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Zinc ion battery on a polyester-cotton textile

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Introduction

In an e-textile system sufficient electrical energy from an external electrical connection, battery or supercapacitor [3] is required for devices such as sensor nodes [1], microprocessors and transceivers [2]. In the past flexible secondary battery have been achieved with a layer of polyester cotton textile and achieved an operating voltage between 0.9 – 1.9 V [4]. This poster presents a rechargeable zinc ion battery that can be realised on top of polyester cotton fabric**.** This work proposes an approach for integrating an encapsulated, secondary battery on top of the textile.

Device Characterization

The manganese oxide cathode textile, cathode textile with membrane coating and zinc anode layer with encapsulation film are shown in figure 2. The device is assessed using a potentiostat Autolab pgsatat101(Metrohm Autolab, The Netherlands). Its electrochemical performance was obtained from galvanostatic cycling (GC) at 1 $mA.cm^{-2}$ and cyclic voltammetry (CV) at 10 $mV.s^{-1}$ between 0.9 and 1.9 V.

Device Fabrication

- Membrane ink- Mix PEVA, PMMA and solvents in the correct percentage.
- Electrode ink – Zinc (anode), Manganese oxide and carbon powder ((cathode), mixed with polymer binder and solvent.
- Electrolyte – Aqueous zinc sulphate and manganese sulphate.
- Screen print silver conductive layer on top of textile and hot melt PEVA encapsulation layer (figure 1a&b)
- Spray coat anode layer on silver coated encapsulation layer. (figure 1c)
- Sputter coat nickel inert layer on top of silver coated textile.
- Spray coat cathode electrode on nickel (figure 1d).
- Punch a hole in the anode/encapsulation layer (figure 1e).
- Fabricated battery membrane on top of cathode layer (figure 1 f).
- Encapsulate the device using a heat press(figure 1 g).
- Fill the gel electrolyte into electrodes via a hole on the anode layer.
- The size of each device is 0.785 cm^2 × 0.6 mm.

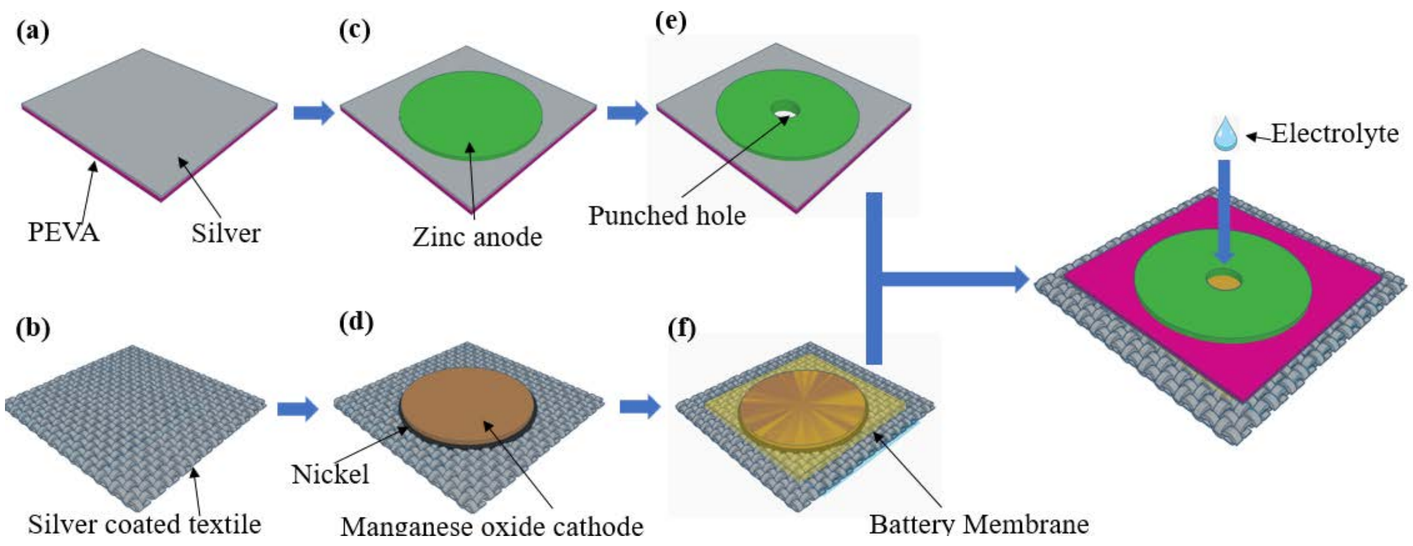

Figure 1. Schematic, illustration of fabrication process

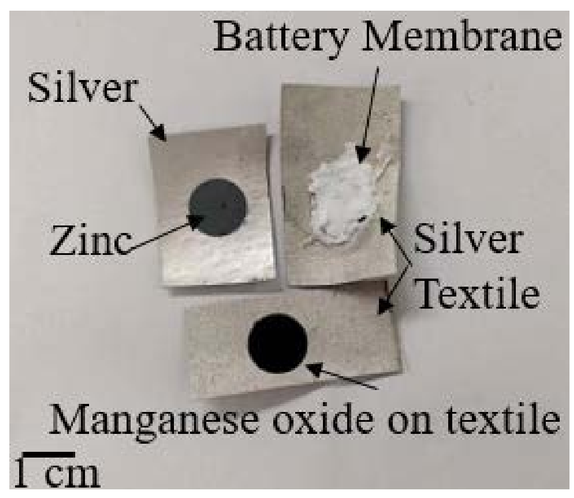

Figure 2. photograph of manganese oxide cathode textile, cathode textile with membrane coating and zinc anode layer with encapsulation film

Results and Discussion

Figure 3. Battery initial voltage reading after encapsulation under 90 degree bending

The voltage result displayed from a multimeter in figure 3 indicates that the textile battery demonstrated an initial voltage of 1.03 V. This result was obtained by bending the textile battery for 90 degrees. This shows the textile battery is mechanically durable and the membrane is strong enough to prevent short-circuits during bending.

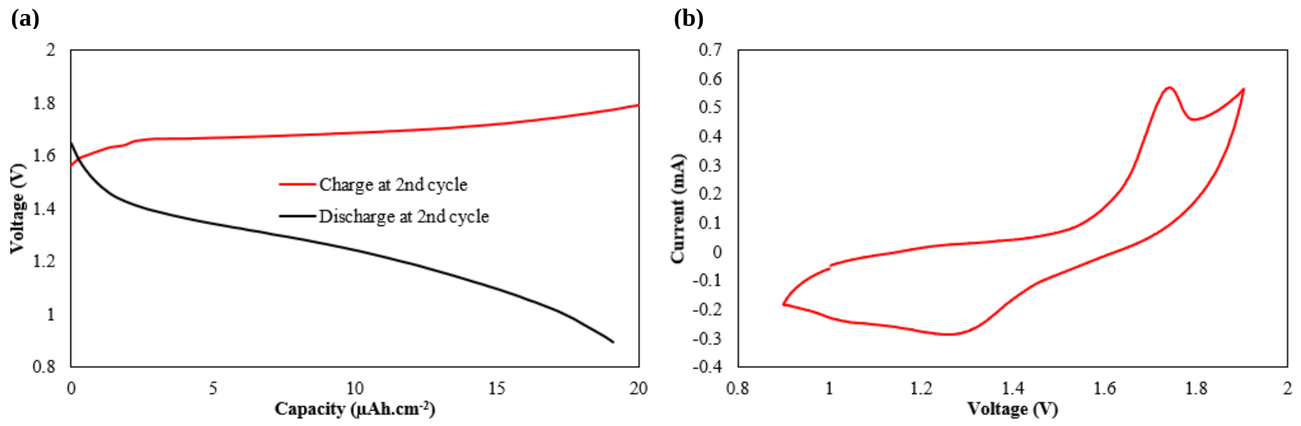

Figure. 4(a) GC derived Voltage charge& discharge result of the zinc ion battery at 1 mA cm-2 tested between 0.9 and 1.9 V, (b) CV tests between 0.9 V to 1.9 V at the scan rate of 10mV.s-1

The cycling test in figure 4a was derived from GC test at 1; This battery achieved an area capacity of 19.1 $\mu Ah.cm^{-2}$ between 1.9 and 0,9 V after the initial test cycle. Figure 4b shows the CV test results after the 1st test cycle for the zinc ion battery on the textile. The oxidation (charging) peak occurred at 1.72 V it also demonstrated a reduction (discharging) peak at 1.26 V. These are typical voltage peaks for the redox reactions in zinc ion secondary battery with manganese oxide cathodes

Conclusion

This poster presents an encapsulated flexible zinc ion battery on a single piece of polyester cotton. The operating voltage for this textile battery in this work were between 0.9 - 1.9 V and achieves area specific capacity of 19.1 $\mu Ah.cm^{-2}$ and demonstrated a good bending durability. In comparison with the previous devices [4], the proposed zinc ion battery are encapsulated and tested without tube fitting. Future work will include optimizing the formulation and fabrication method of the polymer membrane in the textiles for better electrochemical performances and durability. The final device can be applied in a wide range of e-textile system.

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