Green Electroless Plating Method Using Gold Nanoparticles for Conducting Microbeads: Application to Anisotropic Conductive Films

Conducting beads of micron dimension used in anisotropic conductive films are usually prepared by metallizing plastic cores via electroless plating processes involving the use of strong acids or alkaline and other highly toxic chemicals such as cyanides. A group of researchers at the Osaka Prefecture University of Japan recently reported a green electroless plating method based on the use of gold nanoparticles. In this study, the authors employed a self-assembling reaction between gold nanoparticles that are synthesized by combining a nonhazardous reducing agent (sodium citrate), and a nontoxic thiol binder. These thiol-modified nanoparticles were then adsorbed onto the plastic core beads' surfaces. Subsequent reduction of $HAuCl_4$ by ascorbate was performed in suspensions of the beads. This electroless plating resulted in the growth of the adsorbed gold nanoparticles and eventually led to the formation of gold shells on the beads. Various plastic cores, including acrylic resin, nylon 6, nylon 12, polylactic acid, and polystyrene, were used in this study. The prepared beads were well dispersed in an epoxy resin film. The electrical resistance of the acrylic resin beads was comparable to the resistance of commercially available beads. The prepared microbeads were successfully applied to an anisotropic conductive film with a 1.9 W resistance.

From: J. Electrochem. Soc., ***156****, D558 (2009).*

Photoelectrochemical Conversion of the By-Products of the Ethanol Fuel Cell into Hydrogen

Research in direct alcohol fuel cells has focused primarily on the direct methanol fuel cell (DMFC), with some additional attention on the use of ethanol due to its lower toxicity and its availability as a biofuel. However, one of the factors that has hampered direct ethanol fuel cell (DEFC) development is the generation of acetic acid and acetaldehyde as the principal reaction products, both of which are environmentally undesirable. Augustynski and coworkers at the University of Warsaw in Poland recently reported the results of a study aimed at photoelectrochemical conversion of acetic acid and acetaldehyde into CO_2 at a mesoporous tungsten oxide (WO_3) photoanode. This visible light-driven photo-oxidation is very efficient, with measured incident photon-to-current conversion efficiencies (IPCEs) of about 100% for acetic acid and about 160% for acetaldehyde. Further, the reaction is accompanied by production of H_2 at the cathode. The researchers propose that this photoelectrolysis cell could be coupled with a photovoltaic cell to form a tandem device that could convert the by-products of the DEFC into H_2 fuel using solar light as the only energy input. The H_2 could then be used by a polymer electrolyte membrane (PEM) fuel cell to produce additional energy.

From: Electrochem. Solid-State Lett., ***12****, B165 (2009).*

Inhibiting Electrolyte Oxidation in High-Voltage Lithium Ion Batteries with Electrolyte Additives

The cathodic stability of common lithium ion battery electrolytes and the properties of the solid-electrolyte interphase (SEI) formed by the reduction of electrolyte components at the negative electrode have been extensively reported in the literature. Film-forming additives in the electrolyte are sacrificially reduced at the negative electrode surface, thereby creating a more stable SEI. With the development of high-voltage cathode materials, electrolyte anodic stability and the characteristics of the positive electrode SEI become significant for cell performance and longevity. Researchers from Rhode Island investigated the effects of adding 2,5-dihydrofuran (2,5-DHF) or γ-butyrolactone (GBL) to a standard electrolyte composed of 1 M $LiPF_6$ in 1:1:1: ethylene carbonate/diethyl carbonate/dimethyl carbonate. The 2nd and 3rd cycles of cyclic voltammograms of a glassy carbon electrode show either insignificant or lower faradaic current in 2% 2,5-DHF or 2% GBL electrolytes than in the standard electrolyte—indicating the formation of a passivating film. Incorporating 0.5% 2,5-DHF or 1% GBL in the standard electrolyte of $Li/Li_{1.17}Mn_{0.58}Ni_{0.25}O_2$ cells decreased capacity fade by 47% and 27%, respectively, after 50 cycles. Surface analysis of the cycled electrodes supported the hypothesis that low concentrations of 2,5-DHF or GBL in the electrolyte sacrificially form thin, passivating films that inhibit further electrolyte oxidation.

From: Electrochem. Solid-State Lett., ***12****, A229 (2009).*

Optimization of Nonaqueous Electrolytes for Primary Lithium/Air Batteries Operated in Ambient Environment

Li/air batteries are actively researched because of their high theoretical specific energy and an abundance of air which contains oxygen, the species reduced at the cathode. Electrolyte solvents have been investigated for optimum properties in a Li/air battery operated at an oxygen partial pressure of 0.21 atm under dry conditions. High polarity, viscosity, ionic conductivity, and oxygen solubility are all metrics of interest in organic electrolytes. Researchers at the Pacific Northwest National Laboratory have determined that ethylene carbonate (EC) and propylene carbonate (PC) mixtures with lithium bis(trifluoromethanesulfonyl)imide (LiTFSI) salt are the best nonaqueous electrolytes for ambient operation. Specifically, the long-term evaporation rates and boiling of neat solvents 1,2 dimethoxyethane (DME), 1,2, diethoxyethane (DEE), diethyl carbonate (DEC), 1-tert-butoxy-2-ethoxyethane (BEE), diglyme (DG), diproglyme (DPG), ethyl diglyme (EDG), and PC were compared. The researchers found that ether- and glyme-based electrolytes result in poorer discharge capacity than cyclic carbonates because their easy accessibility to the pores causes them to block needed air pathways. The high polarity of cyclic carbonate electrolytes is desirable and their low affinity to carbon pores creates triphase reaction sites for Li/air chemistry. For ambient conditions, low electrode wettability and vapor pressure are the most important criteria. A wide range of EC/PC ratios and LiTFSI concentrations gives a discharge capacity of ~170 mAh/g and specific energy of ~100 Wh/kg.

From: J. Electrochem. Soc., ***156****, A773 (2009).*

Breakdown Kinetics at Nanostructure Defects of Passive Films

Pitting initiates at sites on a passive metal surface where the oxide film has been locally breached. In previous work, the authors developed a model for passivity breakdown which included the effect of grain boundaries in the oxide layer. In this paper, the authors build upon that model by addressing specific phenomena which may lead to local breakdown at such boundaries. As the grain boundaries have a substantially larger ionic conductivity than the grains themselves, the potential drop at the metal/oxide or oxide/electrolyte interface at such locations is larger, favoring enhanced interfacial reaction in those locations. Two specific mechanisms are discussed depending on where the increased potential drop is located. In the first case, the enhanced potential drop is considered at the oxide/electrolyte interface, and passivity breakdown occurs via enhanced dissolution (i.e., oxide thinning) at that site. In the second case, the enhanced potential drop is considered at the metal/oxide interface, and breakdown results from accelerated interfacial voiding at the metal/oxide interface followed by collapse or rupture of the passive film. Both of these phenomena are accelerated at the intergranular defect sites, and oxide breakdown may be dominated by either of the mechanisms, or a combination of the two.

From: Electrochem. Solid-State Lett., ***12****, C25(2009).*

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