LiGa(OTf)₄ as an Electrolyte Salt for Li-Ion Cells
This salt could improve rechargeable lithium-ion cell performance.

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Lithium tetrais(trifluoromethanesulfonyl)gallate (abbreviated “LiGa(OTf)₄,” wherein “OTf” signifies trifluoromethanesulfonylate) 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), diethyl carbonate (DMC), ethyl methyl carbonate (EMC), and dimethyl carbonate (DMC). 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 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. Li¹³ 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 solvent 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.

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