MXene-coated cotton fabrics for wearable supercapacitors

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Wearable electronics are expected to become more widespread in the future. Therefore, there is an increasing demand for low-cost, fast-produced and compatible energy storage devices. Supercapacitors differ from conventional capacitors due to their high charge storage capabilities. In addition, they contain a high specific surface area and a thinner electrolyte, thus, they can store hundreds of times more energy in seconds than conventional capacitors, and transfer the stored energy much faster than batteries [1].

High specific surface area of carbon-based materials provides an electrical double layer structure in nanometer sizes at the interface of the electrode and electrolyte molecules. However, these materials have disadvantages such as limited electrical conductivity, low mechanical properties and relatively shorter cycle life. MXenes show superior charge storage capability compared to other two-dimensional materials due to their high electrical conductivity (≈9800 S cm^{-1}), redox activity and volumetric capacitance (≈1500 F cm^{-3}) [2].

The current study investigates the electrochemical performance of $Ti_3C_2T_x$ (MXene) coated cotton fabrics for wearable supercapacitors. $Ti_3C_2T_x$, which has outstanding electrochemical performance and electrical properties, was used as electroactive material for coating process of cotton fabrics. $Ti_3C_2T_x$ was synthesized using Ti_3AlC_2 (MAX) phase according to middle intensive delamination method (MILD). Coating of cotton fabrics was carried out by spray coating using $Ti_3C_2T_x$ dispersions in different concentrations (1, 5 and 10 mg/ml). In this study, X-ray diffraction (XRD) and Fourier transform infrared spectroscopy (FTIR) were used for the characterization of MXene and MXene-coated fabric electrodes. The interaction between MXene and cotton surface was investigated by means of Scanning Electron Microscopy (SEM). Electrocehmical performance of MXene-coated fabric electrodes was investigated via electrochemical impedance spectroscopy (EIS), cyclic voltammetry (CV) and galvanostatic charge/discharge (GCD) tests.

EIS tests were performed using three-electrode configuration in 1 M Na_2SO_4 aqueous electrolyte. Figure 1. shows the Nyquist plot of MXene-coated fabric electrodes in three different concentrations (1, 5 and 10 mg/ml).

The high slope in low frequency region is obvious for all fabric electrodes which is an indication of low ion diffiusion resistance of the electrodes. In addition, relatively similar semi circle of three electrodes show that electrodes have low charge transfer resistance which is advantageous for high electrochemical performance.

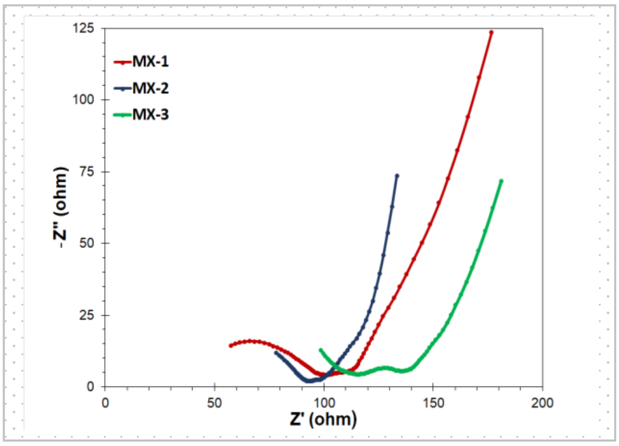

Figure 1. Nyquist plots of MXene-coated cotton fabric electrodes for 1 mg/ml (MX-1), 5 mg/ml (MX-2) and 10 mg/ml (MX-3).

This study provides an important contribution to the studies related to the rapid and facile production of wearable electronics, which will take place in our daily lives more in the future.

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References

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