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Silver-Oxide Battery Technologies

A silver-oxide battery (IEC code: S) is a primary cell with a very high energy/weight ratio. Available either in small sizes as button cells(where the amount of silver used is minimal and not a significant contributor to the product cost), or in large custom designed batteries where the superior performance of the silver-oxide chemistry outweighs cost considerations. These larger cells are mostly found in applications for the military, for example in Mark 37 torpedoes or on Alfa-class submarines. In recent years they have become important as reserve batteries for manned and unmanned spacecraft. Spent batteries can be processed to recover their silver content.

Silver-oxide primary batteries account for over 20% of all primary battery sales in Japan (67,000 out of 232,000 in September 2012).[3]

A related rechargeable secondary battery usually called a silver–zinc battery uses a variation of silver–oxide chemistry. It shares most of the characteristics of the silver-oxide battery, and in addition, is able to deliver one of the highest specific energies of all presently known electrochemical power sources. Long used in specialized applications, it is now being developed for more mainstream markets, for example laptop batteries.

Chemistry

A silver-oxide battery uses silver oxide as the positive electrode (cathode), zinc as the negative electrode (anode) plus an alkaline electrolyte, usually sodium hydroxide (NaOH) or potassium hydroxide (KOH). The silver is reduced at the cathode from Ag(I) to Ag and the zinc is oxidized from Zn to Zn(II). The chemical reaction that takes place inside the battery is the following:

$$Zn + Ag_2O \xrightarrow{KOH / NaOH} ZnO + 2Ag$$

The silver–zinc battery is manufactured in a fully discharged condition, and has the opposite electrode composition, the cathode being of metallic silver, while the anode is a mixture of zinc oxide and pure zinc powders. The electrolyte used is a potassium hydroxide / water solution.

During the charging process, silver is first oxidized to silver(I) oxide: $2Ag(s) + 2OH^- \rightarrow Ag_2O + H_2O + 2e^-$ and then to silver(II) oxide: $Ag_2O + 2OH^- \rightarrow 2AgO + H_2O + 2e^-$, while the zinc oxide is reduced to metallic zinc: $2Zn(OH)_2 + 4e^- = 2Zn + 4OH^-$. The process is continued until the cell potential reaches a level where the decomposition of the electrolyte is possible at about 1.55 Volts. This is taken as the end of a charge, as no further charge is stored, and any oxygen which might be generated poses a mechanical and fire hazard to the cell.

Characteristics

Compared to other batteries, a silver oxide battery has a higher open circuit potential than a mercury battery, and a flatter discharge curve than a standard alkaline battery
Experimental new silver-zinc technology (different to silver-oxide) may provide up to 40 percent more run time than lithium-ion batteries and also features a water-based chemistry that is free from the thermal runaway and flammability problems that have plagued the lithium-ion alternatives.[4]

History

This technology had the highest energy density prior to lithium technologies. Primarily developed for aircraft, they have long been used in space launchers and crewed spacecraft where their short cycle life is not a drawback. Non-rechargeable silver–zinc batteries powered the first Russians Sputnik satellites as well as US Saturn launch vehicles, the Apollo Lunar Module, lunar rover and life support backpack. The primary power sources for the command module were the hydrogen/oxygen fuel cells in the service module. They provided greater energy densities than any conventional battery, but peak power limitations required supplementation by silver–zinc batteries in the CM that also became its sole power supply during re-entry after separation of the service module. Only these batteries were recharged in flight. After the Apollo 13 near-disaster, an auxiliary silver–zinc battery was added to the service module as a backup to the fuel cells. The Apollo service modules used as crew ferries to the Skylab space station were powered by three silver–zinc batteries between undocking and SM jettison as the hydrogen and oxygen tanks could not store fuel cell reactants through the long stays at the station.

Mercury Content

Several sizes of button and coin cells, some of which are silver oxide. Silver oxide batteries become hazardous on the onset of leakage; this generally takes five years from the time they are put into use (which coincides with their normal shelf life). Until recently, all silver oxide batteries contained up to 0.2% mercury. The mercury was incorporated into the zinc anode to inhibit corrosion in the alkaline environment. Sony started producing the first silver oxide batteries without added mercury in 2004.[5]

References

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