Zinc-Air Batteries for Field Charging

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ABSTRACT

In order to realize the operational and service cost savings through the use of rechargeable batteries, the dismounted soldier is burdened with the weight, volume and/or charging logistics of the batteries. By providing the soldier with a high energy density source and a light weight compact battery charger the burden imposed by rechargeable batteries in the forward field can be minimized. Zinc-air batteries have the potential for meeting the energy demands of forward battlefield charging. They are attitude insensitive, have a high specific energy and are inherently inexpensive, lightweight and safe.

Background

The proliferation of portable electronic systems in the commercial and military markets has revolutionized the battery industry. Up until a few years ago, portable electronics were typically either powered by primary, single use, alkaline manganese or lithium sulfur dioxide batteries or rechargeable nickel-cadmium batteries. Since then, rechargeable alkaline manganese, nickel metal hydride, and lithium ion batteries have been introduced commercially and into the military. Rechargeable batteries, with the promise of lower life cycle cost gained through recharging, are becoming the power source of choice.

As the battlefield becomes more and more electronic, and with the growing threats of chemical and biological warfare, the foot soldier needs portable power that is lightweight, reliable, safe, and covert. Metal-air batteries have the potential for meeting the demands of the battlefield. They are inherently inexpensive, lightweight, and safe. The two viable metal-air technologies are aluminum-air and zinc-air. Both the aluminum-air and zinc-air systems have received Army funding for a number of years.

Aluminum-air batteries could be the battery of choice for a number of missions. However they must be kept dry until use, because of the high corrosion rate of aluminum in aqueous electrolytes and are attitude sensitive. Field activation and attitude sensitivity can be logistical and operational liabilities, limiting their use in the forward field.

Zinc-air batteries are attitude insensitive and the only activation required prior to use is removal from a high barrier film pouch. However, primary zinc-air battery technology, in a form suitable for battlefield missions, is not currently available. While zinc-air batteries are sold commercially as
hearing aid button cells and remote signaling batteries (railroads, navigational aids), these products are either too small (button cells are generally limited to about 1 Ah), or power limited (signal batteries are designed for 1 A continuous current). Zinc-air batteries have demonstrated a practical specific energy up to 500 Wh/kg (1, 2) and are a candidate for a number of present and future portable power missions in the forward battlefield.

Discussion

Existing and planned systems for the dismounted soldier could easily require a total energy consumption of 800 Wh for a 72 hour mission. The best rechargeable batteries have a specific energy of about 100 Wh/kg, which would mean that the soldier would have to carry around 8 kg of batteries, which would unnecessarily burden the soldier. State of the art lithium primary batteries have a specific energy of 225 Wh/kg this requires 4.5 kg of batteries. As mission times increase the total weight of batteries required increase or a logistical trail for recharging needs to be established.

A solution to providing the dismounted soldier with the energy and power required to perform his mission has been proposed. Providing the soldier with a high energy density power source and a light weight compact battery charger the burden imposed by using rechargeable batteries in the forward field can be minimized. This solution gives the forward field unit the ability to charge their batteries in place.

Zinc-air batteries have the potential for providing the energy required for forward battlefield charging. Zinc is the most negative electrode material which can be easily replated from alkaline electrolytes. Therefore the zinc electrode systems have a high voltage and high energy density. For zinc-air cells the theoretical specific energy is 1085 Wh/kg. Figure 1 shows the characteristic power and energy profile for state of the art zinc-air cells. (1, 2)

![Figure 1. Discharge characteristics of state of the art zinc-air cells.](image-url)

The next generation of zinc-air batteries for Army missions and commercial portable electronics will require high specific energy and energy density at moderately high (C/10) discharge rates, while remaining safe and cost effective.

The data presented in Figure 1 shows the power limitation of the zinc-air technology. Improvement in power capability over the current state of the art zinc-air are current areas of effort.
Conclusion

Rechargeable batteries offer operational and service cost savings. However, in order to fully realize this saving a means of recharging batteries in the field is required. Additionally the dismounted soldier needs portable power that is lightweight, reliable, safe, and covert.

Zinc-air batteries coupled with a small lightweight battery charger provide the capability of forward field charging. Zinc-air batteries are attitude insensitive, have a high specific energy and are inherently inexpensive, lightweight and safe. The specific energy of zinc-air batteries is four times that of rechargeable batteries, therefore minimizing the weight required to be ported by the dismounted soldier. Additionally, by providing the soldier the means of recharging his own batteries with a high energy zinc-air battery eliminates the need for the logistic trail required for battery charging. This is especially important during extended missions.

References
