# SILVER – IODINE BATTERIES

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# Introduction

The advances in battery technology, electronics and medical knowledge have produced a wide variety of sophisticated implantable devices to treat ailments ranging from irregular heartbeat to pain and epilepsy. Also a great diversity of battery powered external devices are used to administer drugs, treat ailments and monitor bodily functions.

Generally, for the safety of patients, it is used the solid state batteries which have a number of very desirable features such as absence of any possible liquid leakage or gassing and the possibility of operation over a wide temperature range. The batteries with  $RbAg_4I_5$  solid electrolyte are made part from these galvanic cells.

The solid electrolyte  $RbAg_4I_5$  belong to the compounds-group of general formula  $MAg_4I_5$  (where  $M^+ = Rb^+$ ,  $K^+$ ,  $NH_4^+$ ) having an exceptionally high ionic conductivity (about  $10^{-1}$  S/cm) at room temperature. The structures of these solid electrolytes are not close-packed, but contain two- or three networks of passageways intercalated in crystalline structures.

The crystallographic structure of RbAg<sub>4</sub>I<sub>5</sub> was determined by X-ray diffraction. There are three crystalline modifications of RbAg<sub>4</sub>I<sub>5</sub>, labeled as the  $\alpha$ ,  $\beta$  and  $\gamma$  phases in order of decreasing temperature. The  $\alpha$  form has a cubic crystal lattice of P4<sub>1</sub> 32 (O<sup>7</sup>) or P4<sub>3</sub> 32 (O<sup>6</sup>) symmetry,  $\beta$  form has a rhombohedral crystal lattice of R 32 (D<sub>3</sub><sup>7</sup>) symmetry and  $\gamma$  modification has a hexagonal structure of loss P 321 (D<sub>3</sub><sup>2</sup>) symmetry.

The high conductivity is due to a combination of a high concentration of mobile ions and a low activation energy for ionic motions from site to site. For these materials the silver ion is mobile specie and its transport into lattice takes place by a defect mechanism [1-5].

# Experimental

The solid electrolyte RbAg<sub>4</sub>I<sub>5</sub> was prepared by an original method [6-9].  $bAg_4I_5$  samples were obtained by isothermal crystallization (at 55 °C) from acetone solution containing a mixture of RbI and AgI in molar ratio 1:2. By gravimmetric and chemical analyses, it was established that the prepared powder is RbAg<sub>4</sub>I<sub>5</sub> having a 98.894% purity. The structural characterization of the prepared RbAg<sub>4</sub>I<sub>5</sub> was performed by X-ray diffraction.

With RbAg<sub>4</sub>I<sub>5</sub> solid electrolyte prepared were realized two types (I- and II-type) of Ag/RbAg<sub>4</sub>I<sub>5</sub>/RbI<sub>3</sub> button cells. The cathodes for both types of batteries were performed from a mixture of RbI<sub>3</sub> (87.30%), graphite (6.75%) and RbAg<sub>4</sub>I<sub>5</sub> (5.95%), which was pressed. The anode for the I-type cell was an amalgamated silver disk of 0.02 mm thickness and for II-type cell a mixture of Ag powder (88.00%), graphite (8.00%) and RbAg<sub>4</sub>I<sub>5</sub> (12.00%), which was pressed. The cells were assembled by pressing of their components (anode, solid electrolyte and cathode) at 1700 kgf/cm<sup>2</sup> for 20 minutes.

# **Results and discussion**

From X-ray diffraction pattern of obtained powder it comes that are present only specific diffraction lines of  $\alpha$  -RbAg<sub>4</sub>I<sub>5</sub> solid electrolyte.

The values of e.m.f. for I-type cells were situated in the range 590-600 mV and for II-type were 650-660 mV. The electrochemical behavior of  $RbAg_4I_5$  solid state cells was investigated by performance curves under constant load and galvanostatic regime.

From Fig.1, where are showed the discharge curves of I-type and II-type cells under constant resistance (R=100  $\Omega$ ), it can see that the II-type cell has higher characteristics than the II-type battery. Thus the discharge plateau of II-type was situated in the domain 525-575 mV, whereas for I-type in range 350-400 mV. The average discharge intensity was of 1.33mA for II-type and 1.28mA for I-type cell.



Fig. 1 Discharge curves of I-type and II-type cells under  $R=100 \Omega$ .

The batteries were discharged at two current densities:  $i=2 \text{ mA/cm}^2$  (Fig.2) and  $i=0.2 \text{ mA/cm}^2$  (Fig.3) in galvanostatic regime. From the discharge curves it can ascertain that at less current density (0.2 mA/cm<sup>2</sup>) the discharge plateaus have higher values for I-type cell, close to those of II-type cell. At the current density of 0.2 mA/cm<sup>2</sup> the total yielded energy was of 10.20 mWh for I-type cell and 11.89 mWh for II-type cell.



Fig. 2 Discharge curves of cells at  $i=2mA/cm^2$ .



Fig. 3 Discharge curves of cells at  $i = 0.2mA/cm^2$ .

The electrochemical characteristics of  $Ag/RbAg_4I_5/RbI_3$  cells are presented in Table 1, where from the experimental data were calculated: C-the mass capacities and W- the energy densities.

As can be seen from Table 1, the all calculated parameters are better for II-type cells than for I-type cells. The mass capacities and energy densities depend on the discharge regime, they are higher under galvanostatic at less current densities (0.2 mA/cm<sup>2</sup>).

Table 1 The electrochemical characteristics of batteries with RbAg4I5 solid electrolyte

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	Туре	Mass	Discharge	i	Cg	Wg
	cell	[g]	regime	[mA/cm <sup>2</sup> ]	[Ah/kg]	[Wh/kg]
	I	1.096	Load	2.52	13.80	5.92
	II	1.037	R=100Ω	2.63	16.49	9.79
	I	0.995	galvanostatic	2	15.07	6.22
	П	1.053			15.20	9.00
	I	0.915	galvanostatic	0.2	20.22	11.15
	П	0.954			20.44	12.46

### Conclusions

From the obtained results it can be establish that Ag/RbAg<sub>4</sub>I<sub>5</sub>/RbI<sub>3</sub> batteries present good electrochemical characteristics to use in medical devices such as cardiac pacemaker.

#### References

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