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Flexible Primary Solid State Cell, Based On A Pyridine Containing Poly(Ether Sulfone) Copolymer Membrane

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ABSTRACT : *Conducting membrane blends, consisting of pyridine containing poly - (aryl ether sulfone), have been fabricated after saturation in KH_2PO_4 solution. The contact between the conducting membrane and a Mg foil as anode was achieved by a gel solution of polyvine alcohol and KH_2PO_4. This form of dry cell was efficient enough to provide 6.75 mWh cm^{-3}, 96.03 mWh kg^{-1} and voltage approximately 1.6 V.*
KEYWORDS *- Solid State Primary Cells, Primary Batteries, Pyridine Poly(ether sulfone) Polymer, Polymer Conducting Membranes*

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I. INTRODUCTION

The potential of application of conducting polymer membranes for the construction of dry cells [1 – 9] is well known. Primary and secondary power cells have three components. The first is an electron source (anode), a metal (Li or Mg), the second is a fast – ion conductor, polymer electrolyte for example and the third component is an electron exchanger (cathode), a conducting polymer membrane. The development of polymer blends resulted in the improvement of their mechanical properties [10, 11] and the application of pyridine containing poly – aryl ether sulfone in electrochemical devices has recently been reported [12, 13].

II. PREPARATION OF THE CELL

In this work a polymer blend was prepared in analogy to a previously published report [13] but with small differentiations. More specifically, a mix solution of copolymer (Fig. 1, [12]) and polyethylene oxide (PEO 200 kDa, Sigma – Aldrich), was dispersed in dimethylacetamide (DMAc, Sigma Aldrich) at a 60 : 40 % weight ratio. This mix solution was cast on a glass Petri dish with the solvent slowly evaporated at 80 ºC within 24 h. Thereafter, the obtained membrane was immersed in 250 ml of deionized water for 12 h at 80 ºC to fully extract PEO. The final membrane was dried under vacuum at 100 ºC for 14 h.

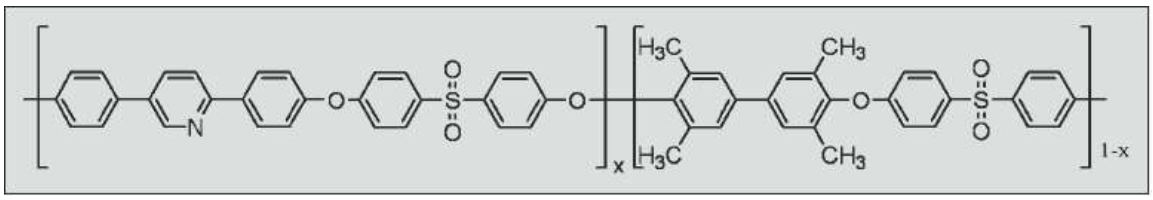

Figure 1. Chemical structure of copolymer [12].

Finally the obtained polymer blend membrane was immersed in saturated KH_2PO_4 solution overnight in order to uptake phosphates and became conducting. Then the conducting membrane was stuck on a magnesium foil (Merck 99 %), using as gluing material a thin film of 10 % wt polyvinyl alcohol (PVA, MW = 60000, Sigma Aldrich) in saturated KH_2PO_4 aqueous solution as shown in Fig. 2.

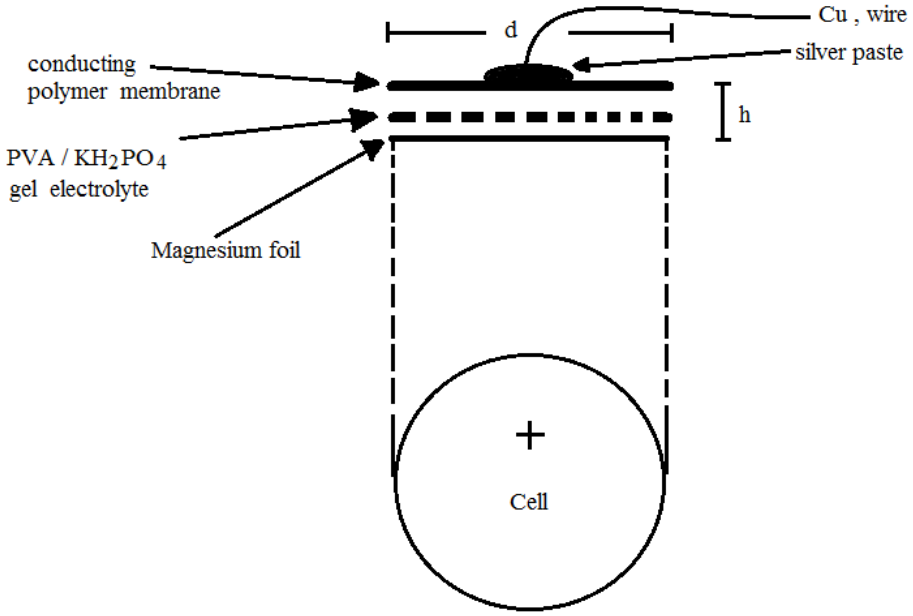

Figure 2. Constructed of the cell presented herein, weight 0.4821 gr , *d* = 1.94 cm, *h* = 1.02 mm.

III. RESULTS AND DISCUSIONS

The electrochemical reaction which produces the electrical energy, is the oxidation of the metal (1). The oxidation reaction controlled by the appropriate combination of the cathode (conducting polymer blend membrane), acting as electron exchanger and the gel electrolyte. The cathode allowing the reduction process, accepts electrons from the external circuit and positive ions through the intercalation [6].

$$Mg \rightarrow Mg^{2+} + 2e \qquad (1)$$

Fig. 3 shows the discharge behavior of the dry cells described above under a load resistance of 2 MΩ. The EMF values were measured by a high impedance volt – meter (10^{12} Ω).

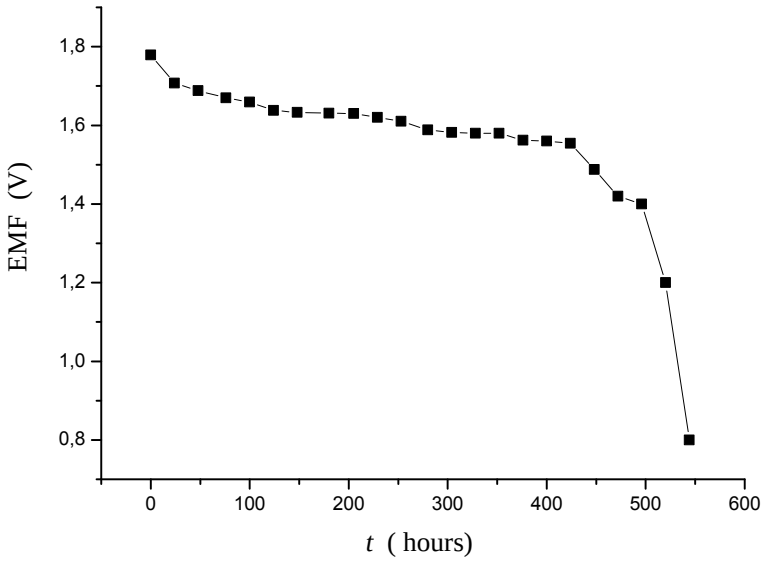

Figure 3. Discharge curve for the constructed dry cell, under a load resistance of 2 MΩ.

A cell voltage of about 1.6 – 1.5 V was maintained for 450 h (the experiments were performed five times and are reproducible). the efficiency of the cell 6.79 mWh cm^{-3} is comparable to other commercial cells [14], working on different principles (rechargeable cells or secondary cells) which are constructed from polyaniline as a cathode and Li/Al alloy as an anode (Bridgestone and Seiko).

Also the energy density of the cell described herein is 96.03 mWh g^{-1}, four times more than the energy density of the $PbO_2 – H_2SO_4 – Pb$ multiple charge, discharge system (20 mWh g^{-1} [8]) and comparable to the energy density of lithium ion rechargeable batteries (80 mWh g^{-1} [8]).

IV. CONCLUSION

It is the first time that this type of flexible solid state cells, friendly to the environment, have been constructed and the perspective of applications in primary batteries is quite attractive. This form of dry cell was efficient enough to provide 6.75 mWh cm^{-3}, 96.03 mWh kg^{-1} and voltage approximately 1.6 V. The potential application of such dry cells span the entire range of battery product, from smart credit cards to standby power in telecommunications, including Polaroid instant film packs and batteries build into printed – circuit boards in laptop personal computers. Their combination of high energy density and mechanical stability make them particular attractive for application in space.

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