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Use of polyaniline in lead acid battery

M.Raghavan* , D.C. Trivedi

Central Electrochemical Research Institute, Karaikudi – 630 006, Tamilnadu, India.

Abstract

The study reports the performance of polyaniline grafted polypropylene sheet as a substrate for electro-deposition of lead/lead dioxide as a lightweight grid for lead acid battery system.

Keywords: Lead acid battery, polyaniline, grafting, coulombic efficiency, charge – discharge.

Introduction

The past two decades have witnessed unabated interest in the conducting polymers and their technological applications. The polymer most widely studied till now is polyaniline, because of its environmental stability and easy method of synthesis [1]. Trivedi [2-4] reported that polyaniline can be grafted easily on any insulating substrate during its synthesis. The grafting occurs via adsorption of free radicals on the substrate, which acts as a centre for nucleation for the growth. Lead is a heavy metal and its density is 11.4. In all electrochemical reactions only the surface of the electrode takes part in electrochemical processes. This implies that in lead acid battery the lead carrys a dead weight and hence any method to reduce the weight of the grid is a welcome feature to increase its charge storage capacity or energy density. For an electrical powdered vehicle requirement is that battery should have an energy density of 80 wh/kg. In this paper, we describe the performance of polyaniline grafted polypropylene sheet, used for the electro-deposition of lead and lead dioxide as a lightweight grid for lead acid battery.

Experimental

Polyaniline on 0.5 mm thick (140 mm x 140 mm) polypropylene sheet was grafted as described earlier [2] from 0.1 molar solution of aniline in 1 M solution of para – xylene - 2,4-disulphonic acid by adding drop by drop 0.1 molar solution of ammonium persulphate. During addition of persulphate the specimen was swirled vertically to ensure uniform deposition. The grafted polyaniline substrate showed the resistance of 10 Ω/cm. Polyaniline grafted polypropylene substrate were undoped using 0.1 mole of ammonia solution and thoroughly rinsed with distilled water. The undoped substrate was treated with 0.1 percent solution of palladium chloride. The palladium chloride treated substrates were made as cathode for the electro-deposition of copper from copper sulphate bath containing 200 g/l of copper sulphate and 100 g/l of H_2SO_4, the current density for deposition was for five minutes. On this copper deposited substrate the 1mm thick lead was deposited from an electrolyte containing 150 g/l of lead tetra fluoroborate and 100 g/l of fluoro boric acid and 1% of polyvinyl alcohol containing 30% by weight of polyaniline to ensure adherent thick coating at a current density of 15 mA/cm2. Thus the lead acid battery grid had a following composition.

Polypropylene base ---- Polyaniline as inner layer over which first copper layer and then 1mm thick lead layer, this configuration was used as a negative plate.

The positive plate was prepared by subjecting lead deposited plate to anodic oxidation in an electrolyte containing sulfuric acid of density 1.28. After the formation of lead dioxide the electrode was rinsed thoroughly and dried under vacuum. This dried lead dioxide anode was kept immersed in 20% by weight solution of polyaniline in concentrated methane sulphonic acid for thirty minutes and rinsed with sulfuric acid of density ~1.28 to achieve the precipitation of polyaniline particles in the pore of lead dioxide to ensure not only the better conducting network but also to act as a binder for loosely held lead dioxide to prevent the failure of anode during charge discharge cycle.

The cell was assembled with one positive plate and two negative plates and electrolyte was Analar grade sulfuric acid of density 1.28. The cell was then subjected to cycling at 32 hrs rate of discharge followed by 32 hrs rate of charging. The charge – discharge study was carried out for 100cycles by charging and discharging at 150 mA.

* Email : ragha@cscecri.ren.nic.in fax : +91 4565-27779

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The cell attains the 90% of capacity within first four cycles. No deterioration in cell performance was observed on repeated charge-discharge up to 100 cycles. The charge –discharge cycles is depicted in Fig-1. The coulombic efficiency and discharge capacity as a function of number of cycles was carried out by keeping cut off voltage at 2.0V for charging and 1.8V for discharging period. The observations are recorded in Fig-2.

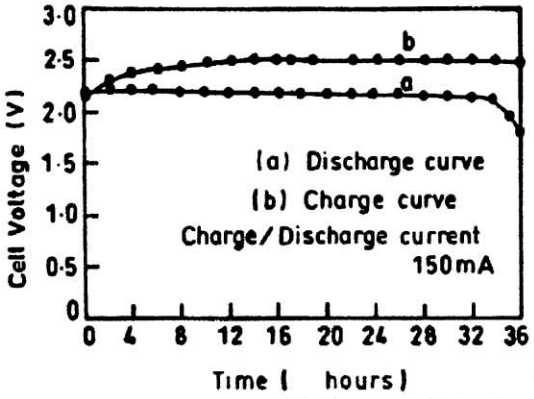

Fig.1 Charge/discharge at 150 mA

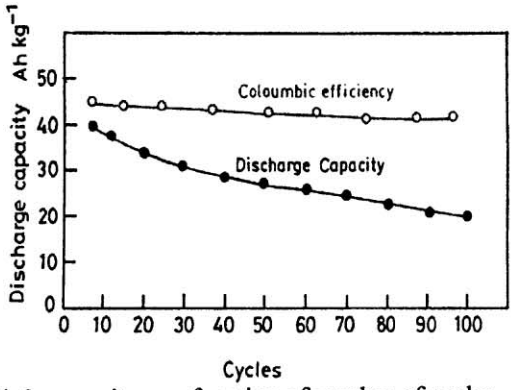

Fig2- capacity as a function of number of cycles

Results and Discussion

The lead acid battery is a proven system and any weight reduction in a conventional system would prove beneficial for its application in battery driven vehicles. Earlier attempts have been made to reduce the weight of the grid by electroless deposition of lead on plastic surfaces, however; such a deposition suffers from bulging and ultimate failure in few cycles mainly due to poor surface bonding of metal to substrate. In the present work conducting polyaniline was grafted on an aniline pre-treated surface of polypropylene to ensure that conducting polyaniline forms on this surface gets deeply embedded in the polypropylene substrate to ensure better adhesion of electro-deposited metal. To achieve better electro-deposition of a lead a pre coat of a copper was given. The SEM micrograph shows that copper has a granular structure Fig-3. The deposition of lead over this surface is convenient and has regular pattern without any crack Fig-4.

The perusal of Fig-2 indicates that coulombic efficiency decreases after 100 cycles. However, the discharge capacity on other hand decreases steadily from initial 40 Ah/kg to 20 Ah/kg after 100 cycles. This aspect needs detailed study on deposition of copper and lead over polyaniline.

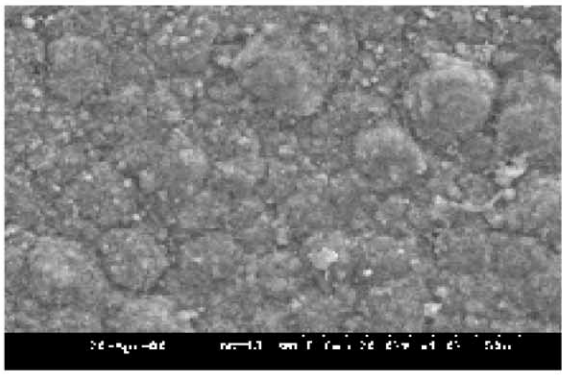

Fig-3 SEM micrograph of copper on PAn

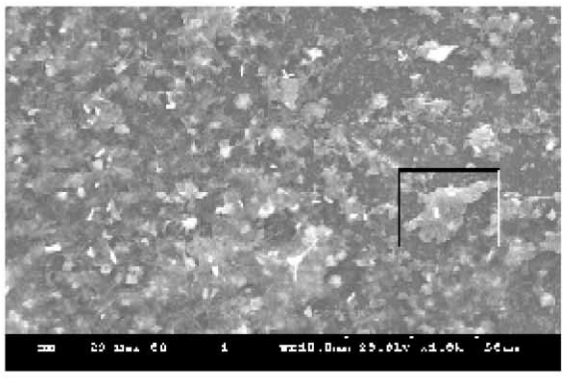

Fig-4 SEM micrograph of lead on PAn / copper

Conclusion

This preliminary work shows that using polyaniline grafted surface for the preparation of electrodes can reduce the weight of lead acid system by half. This study needs an investigation on various aspects of metal deposition on polyaniline.

Acknowledgement

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