Use of iodine-2,2'-azinobis (3-ethylbenzothiazole-6-sulphonate) mixture as cathode in a solid state cell

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Abstract. A new solid state test cell having a configuration of (-) Ag, Ag6I4WO4/Ag6I4WO4/I2, ABTS (+) [ABTS: 2,2'-azinobis (3-ethylbenzothiazole-6-sulphonate)] has been investigated through polarization and ageing studies. The cell has an open circuit voltage and short circuit current of 640 mV and 18.5 µA respectively at room temperature.

Keywords. Solid state cell; 2,2'-azinobis (3-ethylbenzothiazole-6-sulphonate); solid electrolyte; cathode; polarization.

1. Introduction

The market potential for self-contained and portable batteries for day-to-day applications, for instance power tools, toys and cost-effective batteries in place of expensive Ni–Cd cells, is quite attractive. In spite of the fact that practical considerations for large-scale production are currently at an early stage and much more developmental work needs to be completed, recent efforts have indicated the possibility of developing new fabrication technologies for such batteries. The technical feasibility of such solid state systems, capable of operating flash lights has already been explored at Harwell (Hooper and Tofield 1984).

The primary requirement of a solid state cell is an electrolytic medium characterized by high ionic conductivity with negligible electronic mobility. The choice of cathode materials for solid state electrochemical cells is governed by two factors: (i) the cathode reversible potential should be less positive than the decomposition potential of the electrolyte, and (ii) the half-cell reaction must be electrically compatible with the mobile ion in the electrolytic phase. In order to reduce electrode polarization effects, particularly cathode polarization which generally results in loss of power output, it is necessary to use electronically conducting iodine charge transfer complexes as cathodes in silver iodine batteries (Vincent et al 1984). Power ratings of a silver anode primary battery system, constituted by five cells in the series mode, with Ag6I4WO4 as the solid electrolyte and the I2–phenothiazine charge transfer complex as cathode have been reported in our earlier work (Suthanthiraraj 1986).

This paper deals with our investigations on a silver–iodine solid state cell having a new cathode mixture containing 2,2'-azinobis (3-ethylbenzothiazole-6-sulphonate) (ABTS) and iodine. From the family of stable silver ion conductors, Ag6I4WO4 has been chosen as the electrolyte.

2. Experimental

2.1 Materials

2.1a ABTS: A Boehringer (West Germany) sample of 2,2'-azinobis (3-ethyl-
benzothiazole-6-sulphonate) in the form of a diammonium salt having a formula of 
\[ C_{18}H_{16}N_{4}O_{6}S_{4}-(NH_{4})_2 \] was used as such.

2.1b Anode: A mixture of 99.9% pure silver powder (40 mg) and \( \text{Ag}_6\text{I}_4\text{WO}_4 \) solid electrolyte powder (10 mg) was used as the anode. The incorporation of the electrolyte in the negative electrode structure is to maximise the anode/electrolyte interface area and to ensure the best interfacial contact between the electrode and electrolyte layers.

2.1c Cathode: The cathode was a complex containing iodine (30 mg) and ABTS (20 mg).

2.1d Electrolyte: \( \text{Ag}_6\text{I}_4\text{WO}_4 \) solid electrolyte was synthesized from AnalaR grade chemicals of AgI, AgNO\(_3\), and Na\(_2\)WO\(_4\)·2H\(_2\)O as suggested by Takahashi et al (1973) and examined by powder X-ray diffraction and electrical conductivity techniques. 500 mg \( \text{Ag}_6\text{I}_4\text{WO}_4 \) was used as electrolyte in the cell.

2.2 Cell design

A circular cell of 8 mm dia and 4 mm thickness was fabricated by pressing the three cell components together at a pressure of 4 ton cm\(^{-2}\). The button cell thus prepared was placed between two silver foils (the anode face was directly attached to the foil while the cathode face was held via a graphite disc, acting as a current collector). This stack was mounted between two ebonite discs through screw arrangements and electrode leads taken out for measurements.

2.3 Cell performance

The button cell was drained at different currents and the values of voltage corresponding to each load resistance measured using a Keithley 614 Electrometer. The cell was kept at 30°C for a period of 90 days and various polarization effects analysed through performance plots.

3. Results and discussion

3.1 Discharge features

Typical discharge curves for the cell operating at 30°C under various loads are shown in figure 1. These isothermal curves corresponding to constant loads 15, 47, 150 k\( \Omega \) and open circuit conditions, respectively, are similar in shape, indicating a well-defined mechanism of the electrode processes. The open circuit voltage of the fresh cell has been found to be 640 mV against a theoretical value of 687 mV. In fact, the presently observed open circuit voltage value coincides with that obtained with an \( I_2 \) phenothiazine cathode. This is due to the fact that the overall cell reaction remains the same in all the cases based on the \( Ag^+ \) ion motion. It is also clear from figure 1 that low current discharges are more stable than the high current ones.