Carbon in Electrochemistry
Faraday Discussion 172

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Aqueous supercapacitor on textiles with carbon electrode

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Introduction

Supercapacitors [1] are a commonly used to store energy for smart sensor nodes [2] and energy harvesting systems [3]. Flexible supercapacitors have been realised on inexpensive standard polyester-cotton fabrics by formulating electrode solutions and soaking the materials [4]. This poster presents details of the design, fabrication and characterisation of these textile supercapacitors with carbon coated current collectors. This work demonstrates the electric double layer supercapacitor can be used to store energy for wearable applications . The electrode and current collector solutions are formulated using various inexpensive commercial carbon powders and polymer binders.

Device fabrication

- Carbon powder mixed with polymer binder and solvent in correct percentage.
- Single fabric sample size: 78.5 $mm^2 \times 0.6$ mm
- Fabric soaked in carbon solution for 10 mins, then dried at room temperature
- Sample cured at 60^oC for 30 mins in box oven

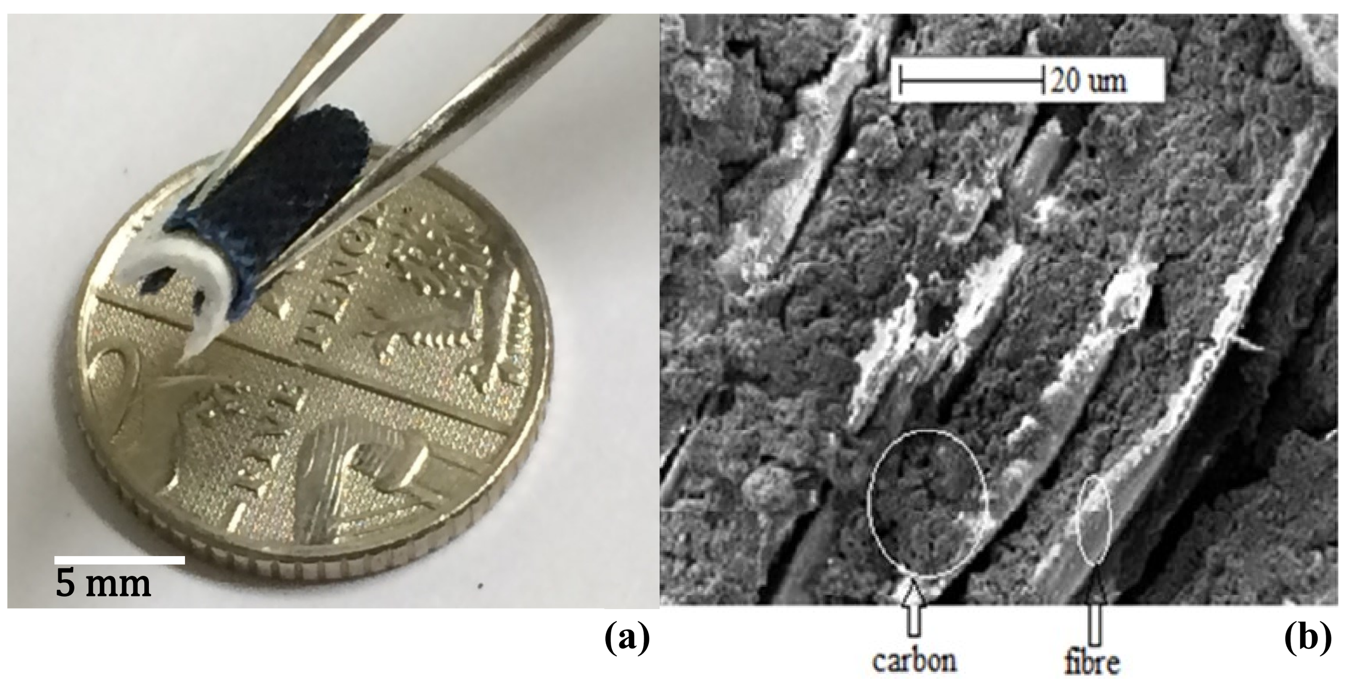

Figure 1. (a) wearable carbon fabric and paper separator (b): SEM images of fabric electrode

Current collector fabrication

- Carbon powder mixed with binder and solvent in correct percentage.
- Spray the carbon solution on top of metal current collector
- Sample cured at 90^oC for 30 mins in box oven
- Coated carbon film size: 126.7 $mm^2 \times 10$ µm

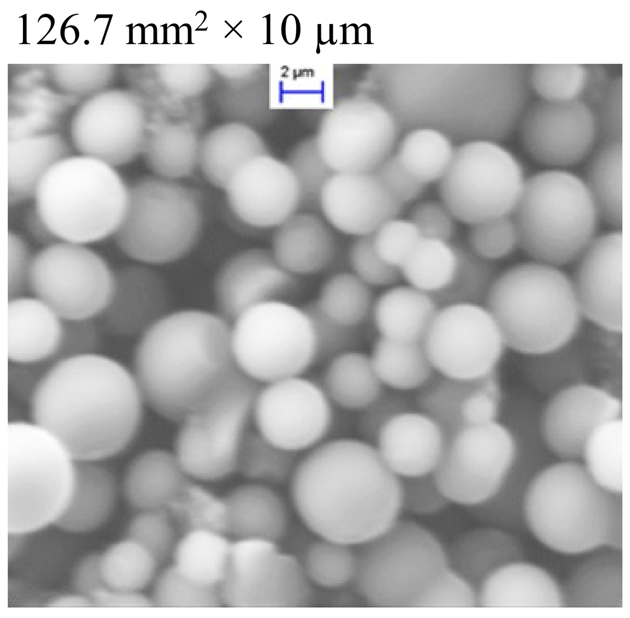

Figure 1. SEM images of carbon film

Device Characterization

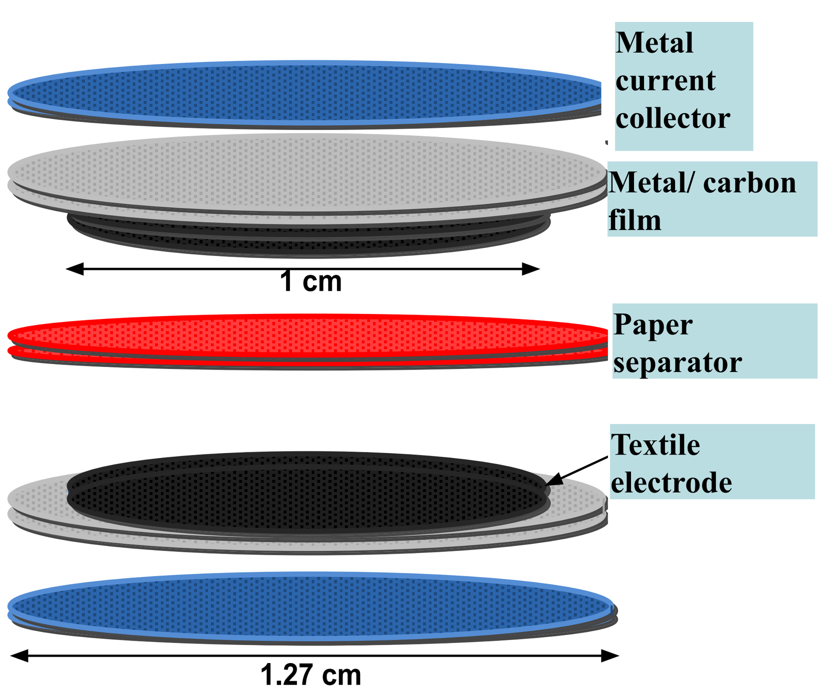

Figure 3: cross-sectional view of testing setup with fabric electrode on metal foil and steel corrector

- Two types of textile based supercapacitors are sealed by metal or carbon current collectors and assessed using a VMP2 potentiostat/galvanostat (Biologic, France).
- First, the encapsulated device is tested using electrochemical impedance spectroscopy (EIS), and then the stability of the device is examined by cyclic voltammetry (CV) at different scan rates.

The Capacitance/ equivalent series resistance measurement were obtained as follows:

1) Applying various scan rate across the sample while obtaining the ratio of the maximum current to the scan rate (CV),

2) Drive a small amplitude alternating signal across the cell while monitoring its capacitance and equivalent series resistance (ESR) via bode plot extract from EIS response.

The Stability test were performed by applying scan rate of $200 mV.s^{-1}$ across the sample for continues 15000 cycles (CV)

Result

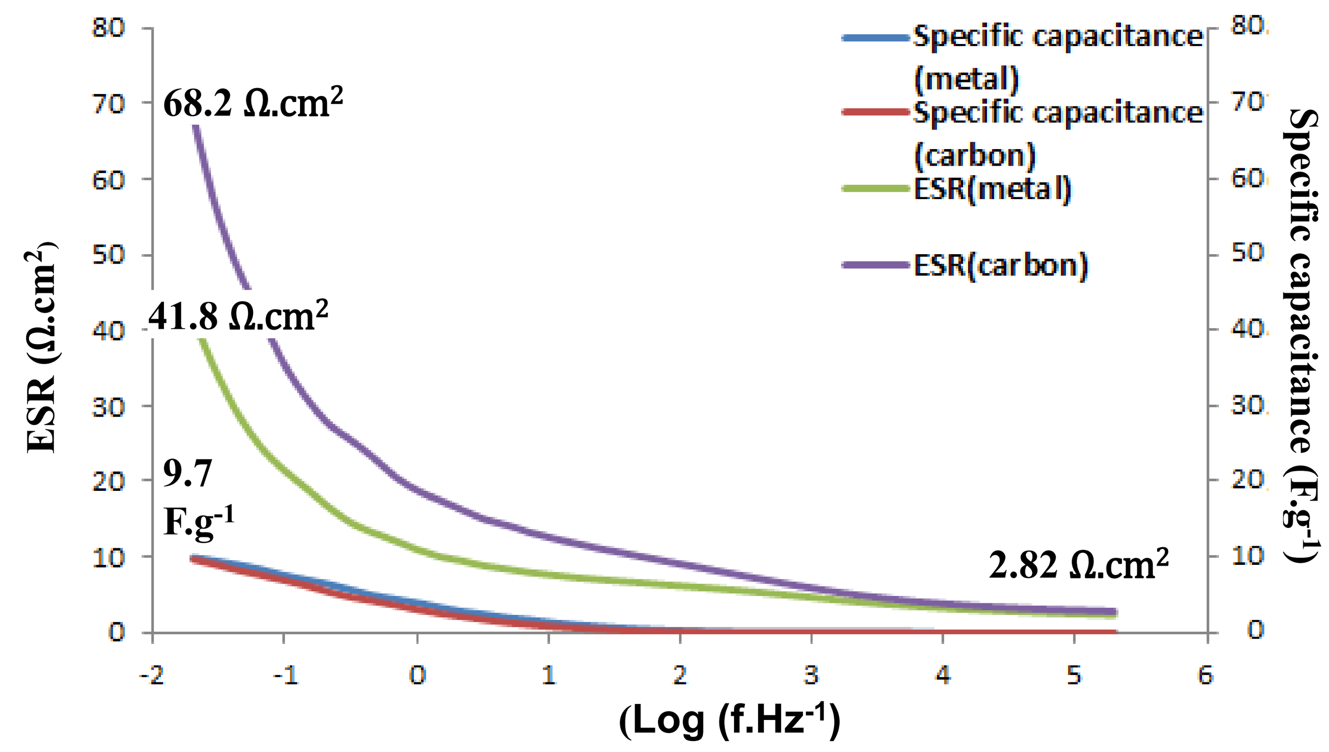

Figure 4: Bode plot of two type of devices from 10 kHz to 20 mHz, extract from EIS test with equivalent series resistance (ESR) marked

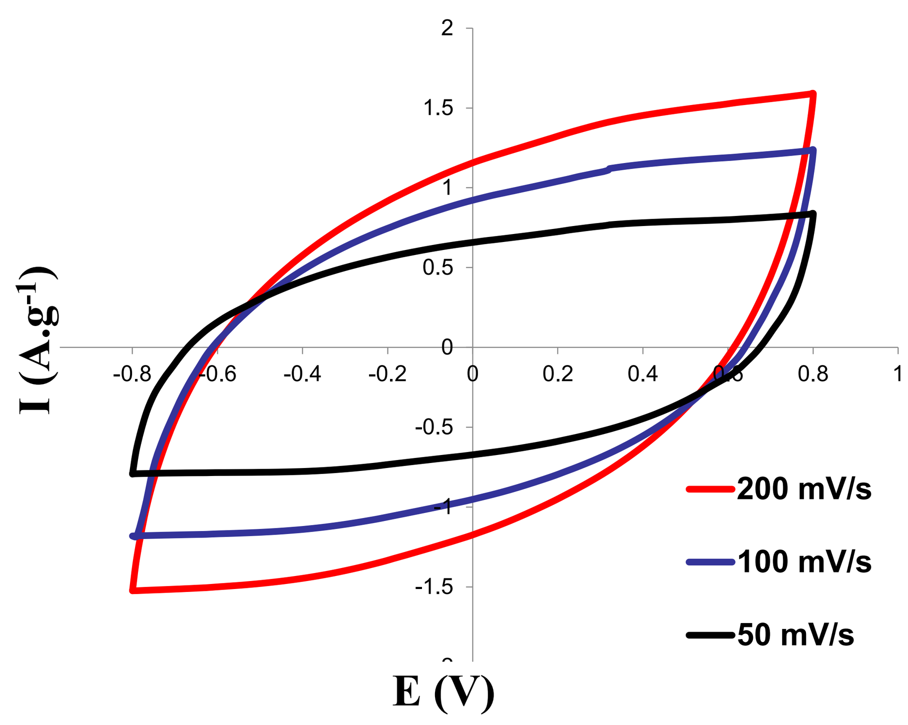

Figure 5: CV test of the carbon film encapsulated device between +/- 0.8 V at the scan rate of 200, 100, 25 $mV.s^{-1}$

The bode plot shows in figure 4 indicates our textile supercapacitors both achieve specific capacitance values about 9.7 $F.g^{-1}$ at low frequency (20mHz) and minimum normalised ESR of 2.82$\Omega.cm^2$

The CV curve show in figure 5 indicates our carbon film encapsulated supercapacitor is electrochemically stable at scan rates from 25 to 200 mV, and achieves specific capacitance values about 10 $F.g^{-1}$

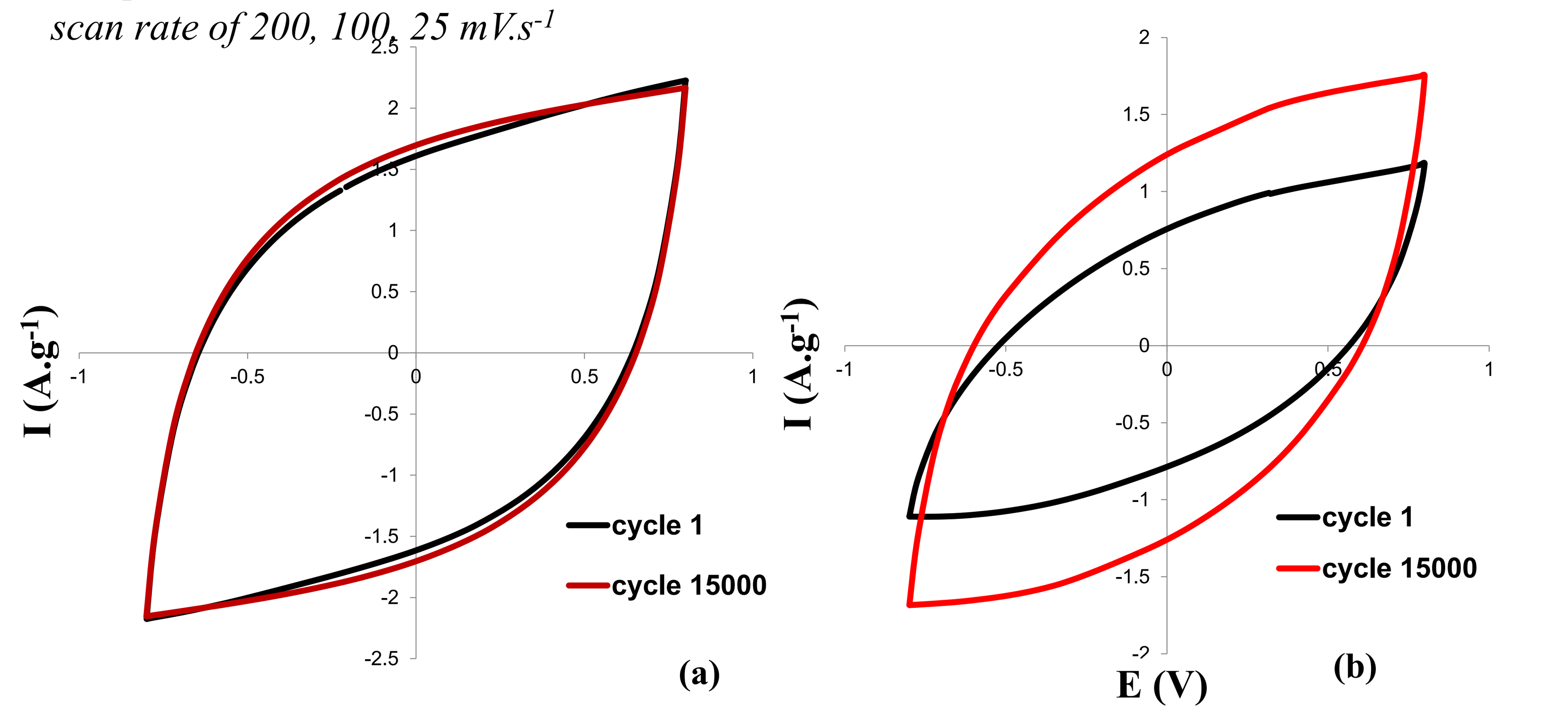

Figure 6:CV test of the device for 15000 cycles between +/- 0.8 V at the scan rate of 200 $mV.s^{-1}$ (a) metal encapsulated supercapacitor, (b) carbon film encapsulated supercapacitor

In comparison with other devices this fabric supercapacitor achieves a high device stability with no discernable chemical reaction. Capacitance variation is correlated with temperature changes to the variation of the diffusion coefficients. This shows an excellent level of adhesion of carbon material which form a continues conducting network

Conclusion

This poster presents a three layer supercapacitor on a fabric substrate. The device fabricated in this work achieves a mass specific capacitance of 9.7 $F.g^{-1}$, area specific capacitance of 100 $mF.cm^{-2}$, a low normalized ESR of 2.82 $\Omega.cm^2$ and achieves good chemical stability over 15000 cycles. In comparison with other similar devices [3], the electrode and separator materials of the device are potentially wearable, fully scalable, and inexpensive.

Acknowledgement

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Reference

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