Physical Sciences

Ester-Based Electrolytes for Low-Temperature Li-Ion Cells

NASA's Jet Propulsion Laboratory, Pasadena, California

Electrolytes comprising $LiPF_6$ dissolved at a concentration of 1.0 M in five different solvent mixtures of alkyl carbonates have been found to afford improved performance in rechargeable lithium-ion electrochemical cells at temperatures as low as -70° C. These and other electrolytes have been investigated in continuing research directed toward extending the lower limit of practical operating temperatures of Li-ion 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 "Low-EC-Content Electrolytes for Low-Temperature Li-Ion Cells" (NPO-30226), *NASA Tech Briefs*, Vol. 27, No. 1 (January 2003), page 46. The ingredients of the present solvent mixtures are ethylene carbonate (EC), ethyl methyl carbonate (EMC), methyl butyrate (MB), methyl propionate (MP), ethyl propionate (EP), ethyl butyrate (EB), and ethyl valerate (EV). In terms of volume proportions of these ingredients, the present solvent mixtures are

- 1EC + 1EMC + 8MB,
- 1EC + 1EMC + 8EB,
- 1EC + 1EMC + 8MP,
- 1EC + 1EMC + 8EV, and
- 1EC + 9EMC.

These electrolytes were placed in Li-ion cells containing carbon anodes and $LiNi_{0.8}Co_{0.2}O_2$ cathodes, and the low-temperature electrical performances of the cells were measured. The cells containing the MB and MP mixtures performed best.

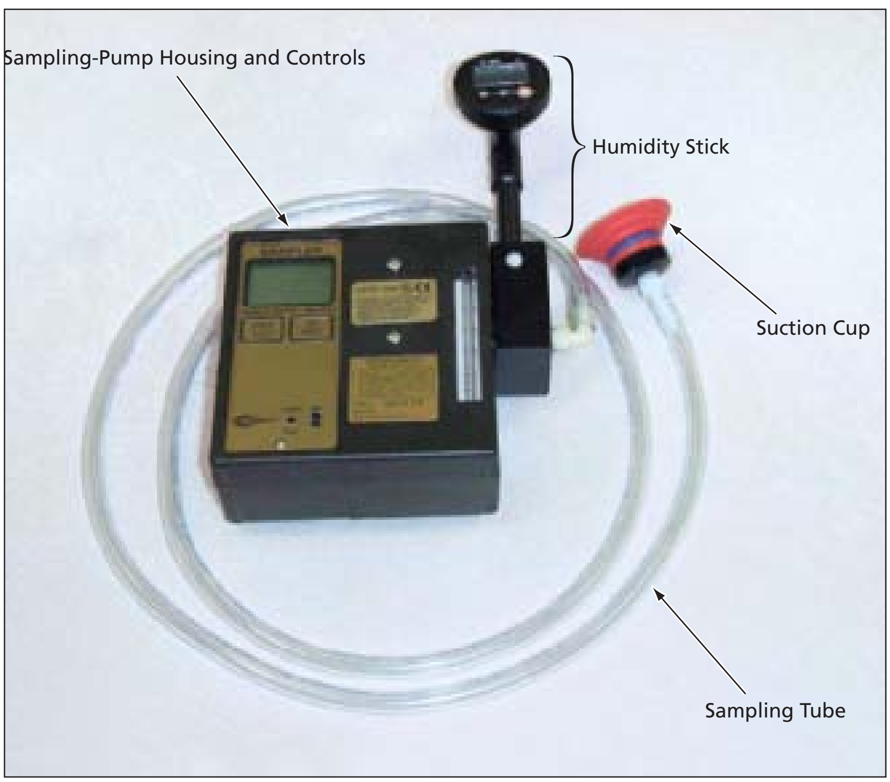
This work was done by Marshall Smart and Ratnakumar Bugga of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-41097

Hygrometer for Detecting Water in Partially Enclosed Volumes

This portable instrument samples humid air from difficult-to-reach spaces.

John F. Kennedy Space Center, Florida

A portable hygrometer has been devised to implement a pre-existing technique for detecting water trapped in partially enclosed volumes that may be difficult to reach and cannot be examined directly. The technique is based on the fact that eventually the air in such a volume becomes saturated or nearly so. The technique is straightforward: One measures the relative humidity and temperature of both the ambient air and a sample of air from the enclosed volume. If the relative humidity of the sample is significantly greater than that of the ambient air and/or if the sample is at or close to the dew point, then it can be concluded that water is trapped in the volume. Of course, the success of this technique depends on the existence of an access hole through which one can withdraw some air from the enclosed volume.



This **Portable Hygrometer** was assembled from commercially available components and materials.

The portable hygrometer (see figure) includes (1) a commercially available small electronic temperature-and-humidity sensor of the "humidity stick" type, (2) a flexible plastic sampling tube with a suction cup at its inlet, and (3) a commercially available sampling pump, the air-intake manifold of which is modified for coupling to both the outlet of the sampling tube and the sensory tip of the humidity stick. The total cost of these and ancillary components was about $1,300 in 2003.

At the beginning of operation, the inlet end of the sampling hose is positioned to collect ambient air and the humidity stick and the sampling pump are turned on. After allowing about 20 seconds for the humidity stick to equilibrate with the sampled ambient air, the temperature and humidity readings of the humidity stick are recorded. Next, the suction cup is placed over the access hole to withdraw air from the enclosed volume. If water drops are observed in the sampling tube, then there is no need for further sampling, and the sampling pump is stopped immediately to avoid drawing liquid water into the humidity stick and pump. If water drops are not observed in the sampling tube, then the relative-humidity reading is monitored until it reaches a maximum (usually after about 20 seconds), at which time the relative-humidity and temperature readings are recorded.

The suction cup is removed from the access hole and after about 30 seconds for equilibration, the temperature and humidity readings for ambient air are taken again. The suction cup is again placed over the access hole and the air from the enclosed volume sampled again to obtain second temperature and humidity readings to confirm the first readings. Because some ambient (presumably drier) air could have entered the enclosed volume between the first and second humidity readings, the second enclosed-air humidity reading could be lower than the first one.

This work was done by Robert C. Youngquist of **Kennedy Space Center** *and Jan Surma and Steve Parks of ASRC Aerospace. For further information, contact the Kennedy Innovative Partnerships Office at (321) 867-1463.*
KSC-12593

Radio-Frequency Plasma Cleaning of a Penning Malmberg Trap

This method is superior to cleaning by baking.

Marshall Space Flight Center, Alabama

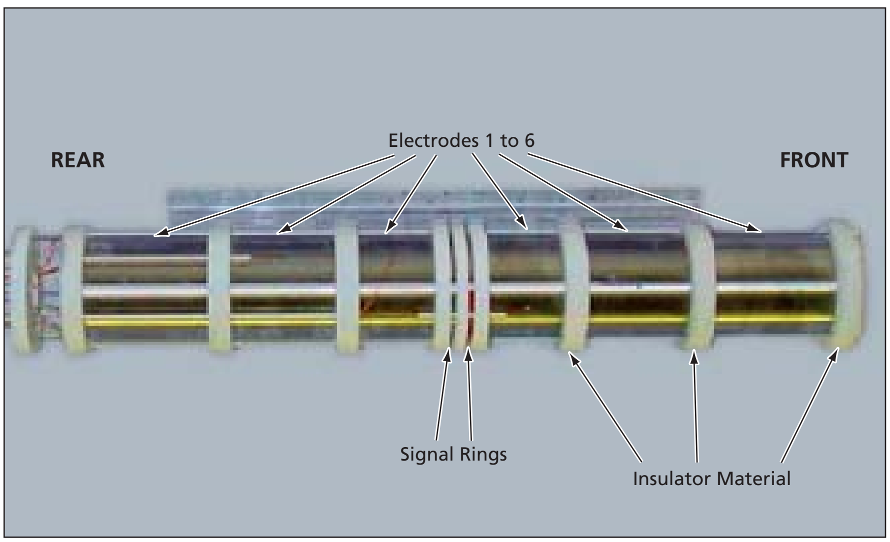


Figure 1. The **Ring Electrodes** used in the operation of a modified Penning-Malmberg trap can also be used in RF generation of plasma for cleaning the trap.

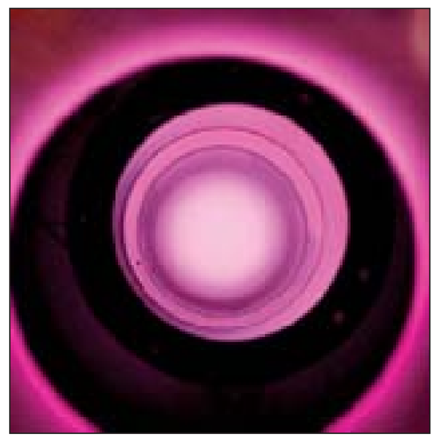


Figure 2. This **View Along the Axis of a Penning-Malmberg Trap** shows a plasma discharge being used for cleaning.

Radio-frequency-generated plasma has been demonstrated to be a promising means of cleaning the interior surfaces of a Penning-Malmberg trap that is used in experiments on the confinement of antimatter. {Such a trap was reported in "Modified Penning-Malmberg Trap for Storing Antiprotons" (MFS-31780), *NASA Tech Briefs*, Vol. 29, No. 3 (March 2005), page 66.} Cleaning of the interior surfaces is necessary to minimize numbers of contaminant atoms and molecules, which reduce confinement times by engaging in matter/antimatter-annihilation reactions with confined antimatter particles.

A modified Penning-Malmberg trap like the one described in the cited prior article includes several collinear ring electrodes (some of which are segmented) inside a tubular vacuum chamber, as illustrated in Figure 1. During operation of the trap, a small cloud of charged antiparticles (e.g., antiprotons or positrons) is confined to a spheroidal central region by means of a magnetic field in combination with DC and radio-frequency (RF) electric fields applied via the electrodes.

In the present developmental method of cleaning by use of RF-generated plasma, one evacuates the vacuum chamber, backfills the chamber with hydrogen at a suitable low pressure, and uses an RF-signal generator and baluns to apply RF voltages to the ring electrodes. Each ring is excited in the polarity opposite that of the adjacent ring. The electric field generated by the RF signal creates a discharge in the low-pressure gas. The RF power and gas pressure are adjusted so that the plasma generated in the discharge (see Figure 2) physically and chemically attacks any solid, liquid, and gaseous contaminant layers on the electrode surfaces. The products of the physical and chemical cleaning reactions are gaseous and are removed by the vacuum pumps.

This cleaning method is much more aggressive than is the standard baking of ultrahigh-vacuum systems; adsorbed