

POLY(ANILINE)-COATED ELECTRODES FOR GAS RECOMBINATION IN LEAD/ACID BATTERIES

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Introduction

Conducting organic polymers have attracted considerable interest in recent years [1 - 3], stimulated in large part by their possible application in batteries. For example, a study has been made [3] of the performance of poly(pyrrole) (PPY)- and poly(aniline) (PA)-coated electrodes as cathode materials in non-aqueous [3a, c] and commercial dry cells (*i.e.*, by replacing the carbon rod by polymer-coated carbon rod) [3b]. In this paper, an investigation is reported of the possibility of using a poly(aniline)-coated lead plate as an improved electrode for lead/acid batteries. Poly(aniline) has been chosen as it is readily formed in sulphuric acid [3] and is also stable with excellent electronic conducting properties [2].

Experimental

The lead plates were obtained from a commercial lead/acid battery (Chloride, India) and had dimensions: 7 cm × 7 cm. The plates were lightly etched [4] with dilute HNO₃, washed several times with distilled water, and then coated on both sides with poly(aniline) using an electrochemical procedure [3a]. Electron micrographs of the PA-coated surface are shown in Fig. 1. These PA-coated lead plates were coupled with positive plates (7 cm × 7 cm, Chloride, India), using a commercial separator, and placed in a laboratory test cell, shown in Fig. 2. Sulphuric acid (GR grade) of sp. gr. 1.250 was used as the electrolyte. Extreme care was taken to render the cell airtight. For comparison purposes, similar laboratory cells were set up with uncoated lead electrodes; these cells were designated as reference cells. Both the test and reference cells were charged under identical conditions. The level of the liquid in the graduated side tube (Fig. 2) indicated either the development of a gas pressure or the recombination of gas in the cell.

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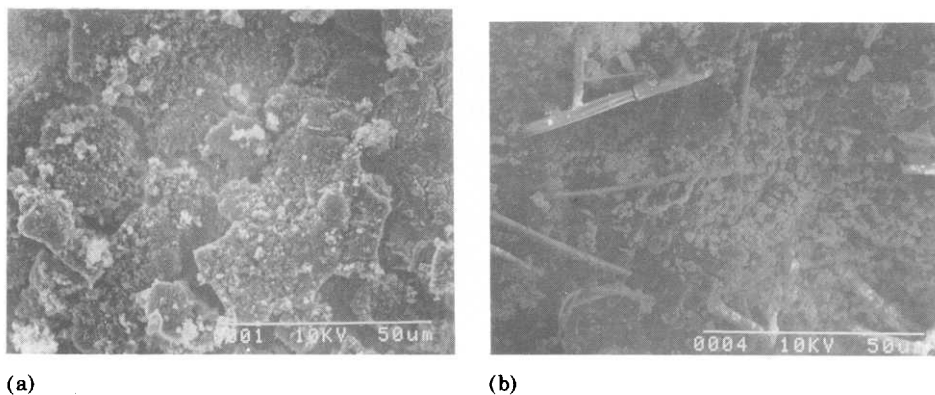


Fig. 1. Electron micrographs of PA film on lead plate: (a) light deposit; (b) heavy deposit.

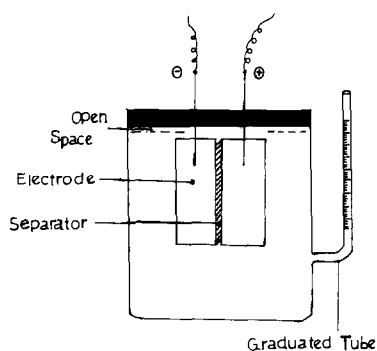


Fig. 2. Laboratory test/reference cell.

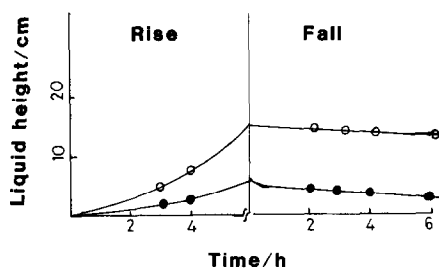


Fig. 3. Rise/fall of liquid level during charging/recombination: ○, reference cell; ●, test cell.

Results and discussion

Figure 3 shows the gas pressure developed (in terms of height of the liquid column) within the test and reference cells when both types of cell were charged at 0.35 A for 6 h. It is interesting to note that the gas pressure in the test cells is less than that in the reference cells. Because of the

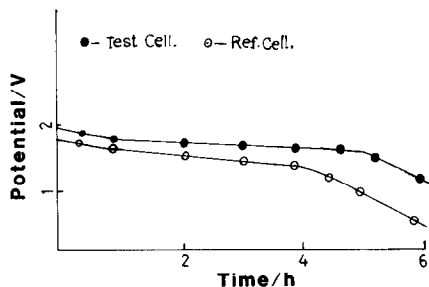


Fig. 4. Discharge curve of test and reference cells through $3.0\ \Omega$ load.

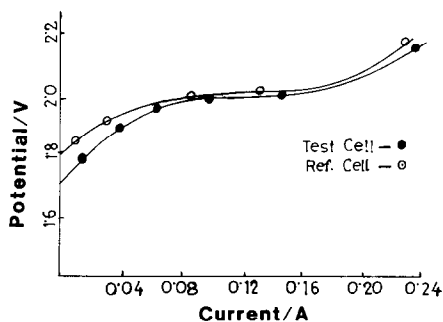


Fig. 5. Galvanostatic polarization curve.

catalytic effect of poly(aniline), however, an increased rate of gas evolution would have been expected in the test cells. The observed reverse trend prompted measurements of the water loss in the cells.

In this experiment, the electrode pair in combination with the separator was immersed in a precisely known volume (350 ml) of H_2SO_4 (1.250 sp. gr.) and charged for 7 h at 0.35 A. The subsequent results showed that while an average of $2.9\ \text{ml h}^{-1}$ of water was lost during charging of the reference cells, the value was reduced to $2.1\ \text{ml h}^{-1}$ in the test cells. These findings support the measurements of the pressure developed in each type of cell (Fig. 3).

The discharge behaviour of the test and reference cells (discharge through a torch light bulb of resistance $3\ \Omega$) is given in Fig. 4. The discharge plateaux show that the test cell exhibits the best performance. To understand this, the galvanostatic polarization curves of the system as a whole have been examined (Fig. 5). Since the positive plates of the test and reference cells are identical, the observed polarization curves indicate that Pb^{2+} is deposited at a slightly lower potential on the PA-coated electrode. This may be due to a catalytic effect of PA on the electro-reduction of Pb^{2+} .

The gas-recombination (open-circuit) curves in Fig. 3 are almost the same for the test and reference cells. Thus, it appears that, under ordinary

pressure, gas recombination is a slow process. The slightly higher gas-recombination rate with a PA-coated electrode may again be explained in terms of a catalytic effect.

Conclusions

From the results of this preliminary investigation, it appears that it is possible to reduce water loss (or increase the rate of gas recombination) in lead/acid batteries by using poly(aniline)-coated lead electrodes. Further studies are in progress to evaluate cycling efficiency, the reduction of oxygen on poly(aniline) during exhaustive overcharging, and gas recombination at high pressures. These investigations will determine the suitability of conducting-polymer-coated lead electrodes in low-maintenance or maintenance-free lead/acid batteries.

References

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