

## Safe Testing of Advanced Lithium-Ion Cells

Because of their high energy density, ability to hold their charge after repeated charge/discharge cycles, and durability, lithium-ion batteries are used in portable electronics and are attractive to automotive, military, and aerospace applications. Although these batteries have an excellent safety record in the field, there is a need to further understand and improve safety, especially in light of recent, well-publicized accidents. Furthermore, R&D and prototyping work on Li-ion cells in the lab is often riskier because these cells may have new electrode materials, new electrolytes, and higher energy densities. J.R. Dahn and colleagues at Dalhousie University in Canada describe (in detail) the design, construction, and implementation of a facility that allows the accurate, precise measurement of coulombic efficiency of Li-ion cells ranging in size from coin cells to 40 Ah pouch cells while ensuring the safety of workers and the protection of equipment and facilities. The essential components of the facility are temperature-controlled test boxes (to maintain the cells under test within 0.05 °C) located within fireproof safety chambers, exhaust systems sized to handle the combustion products from a fire, and fireproof walls separating these chambers from the battery charger units. The authors demonstrate that the facility can safely handle accidents by including descriptions and photographs of thermal runaway experiments instigated by intentional abuse of batteries.

From: *J. Electrochem. Soc.*, **160**, A251 (2013).

## Supporting Electrolyte for Corrosion and Cracking Studies in De-aerated Simulated Fuel Grade Ethanol

Ethanol is being increasingly pursued as an alternative for gasoline. Unfortunately, carbon steel, as often used to construct fuel storage containers, is susceptible to stress corrosion cracking (SCC) in ethanol. While the failures to date have been minor, this may change if extensive pipeline transport of ethanol is pursued in the future. Performing the electrochemical measurements necessary to study this phenomenon is hindered, however, due to the high electrical resistivity of this organic liquid. Reducing the resistivity of the ethanol through the addition of a supporting electrolyte is one route to overcoming the high resistance and also allows traditional SCC susceptibility tests, such as slow strain rate testing, to be performed using standard sample geometries. Identification of an appropriate supporting electrolyte is difficult, as in addition to accomplishing the goal of reducing electrical resistance of the solution, it must also not alter the electrochemical processes which take place. After the screening of a number of inorganic and tetraalkylammonium salts for their impact on the anodic and cathodic kinetics, as well as the SCC of carbon steel

in fuel grade ethanol, tetrabutylammonium tetrafluoroborate (TBA-TFB) was identified as particularly promising. Under de-aerated conditions, TBA-TFB had only minor effects on the electrochemical properties and no impact on the SCC behavior of X-52 carbon steel.

From: *J. Electrochem. Soc.*, **160**, C19 (2013).

## Anchoring Metallophthalocyanine Molecules in Dye-Sensitized Solar Cells

Development of dye-sensitized solar cells (DSSCs) to compete with better-performing crystalline Si solar cells continues in the areas of efficiencies and increased and broader photon spectrum absorption. Metallophthalocyanines are suitable candidates for absorbing in both the visible and IR wavelength regions. However, anchoring these macrocyclic compounds to the metal oxide nanoparticles layer in such a manner as to ensure efficient injection of electrons to the photoanode surface can be complicated. Researchers in Japan explored an anchoring system based on metal-O-metal linkages between the SnO<sub>2</sub> nanoparticle and a metallophthalocyanine. They found that tandem DSSCs consisting of SnO<sub>2</sub> stained with indium(III) phthalocyanine chloride (PcInCl) performed better than cells consisting of TiO<sub>2</sub> nanoparticles. Although PcInCl showed comparable adsorption, the difference in performance was due to higher charge recombination kinetics (determined via transient absorption spectroscopy) at TiO<sub>2</sub> than at SnO<sub>2</sub>. The slower recombination on the SnO<sub>2</sub> nanoparticles was attributed to a lower density of trap (surface) states than that on TiO<sub>2</sub> nanoparticles. The authors compare this finding to a reported success using a longer carboxylic (-COO-) linkage to TiO<sub>2</sub>. The authors propose using the metal-O-metal linkage strategy on SnO<sub>2</sub> electrodes.

From: *ECS J. Solid State Sci. Technol.*, **2**, Q6 (2013).

## Can Silver Be a Reliable Cathode Current Collector for Electrochemical Tests at Elevated Temperatures?

As a structural part of an electrode assembly, a current collector is primarily used to conduct the electricity between the actual working (reacting) parts of the electrode and the external electrical terminals of an electrochemical cell. Among the popular noble metal current collectors used in solid oxide fuel cell development, Ag is frequently chosen for cathode studies below 800 °C due to its high electronic conductivity and its affordability. However, a recent report by researchers from the University of South Carolina and Benedict College calls for caution on the use of Ag for such purpose. In their study, the authors investigated the effect of curing temperature of Ag on the polarization area specific resistance (ASR) of a cathode. They found that a cathode

with Ag cured at 800 °C exhibited more than one order of magnitude lower ASR than one cured at 650 °C. Further microscopic analysis of the 800 °C-cured cells indicated that Ag had penetrated the bulk electrode material and formed finely dispersed Ag particles in the cathode/electrolyte interfacial region. These particles participated in the oxygen reduction reaction and thus overshadowed the true properties of the cathode. These results indicate that caution should be exercised when using Ag as a current collector at temperatures ≥ 650 °C.

From: *ECS Electrochem. Lett.*, **2**, F4 (2013).

## Vapor Phase Growth of Bismuth Telluride Nanoplatelets on Flexible Polyimide Films

Group V-VI chalcogenides such as Bi<sub>2</sub>Te<sub>3</sub>, Bi<sub>2</sub>Se<sub>3</sub>, and related compounds are widely used for thermoelectric power generation or refrigeration at temperatures below 300 °C. Their unique charge transport behavior as topological insulators, and good Seebeck coefficients as n-type conductors make them viable materials in electronics, spintronics, thermoelectrics, and infrared detectors. Synthetic methods for two-dimensional (2D) nanosheets (or films) of Bi<sub>2</sub>Te<sub>3</sub> is a key development need. The behavior of their topological states, and electrical and thermal conductivities are inherently linked to their size and structure. Developing practical devices is dependent on novel and upscalable film deposition and growth methodologies. Researchers at University of Alabama and Georgia Institute of Technology have successfully grown Bi<sub>2</sub>Te<sub>3</sub> nanoplatelets on flexible Kapton films using a chemical vapor transport method. They demonstrate the potential of this method for low cost, flexible devices with topological insulator behavior. Their nanoplatelet dry transfer technique is based on electrostatic attraction of nanosheets from the surface potential of the Te-terminated basal plane of the Bi<sub>2</sub>Te<sub>3</sub> nanoplatelets. The team's surface probe characterization hinted at a van der Waals epitaxy leading them to suggest a vapor phase growth from a seeded layer on the Kapton film. The researchers propose that the technique could be extended to the growth of other related chalcogenides on flexible plastic films.

From: *ECS Solid State Lett.*, **2**, P19 (2013)

*Tech Highlights was prepared by Zenghe Liu of Google Inc., David Enos and Mike Kelly of Sandia National Laboratories, Colm O'Dwyer of University College Cork, Ireland, and Donald Pile. Each article highlighted here is available free online. Go to the online version of Tech Highlights, in each issue of Interface, and click on the article summary to take you to the full-text version of the article.*