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ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY STUDY IN-SITU STATE OF HEALTH OF THE ALKALINE Zn-MnO_2 BATTERIESUNDER CHANGING OF THERMAL MODES

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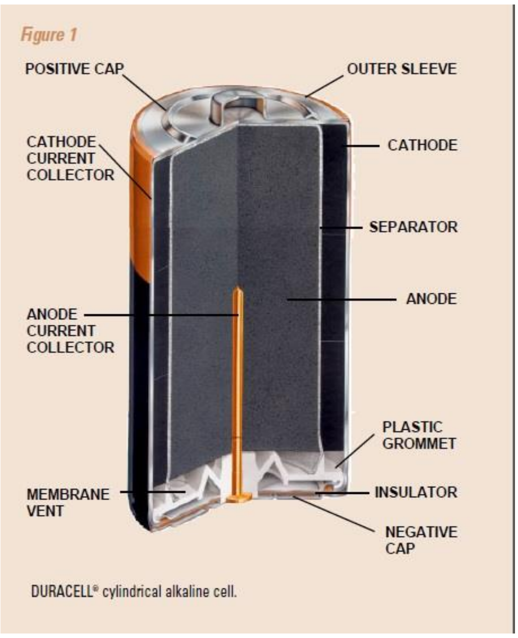
The purpose and objectives.

Alkaline Zn-MnO_2 elements are extensively used type of batteries today. Studies of the zinc oxidation mechanisms, the mechanisms of MnO_2 reduction and influence of various chemical additives in the electrolytes have been used for significantly increasing the lifetime of such systems in conditions of power loads. However, the available data does not allow to evaluate the degree of the changes in the composition and structure of the electrodes and electrolyte in the electrochemical current source as they are derived from compromising the integrity of the working element. Electrochemical impedance spectroscopy (EIS) is a powerful technique for electrode kinetic analysis. This is because it can give the individual impedance for each reaction process, including that of the electrolyte, the passivation layer, charge-transfer, and metal diffusion, provided that the individual time constants are separable.

Object of study.



DURACELL® cylindrical alkaline cell.

The anode material of the alkaline cell is a powdered zinc metal. Manufacturing of the zinc powder is carefully controlled to ensure chemical purity and correct particle size, resulting in good surface area available during the cell reaction. This increased surface area provides greater particle to particle contact within the anode, thereby lowering the cell internal resistance, generating higher power density. Keeping pace with regulatory requirements worldwide, environmentally responsive anode designs have been implemented by Duracell. Contact your local Duracell sales representative for the latest information on these designs.

The cathode material of the cell is a powdered manganese dioxide (MnO2), produced synthetically through an electrolytic process. Its purity and oxygen availability are far superior to the natural material. This contributes to the cell increased energy density and performance.

Additives are used in the major cathode components to enhance performance capability. For example, graphite is mixed with the manganese dioxide to improve conductivity. When mixed with the other ingredients, the electrolytic manganese dioxide provides a cathode of excellent conductivity to assure good cell performance over a wide range of temperatures and discharge rates.

The electrolyte consists of a concentrated aqueous solution of potassium hydroxide (KOH) to which zinc oxide is added to retard corrosion of the zinc. This inhibits the dissolution of the zinc anode and extends the shelf life. In some cell designs, a gel-type electrolyte is formed by the addition of a gelling agent. This electrolyte is alkaline (basic) in contrast to the electrolyte of regular zinc-carbon cells, which is acidic. The concentrated potassium hydroxide solution offers high ionic mobility with a low freezing point.

Methods and tools for research.

The effect of temperature factor on the electrochemical characteristics of the charged commercial alkaline zinc-manganese batteries (DuracellAAA) in size (MN 2400) was investigated in the current study. The EIS data was recorded in a two-electrode system using electrochemical module Autolab-30 (PGSTAT302N MetrohmAutolab) that was equipped with an FRA (Frequency Response Analyzer) analyzer. In order to ensure the temperature measurement mode an electromechanical medium temperature thermostat with the precision of temperature measurement± 1^0C was used.

Science novelty is that the practitioners value the results.

The method of electrochemical impedance makes it possible to study the elements without destroying them and without reducing their capacitance.

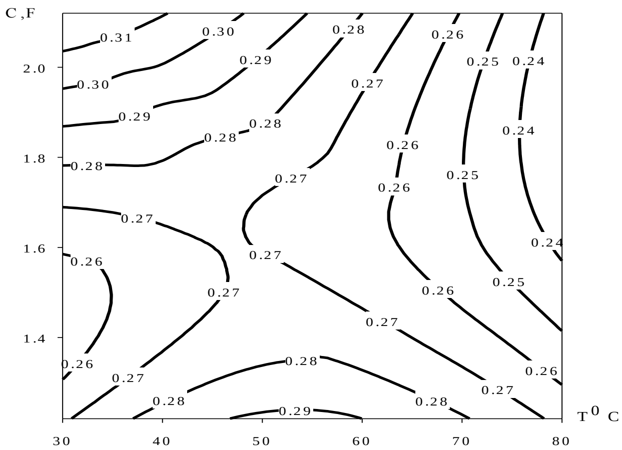


Figure 1. The energy contour map of thesurface capacitances and voltagevariations of alkaline zinc-manganese batteries

Research results.The EIS data in Bode coordinates was used for determination of the values of the surface capacitances and voltage variations in an element for construction of the energy contours map (Figure 1).

Conclusions. The optimal range of frequencies (102-105 Hz) for definition of the state of health of the studied elements was determined.

Keywords. Impedance spectroscopy, temperature factor, optimal range.