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LONG-TERM DISCHARGE CHARACTERISTICS OF LITHIUM–IODINE CELLS WITH AN ADDITIVE IN POLY(2-VINYLPYRIDINE) IODIDE

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Summary

Long-term discharge characteristics of lithium–iodine cells using a cathode additive (a charge transfer complex with low resistivity) have been tested under several conditions. Data for continuous discharge over three years show that the load voltage is better than that of cells without an additive. The discharge capacity under a heavier load is considerably superior to that of the usual lithium–iodine cell. Calorimetric data of heat dissipation caused by self-discharge have also been obtained.

Introduction

In a previous paper [1], it was reported that an improvement in the discharge rate and the low-temperature performance of a lithium–iodine cell had been achieved by adding an iodine-containing charge transfer complex (which has a low resistivity over a wide temperature range) to poly(2-vinylpyridine) iodide to form the cathode material. The improved cell can be discharged at several milliamperes (37 °C). The load voltage remains stable above 2.0 V under a constant current of up to 20 μA, even at temperatures as low as −50 °C. The donor weight of the additive is only about 0.7 - 1.4% of that of poly(2-vinylpyridine) iodide. Furthermore, a small amount of additive donor replaced part of the poly(2-vinylpyridine) and therefore the improved cell is capable of a higher energy density. The cathode materials, *i.e.*, the additive, poly(2-vinylpyridine) iodide, and pure iodine, are pelletized and the cell assembly can be machine fabricated.

The long-term discharge characteristics of the above improved cell are reported in this paper. The data have been collected over a period of three years.

Results and discussion

The cathode of each test cell consisted of 95% active material and a given amount of the additive. The performance of these cells was compared

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with that of lithium–iodine cells used as power sources for pacemakers. Both types of cell had the same size, construction, technology, and design capacity. Figure 1 shows the discharge characteristics of both cells under a constant current of 30 μA at 37 °C.

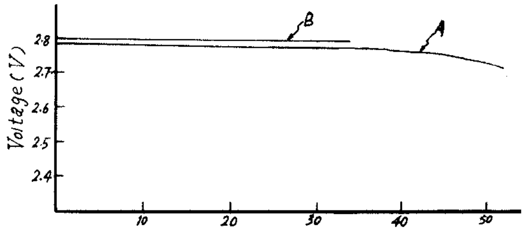


Fig. 1. *V–t* characteristics of test cells at 37 °C, 30 μA constant current. A, Without the additive; B, with the additive.

The cell with the additive has operated for 35 months and is still under test. The *V–t* curves show that the operating voltage of the cell with the additive remains stable at about 2.8 V and is 20 mV higher than that of the cell having no additive.

A comparison of the voltage/capacity curves for cells with and without the additive reveals (Fig. 2) that the presence of an additive gives an improved performance under a heavier load. Although the latter current was 2.5 times greater than that of the normal cell, the operating voltage was about 30 mV higher. Furthermore, the calculated discharge capacity (cut-off voltage is 2.300 V) increased by 53%. When the discharge currents were decreased to their normal values, *i.e.*, 20 μA for the cell with the additive and 30 μA for the cell without the additive, the former cell operated at a higher voltage and with a better voltage stability than the latter.

Recently, a Model 2313 pacemaker lithium–iodine cell was constructed with 5% additive in the cathode mixture. The *V–t* characteristics of this cell (Fig. 3) are similar to those obtained for the test cell (*cf.* Fig. 1). The operating voltage of the Model 2313 cell is about 14 mV higher than that of the cell made by the usual technology.

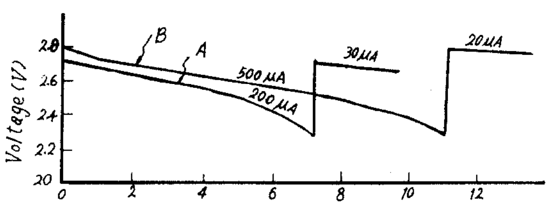
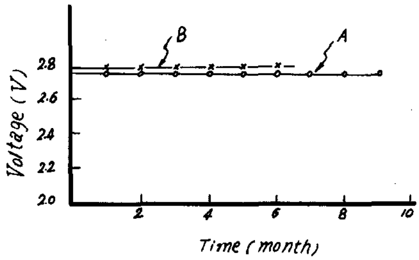


Fig. 2. *V–Q* characteristics of test cells at 37 °C. A, without the additive; B, with the additive.



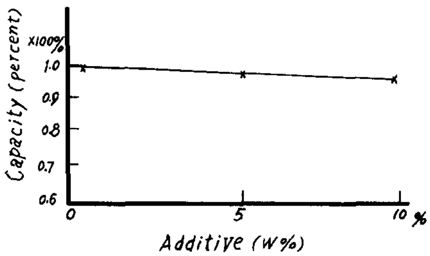


Fig. 3. V–t characteristics of Model 2313 cells at 37 °C, 20 μA constant current. A, Without the additive; B, with the additive. The test is still underway.

Fig. 4. The effect of additive content on the designed capacity.

In addition to the evaluation of long-term discharge behaviour, the measurement of heat dissipation caused by self-discharge has been carried out using a micro-calorimeter. The results predict that the total capacity loss in a cell with the additive should be less than 5% during its lifetime. It is therefore concluded that the iodine-containing charge transfer complex, when added correctly to the cathode, exerts little effect on the self-discharge caused by internal short-circuits in the cell. Further experimental results, shown in Fig. 4, indicate that the optimum donor content of the additive ranges from 5% to 9% of the cathode material.

Conclusion

In summary, the advantages of improved capacity at high rate, and better low-temperature performance that result from use of the additive, outweigh the disadvantage of capacity loss caused by self-discharge.

Reference

1 Min-liang Lin, Ye-xian Jin, Yong-zhen Zhang and Yu-feng Hou, *J. Power Sources*, *14* (1985) 173 - 177.