio-frequency exciter, a photomultiplier tube, and pulse-generation electronic circuitry, into a small package that is attached to the vacuum tube in alignment with the optical ports on the surface of the tube and with the ion trap inside the tube. A reference mag-

netic-field coil, an inner magnetic shield, and a 40.507-GHz microwave feed with window have also been incorporated.

This work was done by John Prestage of Caltech for NASA's Jet Propulsion Laboratory.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Innovative Technology Assets Management
JPL

Mail Stop 202-233

4800 Oak Grove Drive

Pasadena, CA 91109-8099

(818) 354-2240

E-mail: iaoffice@jpl.nasa.gov

Refer to NPO-43075, volume and number of this NASA Tech Briefs issue, and the page number.

LiGa(OTf)₄ as an Electrolyte Salt for Li-Ion Cells

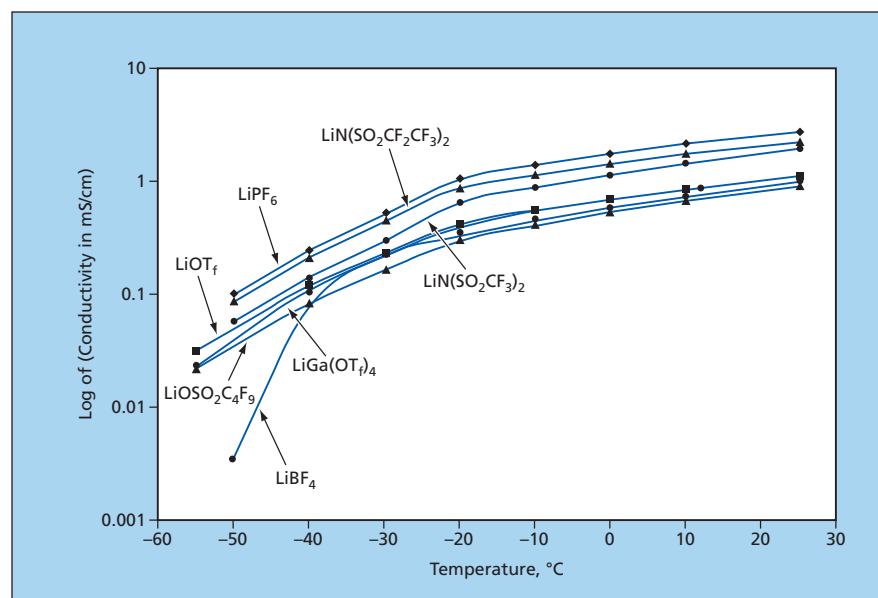
This salt could improve rechargeable lithium-ion cell performance.

NASA's Jet Propulsion Laboratory, Pasadena, California

Lithium tetrakis(trifluoromethanesulfonato)gallate [abbreviated "LiGa(OTf)₄" (wherein "OTf" signifies trifluoromethanesulfonate)] has been found to be promising as an electrolyte salt for incorporation into both liquid and polymer electrolytes in both rechargeable and non-rechargeable lithium-ion electrochemical cells. This and other ingredients have been investigated in continuing research oriented toward improving the performances of rechargeable lithium-ion electrochemical cells, especially at low temperatures.

This research at earlier stages, and the underlying physical and chemical principles, were reported in numerous previous NASA Tech Briefs articles. As described in more detail in those articles, lithium-ion cells most commonly contain non-aqueous electrolyte solutions consisting of lithium hexafluorophosphate (LiPF₆) dissolved in mixtures of cyclic and linear alkyl carbonates, including ethylene carbonate (EC), propylene carbonate (PC), dimethyl carbonate (DMC), diethyl carbonate (DEC), and ethyl methyl carbonate (EMC). Although such LiPF₆-based electrolyte solutions are generally highly ionically conductive and electrochemically stable, as needed for good cell performance, there is interest in identifying alternate lithium electrolyte salts that, relative to LiPF₆, are more resilient at high temperature and are less expensive.

Experiments have been performed on LiGa(OTf)₄ as well as on several other candidate lithium salts in pursuit of this interest. As part of these experiments, LiGa(OTf)₄ was synthesized by the reaction of Ga(OTf)₃ with an equimolar portion of LiOTf in a solvent consisting of anhydrous acetonitrile. Evaporation of the solvent yielded



Ionic Conductivities of 0.10 M Solutions of the indicated lithium salts in equal volume parts of PC and DMC were measured at temperatures from -50 to +25 °C. The salts other than LiPF₆, including LiGa(OTf)₄ have been investigated as candidates to supplant LiPF₆.

LiGa(OTf)₄ as a colorless crystalline solid. The LiGa(OTf)₄ and the other salts were incorporated into solutions with PC and DMC. The resulting electrolyte solutions exhibited reasonably high ionic conductivities over a relatively wide temperature range down to -40 °C (see figure). In cyclic voltammetry measurements, LiGa(OTf)₄ and the other salts exhibited acceptably high electrochemical stability over the relatively wide potential window of 0 to 5 V versus Li⁺/Li. ¹³C nuclear-magnetic-resonance measurements yielded results that suggested that in comparison with the other candidate salts, LiGa(OTf)₄ exhibits less ion pairing.

Planned further development will include optimization of the salt and sol-

vent contents of such electrolyte solutions and incorporation of LiGa(OTf)₄ into gel and solid-state polymer electrolytes. Of the salts, LiGa(OTf)₄ is expected to be especially desirable for incorporation into lithium polymer electrolytes, wherein decreased ion pairing is advantageous and the large delocalized anions can exert a plasticizing effect.

This work was done by V. Prakash Reddy of the University of Missouri-Rolla; G.K. Syria Prakash, Jinbo Hu, and Ping Yan of the University of Southern California; and Marshall Smart, Ratnakumar Bugga, Keith Chin, and Subbarao Surampudi of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.
NPO-41516