Inkjet-printed graphene/nanofiber flexible symmetric supercapacitors

Qingyan Peng[1]*, Xiaodong Tan[1], Mohanapriya Venkataraman[1]

[1] *Department of Material Engineering, Faculty of Textile Engineering, Technical University of Liberec, Liberec 461 17, Czech Republic, e-mail:* qingyan.peng@tul.cz

Abstract: This research employed a reactive inkjet printing (RIP) technique to create flexible symmetric supercapacitors by coating reduced graphene oxide (rGO) on a polyvinylidene fluoride (PVDF) nanofiber substrate. The study demonstrated that L-ascorbic acid (AA) could effectively reduce graphene oxide (GO) to rGO in-situ during the RIP process. Analysis of galvanostatic charge-discharge (GCD) revealed that the specific capacitance of the 1rGO/PVDF electrode reached 83.29 F/g at a current density of 2 A/g, achieving an energy density of 7.5 Wh/kg and a power density of 1.04 kW/kg.

Keywords: *inkjet printing, flexible, symmetric, supercapacitor, graphene*

It is widely recognized that graphene is a powerful new type of carbon material, which has many excellent properties that are difficult to replace, including exceptionally high carrier mobility, unique optical characteristics, superior electrical conductivity, enhanced thermal conductivity, remarkable mechanical strength, and the capacity to withstand significant current densities [1]. Due to these extraordinary properties, graphene is considered an effective material for crafting supercapacitor electrodes. RIP presents a simplified approach that facilitates micro-chemical reactions and the creation of varied patterns in a single operation. This technique utilizes a dual-nozzle system, with one nozzle dispensing precursor inks and the other ejecting reactive chemicals that interact with the initial ink. These inks are sequentially deposited onto the same area of a substrate, where they meet and undergo a reaction, resulting in the formation of a patterned final product [2]. In this study, we employed electrospun polyvinylidene fluoride (PVDF) nanofibers as the foundational substrate for fabricating flexible, all-solid-state supercapacitors with inkjet-printed graphene. The PVDF nanofibers feature a micro-rough surface texture and a compact architecture, which promotes the even application of graphene ink and inhibits the ink from permeating deeply into the substrate. This approach enabled us to attain satisfactory specific capacitance values with a minimal number of graphene layers applied.

Fig. 3 showcases the CV profiles of the rGO/PVDF supercapacitor across a voltage range of -0.5V to 0.5V, with scan rates varying between 10 and 200 mV/s. The CV profiles reveal that at lower scan rates, the electrodes exhibit almost perfect rectangular shapes, suggestive of ideal electric double-layer capacitance. As for GCD, The symmetry between anodic charging and cathodic discharging phases indicates strong reversibility, a characteristic of standard capacitive materials, aligning with earlier CV findings. According to the Nyquist plot it can be obtained the intrinsic resistance of supercapacitor is 64.27 Ω.

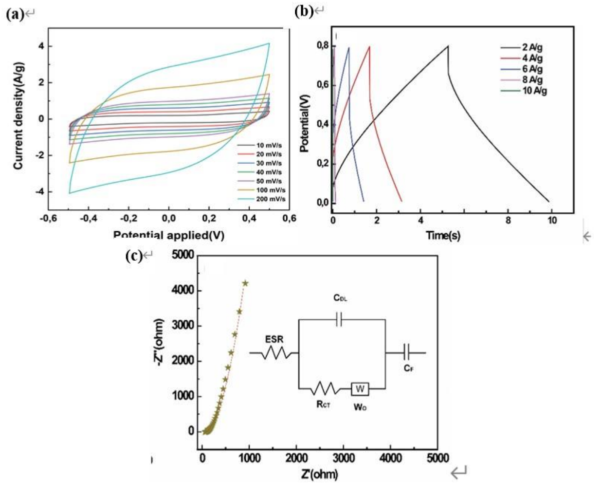

Figure 3 The (a) CV curves, (b) GCD curves of 1rGO/PVDF, (c) Nyquist plot of the 1rGO/PVDF in the frequency range of 100 kHz to 0.01 Hz.

ACKNOWLEDGEMENT*: The work was supported by the project of Student Grant Competition of Technical University of Liberec no. 2024-6449 granted by Ministry of Education Youth and Sports of Czech Republic.*

REFERENCES

[1] L. Huang, D. Santiago, P. Loyselle, L.J.S. Dai, Graphene - Based Nanomaterials for Flexible and Wearable Supercapacitors, 14(43) (2018) 1800879.

[2] K. Kim, S.I. Ahn, K.C. Choi, Simultaneous synthesis and patterning of graphene electrodes by reactive inkjet printing, Carbon 66 (2014) 172-177.