OFFICE OF
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USABC Electric Vehicle Program - Nickel Metal Hydride Battery Development

USABC Supports the Next Generation Battery for Electric Vehicles

The push for electric vehicles is motivated by concerns that today's cars, propelled by the internal combustion engine (ICE), are increasing atmospheric carbon dioxide and other regulated pollutants. Electric vehicles will alleviate the environmental impact of an increasing worldwide fleet that drives more kilometers each year. Market acceptance of electric vehicles will depend on their ability to provide the range, durability, performance, convenient refueling (recharging), and other amenities that consumers have come to expect from conventional vehicles – at a competitive cost. The battery is the main component affecting these factors. A near-term focus of the United States Advanced Battery Consortium (USABC) in collaboration with the U.S. Department of Energy (DOE) is developing battery technology to support the market introduction of zero-emission electric vehicles. Electric vehicles are promoted through incentives and requirements such as California's regulatory program, which has a goal of 4% market share by 2003.

Nickel Metal Hydride Batteries Are a Near-Term Candidate

The development of high-energy batteries that can provide performance comparable with conventional vehicles and at comparable cost is key to making electric vehicles (EVs) practical. Nickel metal hydride (NiMH) batteries, developed for electric vehicles, have represented substantial progress over other batteries. Advances in the specific energy of the battery have improved the EV driving range. Composed of nontoxic, completely recyclable materials, NiMH batteries are environmentally friendly and provide approximately double the range and twice the cycle life of lead acid battery technology.

Technical Background

NiMH batteries are based on storing hydrogen in metal hydride alloys at very high volumetric densities. In a NiMH cell, a nickel hydroxide positive electrode is coupled with a metal hydride negative electrode. During charge, hydrogen is generated by reaction with the electrolyte and stored in the metal alloy in the negative electrode. At the positive electrode, a hydrogen ion is ejected while the nickel is oxidized to a higher valence within the structure of nickel hydroxide. Both reactions are fully reversible.

This charge storage reaction makes the NiMH unit a simple hydrogen transfer battery, in which hydrogen is transferred back and forth between the nickel hydroxide and the metal hydride without soluble intermediates or complex phase changes. It is the simplicity of the NiMH battery that makes for its high power and exceptionally long intrinsic cycle life. The recombination reactions of the NiMH battery do away with the costly need to monitor and balance the cells individually, thereby simplifying battery management. To construct a cell, alternating negative and positive plates are stacked and enclosed in separators. The stack is inserted into a cell container of metal or plastic construction, and the electrode tabs welded to the terminals. Each cell has a nominal voltage of 1.2V. To build a battery with the desired voltage, an appropriate number of cells are connected in series and combined into a final battery module. Typically, 10 cells in series yield a 12 volt module.

Research Achievements and Future Research and Development

Nickel metal hydride batteries have emerged, from the DOE program with the USABC, as an industrial product. USABC has funded two projects with NiMH developers, GM-Ovonic and SAFT, to achieve major cost reductions in NiMH batteries in order to make the batteries more affordable to the automotive industry. In the competitive market place, the developers will seek to further reduce materials and process costs. They will also work with automotive manufacturers to develop subsystems for monitoring and predicting battery performance.

The nickel metal hydride battery has evolved from small cells, used in the consumer electronics market, into large cells capable of powering light duty electric vehicles. Nickel metal hydride batteries are currently used in the electric vehicles offered by major automotive manufacturers. NiMH batteries developed by the USABC are used by DaimlerChrysler Corporation and General Motors Corporation. Many other applications are emerging for this technology. These include its use in heavy duty applications, such as electric buses, and in electric utility systems, where energy storage can serve to defer generation capacity and improve power reliability and quality. It is expected that many other applications for nickel metal hydride advanced batteries will emerge in the coming decade.

Phase I of the DOE-USABC Program ran from 1991 through 1996 and established NiMH technology as the prime mid-term candidate. In August 1996, DOE signed a Phase II agreement with the USABC and electric utility partners to continue the cooperative program until 2000 to complete the development of mid-term battery technology and develop and demonstrate long-term technology.

The energy content of gasoline is about 44 megajoules per kilogram. Converted to the units commonly used for batteries, this is about 13 kWh/kg. Conventional lead-acid batteries can store 30 Wh/kg or so — about 400 times less than does gasoline on a weight basis. As a result energy density has historically been the driving concern for batteries.

Additional Information

The International Electric Vehicle Symposium, held annually in a location that rotates among North America, Europe, and Asia, is the largest technical conference devoted to electric and hybrid vehicles. It features both papers and exhibits, not only by the major auto companies, but also by manufacturers of batteries, chargers, and assorted other components.

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