

Abstract

The energy storage performance of one of the lightest but less researched MXenes, Ti_2CT_x , combined with other materials, was investigated for improved electrodes in electrochemical capacitors (ECs) and lithium-ion batteries (LIBs). This work investigated: (i) Ti_2CT_x combined with carbon nanospheres (CNS) as a symmetric electrode system in an aqueous electrolyte (1M Li_2SO_4); (ii) Ti_2CT_x combined with electrolytic manganese dioxide (EMD) as an anode for LIB. The structure, composition, morphology and electrochemical properties of the synthesized materials were studied. The combined MX/CNS material demonstrated a higher specific capacitance compared to the individual components. The material was fabricated with relatively high ($1.87 \text{ mg}\cdot\text{cm}^{-2}$) and low ($0.17 \text{ mg}\cdot\text{cm}^{-2}$) mass loadings and assembled into a symmetric device. Specific capacitance, power and energy for the lower electrode mass loading of $180 \text{ F}\cdot\text{g}^{-1}$, $37.6 \text{ kW}\cdot\text{kg}^{-1}$ and $14.1 \text{ W}\cdot\text{h}\cdot\text{kg}^{-1}$ were all higher than $86 \text{ F}\cdot\text{g}^{-1}$, $20.1 \text{ kW}\cdot\text{kg}^{-1}$ and $6.7 \text{ W}\cdot\text{h}\cdot\text{kg}^{-1}$ for the higher mass loading. A wide voltage window of 1.5 V, which is larger than the window reported in works involving MXene as symmetric supercapacitor electrodes in an aqueous electrolyte ($<1.0 \text{ V}$), was obtained, but with limited long-term cycling behaviour. Mathematical modelling and simulation of the supercapacitor showed good correlation with the experimental results, validating the model. The cell performance was demonstrated by lighting an LED. This reveals the potential of the Ti_2CT_x to be employed as a viable energy storage system for applications requiring low mass. In the study of MXene combined with EMD, three different ratios were examined as anodes for LIB in a half-cell

configuration. Results showed that the combined MXene/EMD material has a greater capacity, rate capability and cycling stability compared to the EMD. The best ratio was found to be MXene:EMD=80:20. The capacity obtained for this material after 200 cycles is $460 \text{ mA}\cdot\text{h}\cdot\text{g}^{-1}$ at a current density of $100 \text{ mA}\cdot\text{g}^{-1}$. The Li-ion accessibility was found to improve with cycling. This study provides a first insight into the viability of using a light-weight MXene/EMD composite for improved LIB anodes. EMD is a low cost and abundant material, thus provides great opportunities for improved capabilities for light-weight applications at an affordable cost.