

BATTERY FOR CARDIAC PACEMAKER: AN ALTERNATIVE TO LITHIUM-IODINE SYSTEM

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The successful implantation of a cardiac pacemaker into a human body in 1960 opened a new era in health care. Now pacemakers became routine devices. The first implanted pacemakers were powered with Zn/HgO primary cells or with Ni-Cd batteries. Beginning from 1972 and up to date lithium-iodine (and more correctly, lithium-iodine,poly(2-vinylpyridine)) cells remains the most popular power sources for cardiac pacemakers. They have energy density *ca.* 200 Wh/kg, service-life more than 10 years and discharge voltage from 2.8 to 2.4 V. The main feature of lithium-iodine cells is usage of a solid inorganic electrolyte, namely, lithium iodide. The amount, and therefore thickness of the solid electrolyte increases during discharge, resulting in enhancement of the cell internal resistance. Due to very low discharge current, specifically, 20-30 μA this increase of the internal resistance don't make a significant iR loss of voltage. However, high internal resistance hinders the use of such cells in some advanced pacemakers. At the same time a monitoring of internal resistance is a convenient tool for estimation of discharge level and for predicting the approaching end-of-service.

Meanwhile, any increase in service-life of implantable medical devices, including cardiac pacemakers is highly desirable and important. In this connection it seemed worthwhile to use power sources with higher energy densities and lower internal resistance. Indeed, batteries based on other lithium systems were also proposed; lithium-silver chromate, lithium-cupric sulfide, lithium-thionyl chloride being among them. However all these batteries were rejected.

The electrochemical system Li-CF_x is a rather attractive candidate. Theoretical value of energy density for this system is 2435 Wh/kg, which is 4.4-fold of that for Li-I_2 system. Lithium-polyfluorocarbon cells were commercialized about 30 years ago, and now they are widespread. As a rule these cells are manufactured as coin and cylindrical ones. In their traditional usage, as power sources for various electronic devices, Li-CF_x cells have energy

density 150–350 Wh/kg. The upper limit corresponds to the case of cardiac pacemakers, i.e. very low current drain. Lithium-polyfluorocarbon cells have liquid electrolyte, and their internal resistance are small and remains the same within whole service life; only before the very end of discharge some rise of internal resistance occurs. Open circuit voltage as well as discharge voltage of Li-CF_x cells are almost the same as for Li-I₂ ones. This fact ensures interchangeability of both. The discharge curve of Li-CF_x cell, especially, at low currents is rather “flat”; only slight voltage rise occurs in the initial part of the curve and slight voltage decline has place just before the end of discharge.

Elestim-cardio developed Li-CF_x cell specially for cardiac pacemakers. Such a cell BP 5056 has a nominal capacity 2 Ah; discharge voltage at current 20 μA amounts 2.9–3.1 V. Fig. 1 shows typical discharge curve for such a cell.

Fig. 2 demonstrate the dependence of discharge capacity of the cells BP 5056 produced by Elestim-cardio on discharge current. Mind that current range shown in the Fig. 1 is far larger than usual load of usual cardiac pacemakers.

Fig. 3 shows evolution of internal resistance of the cells BP 5056 during discharge. The internal resistance was measured with analyzer Solartron 1255. The resistance rise at the end of discharge is not so high but it is quite sufficient for indication of capacity exhaustion.

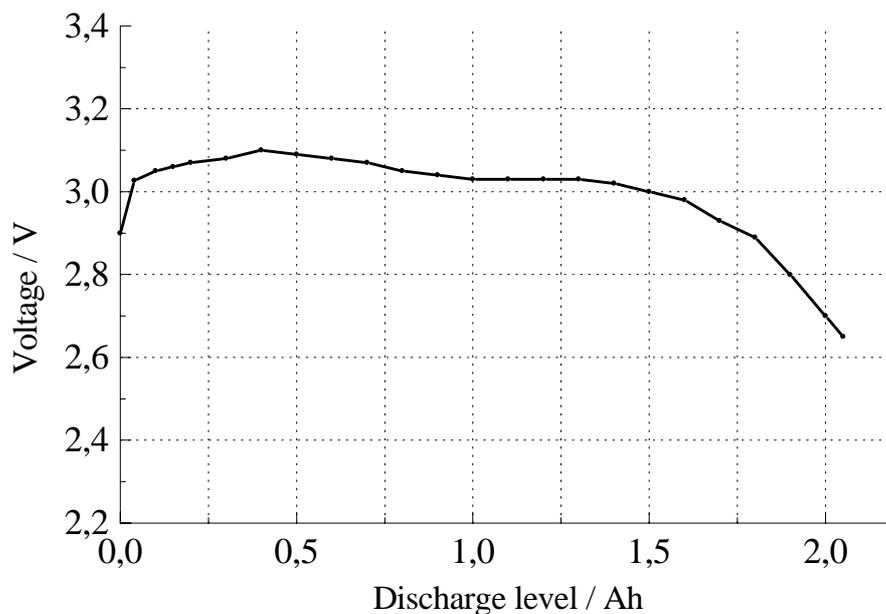


Fig. 1. Discharge curve for the cell 5056

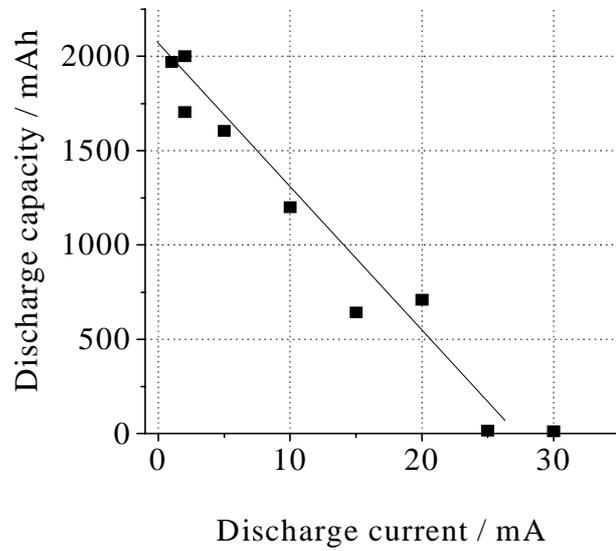


Fig. 2. Discharge capacity of the cells BP 5056 vs discharge current

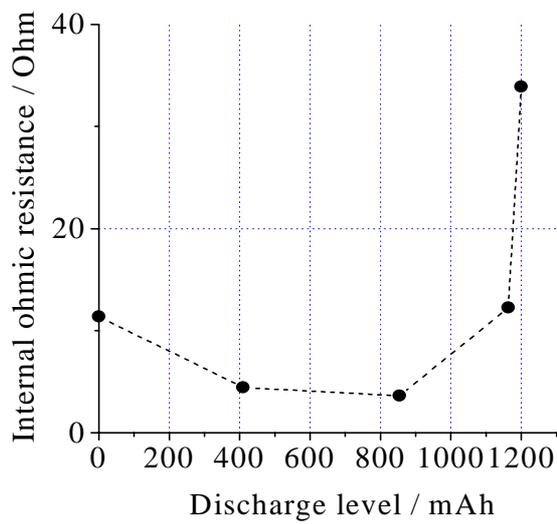


Fig. 3. Internal resistance evolution during discharge of the cell 5056 with current 10 mA