

Electro-spun Nano-fibers: An Innovative Conductive Matrix to produce Self-Standing Electrodes for Sodium-ion Batteries

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Global interest related to climate change and the supply of fuels fossils led to the development of green and sustainable energy alternatives such as solar, wind, and geothermal sources to get by the ever-increasing energy demand. In a way to efficiently connect these inexhaustible and intermittent energy supplies to the grid, an effective electrical energy storage system (EES) is necessary. Among the various energy storage systems, rechargeable batteries appear to be the most promising technology due to their environmentally friendly, flexibility and high energy conversion. One of the energy storage technologies that is growing significantly in the last period and it's introducing into the market is the sodium ion battery. Sodium-ion batteries (NIB) have been re-evaluated as a viable alternative to lithium ion battery (LIB) for large-scale energy storage, thanks to the fact that sodium is cheaper, more abundant and environmentally friendly than lithium. Except for the carrier ions, sodium ion batteries are made up of the same components as lithium ion batteries. Furthermore, the intercalation mechanism of sodium ions is similar to lithium ions so it is possible to use similar cathode materials for both technologies. The standard electrochemical potential of Na (-2.71 V vs. SHE) is close to that of Li (-3.05 V vs. SHE) ensuring a high working voltage of the SIBs. This type of technology is still being explored and there are materials and associated electrocatalytic reactions that are not well studied.

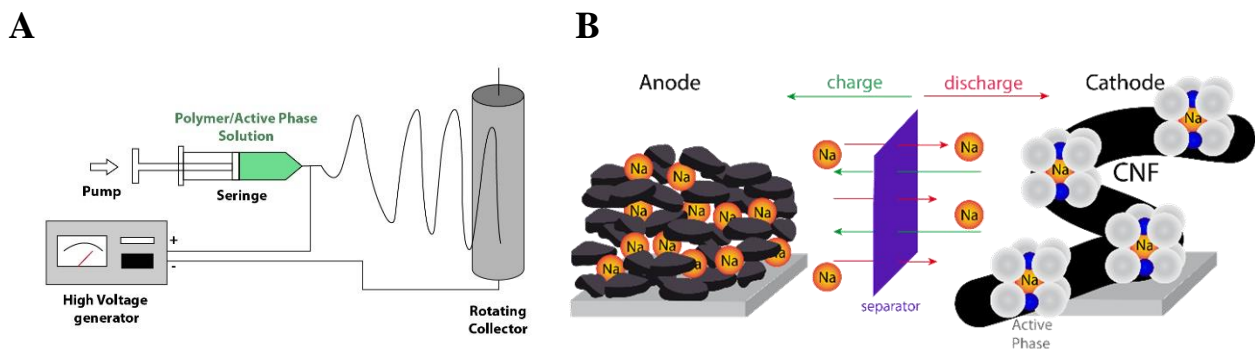


Figure 1. A) Electro-spinning system; B) Scheme of charge - discharge mechanism.

A valid active material for the cathodic compartment, thanks to the low cost and easy availability of manganese and to the high redox potential of the manganese $2+$ and $3+$ ions couple is the sodium

manganese phosphate. The challenge is to obtain a well-defined crystalline structure characterized by high electrochemical activity. Sodium manganese phosphate structures can be classified in two: maricite and olivine (the last one known as the more active phase). Conventionally the method used to obtain a mix of the two species is hydrothermal. The resulting powder is mixed with a polymer and carbon and a solvent to obtain an ink. This ink is spread on a supporting metallic foil to obtain an electrode. An innovative alternative technique is represented by electrospinning. The target consists in distributing the active material inside this carbon matrix (Fig.1) in a way to create a network able to facilitate the reversible electrochemical processes. Cathode material precursors are electro-spun with PAN in dimethylformamide as solvent. The resulting foil was thermal treated in reductive atmosphere at 600°C in order to in situ produce the active species and induce a crystallinity in the carbon matrix. This particular self-standing system allows to produce a good conductive electrode with a low total resistance. The sample containing 40 wt% of active phase was subjected to 100 consecutive charge and discharge cycles. Although the battery is subjected to stress cycles at the highest surface current density, it is possible to achieve good specific capacity values. After one hundred cycles there is a loss in capacity of about 50% compared to the first cycle. This partial progressive loss of capacity is probably due to a rearrangement of the active phase which determines a decrease of the utilization factor. Subsequent charge and discharge processes with lower density make it possible to recover the apparently lost capacity.