Nickel-Tin Electrode Materials for Nonaqueous Li-Ion Cells

Capacity densities exceed those of materials now commercially available for the same purpose.

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Experimental materials made from mixtures of nickel and tin powders have shown promise for use as the negative electrodes of rechargeable lithium-ion electrochemical power cells. During charging (or discharging) of a lithium-ion cell, lithium ions are absorbed into (or desorbed from, respectively) the negative electrode, typically through an intercalation or alloying process. The negative electrodes (for this purpose, designated as anodes) in state-of-the-art Li-ion cells are made of graphite, in which intercalation occurs. Alternatively, the anodes can be made from metals, in which alloying can occur. For reasons having to do with the electrochemical potential of intercalated lithium, metallic anode materials (especially materials containing tin) are regarded as safer than graphite ones; in addition, such metallic anode materials have been investigated in the hope of obtaining reversible charge/discharge capacities greater than those of graphite anodes. However, until now, each of the tin-containing metallic anode formulations tested has been found to be inadequate in some respect.

In preparation for making experimental electrodes, Ni and Sn powders were mixed in various proportions and suspended in a solution of [poly(vinylidene fluoride)-hexafluoropropylene dissolved in 1-methyl-2-pyrrolidinone]. (A carbon powder was also incorporated into some of the suspensions, but subsequent tests revealed that better electrode performances were obtained without the carbon.) The experimental electrodes were then made by coating nickel foils with the suspensions and drying them in air.

The experimental electrodes were characterized through several tests, including cyclic charge/discharge tests in electrochemical cells of several different types that differed in their counter-electrode or positive-electrode materials. The electrolyte in each cell was a 1-M solution of $LiPF_6$ in a mixture of 1 part ethylene carbonate with 3 parts ethyl methyl carbonate. In each cell, the positive electrode was separated from the experimental electrode by a sheet of microporous polyethylene. Positive electrodes were made, variously, of the experimental electrode materials themselves or of lithium-metal, $LiNi_{1-x}Co_xO_2$, or $LiMn_2O_4$. Of the electrodes tested, the best results were obtained with those made from a mixture of 41.6 weight percent Ni powder and 58.4 weight percent Sn powder: These electrodes exhibited high specific charge/discharge capacity (>0.3 A·h/g), capacity density >2.5 A·h/mL (more than three times that of Li-ion-cell negative-electrode materials now commercially available), nearly zero capacity fade, low irreversible capacity (45 to 76 mA·h/g), and long cycle life.

This work was done by Grant M. Ehrlich and Christopher Durand of Yardney Technical Products, Inc., for **Johnson Space Center**.

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:

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Photocatalytic Coats in Glass Drinking-Water Bottles

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According to a proposal, the insides of glass bottles used to store drinking water would be coated with films consisting of or containing TiO_2. In the presence of ultraviolet light, these films would help to remove bacteria, viruses, and trace organic contaminants from the water.

Material systems that contain TiO_2 have been observed to be photocatalytic and, in particular, to be photocatalytically effective for destroying organic compounds. Bacteriocidal films containing TiO_2 have been made, but, heretofore, have not been exploited for bacteriological protection of drinking water.

A glass bottle to be coated on the inside would be filled with a fluid suspension of TiO_2, then inverted. By controlling the rate of release of the suspension, one would control the thickness of the TiO_2 film deposited on the inner surface of the bottle. The bottle could then be fired to produce a stable, photocatalytically active TiO_2 film.

Coating with TiO_2 may also offer an additional advantage by impeding the dissolution of silica from the glass. TiO_2 is not toxic, and its solubility is much less than that of SiO_2.

This work was done by Anders W. Andren, David E. Armstrong, and Marc A. Anderson of the University of Wisconsin – Madison for **Johnson Space Center**. *For further information, contact the Johnson Commercial Technology Office at (281) 483-3809.*
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