Journal of Energy Storage 27 (2020) 101160

Contents lists available at ScienceDirect

Journal of Energy Storage

journal homepage: www.elsevier.com/locate/est

Combustion synthesis of battery-type positive electrodes for robust aqueous hybrid supercapacitor

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ARTICLE INFO

Keywords:
Electric energy storage
Supercapacitors
Double layer capacitors
Activated carbon
LiMnO
Electric cars

ABSTRACT

Producing materials with suitable features including robust, and high electrical conductivity for the realization of excellent electrochemical performance for supercapacitor devices remains a great challenge. In this regard, we optimize and used the combustion synthesis technique assisted with urea for the production of a positive electrode based on battery type lithium manganese oxide (LiMnO) and activated carbon as negative electrode materials for high voltage hybrid devices in aqueous electrolytes. The samples were analyzed with X-ray diffraction, Raman spectroscopy, and scanning electron microscopy. The structural properties of the material were studied and hybrid devices fabricated present a specific capacitance of 65 F g^{-1} and 78 F g^{-1}, at 0.5 A g^{-1} in 1 M Li_2SO_4 and 1 M Na_2SO_4 respectively, with long-term stability after continuous cycling. These result shows that this strategy can revolutionize new ways to the synthesis of a plethora of materials for high voltage energy storage applications.

1. Introduction

The systematic and continuous development of hybrid functional materials has resulted in tremendous improvement in the performance of electrochemical devices such as batteries and supercapacitors (SCs) applications in mobile technologies and electric vehicles (EVs). In the traditional gasoline vehicles, a substantial amount of energy is lost during braking or during periodic acceleration and deceleration. Consequently, the recovery of this energy through regenerative breaking is an effective method to improve the driving range and as such can only be accomplished by EVs. This has become popular and widely accepted, and it is projected that they will play a major function in the new revolution of cars by 2038 [1]. Generally, EVs have become acceptable commercially, and they employ two similar types of electric energy storage devices to satisfy an effective design of the system. These storage systems are batteries that store energy from a chemical reaction and SCs that store energy using a surface phenomenon of adsorption (electrostatic interactions). Recently, SCs have elicited vast research interest as high power devices to complement batteries due to their fascinating properties which include fast recharge capability, high power density, and long cycle life [2]. Nevertheless, they have imposed some challenges such as low energy densities that needs to addressed, if they are to replace or complement batteries that employ chemical reactions for increased driving mileage in EVs. The specific energy is proportional to the specific capacitance and to the square of the voltage ($E = 0.5\,CV^2$) [3,4] which is usually ascertained by the stability of the electrolyte and the catalytic activity of the active materials used [5]. The use of aqueous electrolytes in SCs has been widely studied, and have the highest conductivity in contrast to the non-aqueous electrolyte such as the organic electrolytes and ionic liquids. They are low cost, safe, environmentally friendly and require less packaging and a much easier option for potential laboratory testing and more desirable from an industrial and commercial stand point [6]. However, aqueous electrolytes have voltage limitation to 1.23 V due to thermodynamic dissociation of water in hydrogen (H_2) and oxygen (O_2) beyond this voltage.

Hydrogel electrolytes are also developed for SCs due to their capability to fulfill dual roles of electrolyte and separator. They are swollen polymer networks with large amounts of water absorbed, which makes high ionic conductivity and stability against electrolyte leakage possible. For example, a highly flexible/soft yet device-level dynamically super-tough supercapacitor based on the highly effective energy dissipation of a dual cross-linked hydrogel electrolyte was reported by Liu et al. [7]. The hydrogel matrix contained a covalently cross-linked

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https://doi.org/10.1016/j.est.2019.101160
Received 24 October 2019; Received in revised form 12 December 2019; Accepted 16 December 2019