

Gel Electrolytes

The solution for Supercapacitors?

Authors

Ammara Ejaz,¹ Imran Murtaza,² Bhavani Yalagala,³ Hadi Heidari,³ Des Gibson,^{1,4} Carlos García Núñez¹

Affiliations

¹ Institute of Thin Films, Sensors and Imaging (ITFSI) University of the West of Scotland (UWS), UK

² Flexible Electronics Lab (FELAB), Department of Physics, International Islamic University, Islamabad (IIUI) Pakistan

³ Microelectronics Lab (meLab) University of Glasgow, UK

⁴ AlbaSense Ltd., UK



Introduction

Due to tremendous advancements in the electronics industry, one of the prime concerns of the modern world is efficient energy storage and its alternatives. Modern wearable electronics require a charge storage element onto the same baseline circuitry, stretchable supercapacitors (SCs) fill this gap [1] (Figure 1). SCs consist of active materials, current collectors, and electrolytes also known as separators [2] (Figure 2). Small-size lightweight flexible SCs for wearable electronics require solid-state polymer electrolytes that do not leak without the need for bulky packaging. This challenge is being tackled by designing gel electrolytes that exhibit a high ionic conductivity [3] and can be applied in solid-state SCs due to their excellent mechanical strength, ion migration rate, and high order of work durability due to high water retention [4].

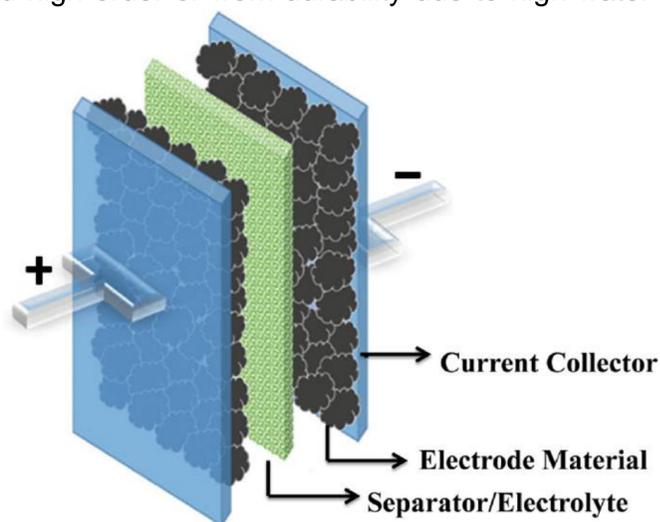


Fig. 2. The internal design of the supercapacitor device.

Objectives

- Design and fabrication of supercapacitor devices.
- Design of symmetric electrodes: activated carbon and PVA gel.
- Characterization of SCs by electrochemical impedance Spectroscopy (EIS) and cyclic voltammetry (CV).

Methodology

Figure 3 (a) shows a PVA-based gel electrolyte with KOH as an ionic migration agent. The SC was fabricated by embedding PVA gel in between the graphene-based activated carbon (AC) as a symmetric active electrode material (Figure 3 (b)).

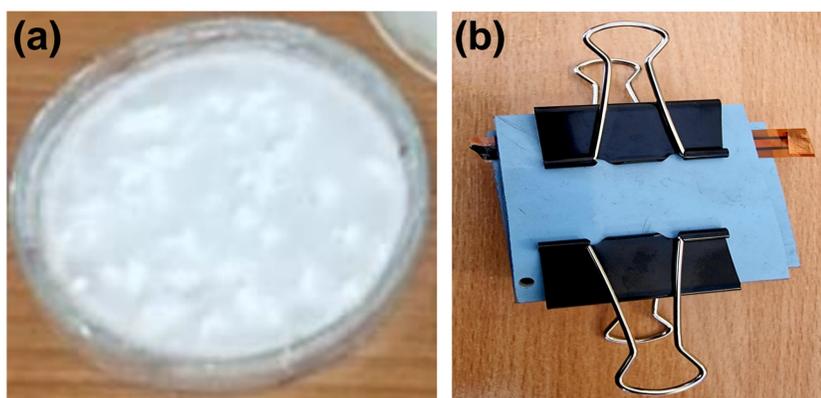


Fig. 3. Photographs of (a) gel electrolyte, and (b) an SC device.

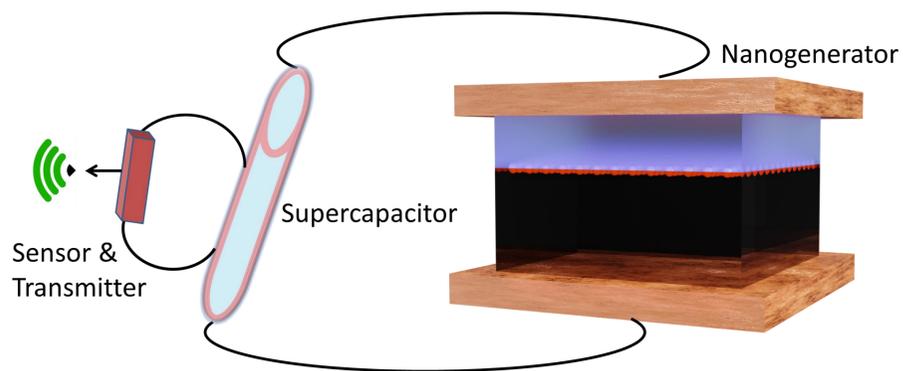


Fig. 1. Flow chart of SC application

Results & Discussions

Figure 4 shows the R_p and R_{ESR} magnitude on the Real-Z scale. The electrolyte resistance which is $\sim 5 \Omega$ at -0.4 V charging conditions remained constant with the increase in the applied voltage. Physically, the R_{ESR} value corresponds to the electrode resistance and R_p is the self-discharge resistance. The value of R_{ESR} and R_p corresponds to $26 - 28 \Omega$ and $44 - 47.6 \Omega$, respectively. For any supercapacitor, " R_p " is the dangerous mode of resistance because if its value is too small, the supercapacitor may charge itself quickly, but as soon as the charging source is removed, it discharges itself very quickly because of the lower R_p magnitude.

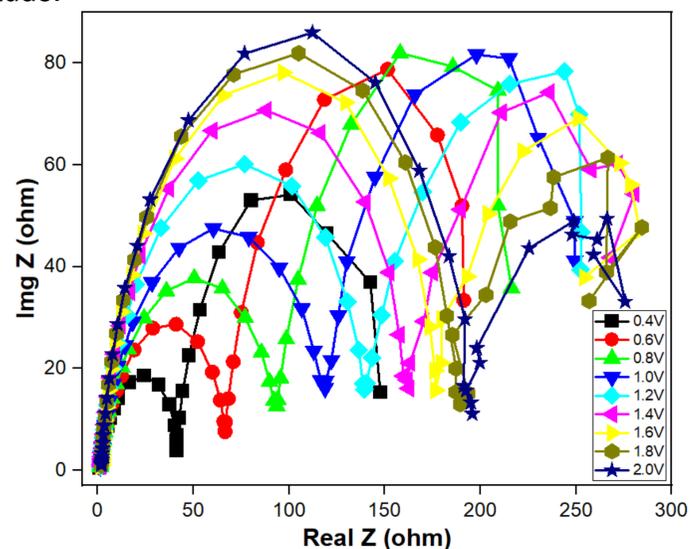


Fig. 4. EIS analysis of the supercapacitor device

Conclusion

The EIS analysis in Figure 4 shows a very low value of R_{SER} suggesting a high charge localization during the charging process. The figure also points toward this specific nature of the slope of the non-linear region, i.e., if the slope is higher, the charging process could be controlled by the EDLC formation and if the slope is lower, the charging process could be limited by the ionic diffusion into the electrolyte itself. For the PVA-based supercapacitor in our case; with the increase in the charging voltages the phenomenon of ionic diffusion started to take over which may limit the entire process. For relatively lower charging biases the EDLC mechanism is strengthened, and the charge may be governed by these phenomena.

Acknowledgment

This work was funded by the British Council & Higher Education Commission (20-ICRG-165/RGM/HEC/2020), Q436CGO.

References

1. Nature 542 (2017)159 – 160
2. Materials Today 20 (2017) 74 – 82
3. Carbon 142 (2019) 599 – 609
4. Journal of Molecular Liquids 301 (2020) 112400

