Hybrid supercapacitors with nickel manganite as a cathode and sodium alginate-derived carbon as an anode material

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Electric energy storage (EES) devices are mainly batteries and supercapacitors. Each have their own set of characteristics. While batteries store energy via diffuse-controlled, Faradaic redox processes, supercapacitors store energy by rapidly forming electrostatic double-layer. Batteries exhibit high energy density, while supercapacitors exhibit high power density [1]. Supercapacitors can have hundreds of thousands life cycles while lithium ion batteries, for example, have around 1000 of them. Hybrid supercapacitors are relatively novel devices that tend to combine advantages of both batteries and supercapacitors while overcoming their disadvantages. Hybrid supercapacitors employ both types of electric energy storage mechanisms, Faradaic redox and capacitive processes [2]. One electrode, typically composed of metal oxides, hydroxides, or phosphates, stores energy through redox reactions, while the other electrode, typically constructed from carbonaceous materials, stores energy through capacitive processes.

Nickel manganite, $NiMn_2O_4$, is a versatile transition metal oxide, with interesting electrical and magnetic properties. Its inverse cubic spinel structure indicates that it contains a variety of nickel and manganese ions at different sites in different oxidation states. This unique arrangement enables high electrical conductivity [3]. $NiMn_2O_4$ has been in the focus of electric energy storage research along with other transition metal oxides in order to downsize the production of cobalt- and lithium-derived oxides in devices that are already commercially used.

Sodium alginate is a polysaccharide naturally found in brown algae. It can be used to synthesize carbonaceous materials [4].

The work presented contains details on synthesis, characterization and EES properties of nano-sized nickel manganite synthesized via electrospinning and glycine-nitrate sol-gel combustion processes followed by calcination at 400 and 800 °C to obtain pure spinel oxide. Amorphous carbon was also synthesized via pyrolitic carbonization of lyofilized sodium-alginate hydrogel. Nickel manganite and amorphous carbon were tested in 6 M KOH, 2 M LiOH, 1 M Na_2SO_4 and 1 M H_2SO_4 in a three-electrode cell via cyclic voltammetry and galvanostatic chronopotentiometry. $NiMn_2O_4$ showed the highest activity in alkaline electrolytes, while amorphous carbon showed capacitive-type energy storage performance in both alkaline and acidic electrolytes. Standard two-electrode sandwich cell was formed with $NiMn_2O_4$ as a cathode and amorphous carbon as an anode material. The cell performance was evaluated via cyclic voltammetry and galvanostatic chronopotentiometry followed by stability tests. Considerable capacitance values of the formed hybrid supercapacitor devices were obtained.

References

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