One-step fabrication of all-in-one flexible nanofibrous lithium-ion battery

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Flexible batteries offer new opportunities to electronic devices making them foldable, bendable, and easily portable. Such qualities can be implemented in wearable electronics, interactive media and medical devices[1]. Flexible batteries can be used as a power source in health monitoring sensors, providing better contact with the human body[2].

The "all-in-one" flexible Li-ion batteries was fabricated by one-stage electrospinning of PVDF-HFP-based precursor solution loaded with active materials, as presented in Fig. 1. Nanostructured graphite and $LiFePO_4$ were used as anode and cathode active materials, respectively. An optimum amount of CNT was added to the electrospinning solutions to increase the electronic conductivity of the fibrous electrodes. The electrochemical performance of the anode and cathode membranes was investigated in lithium half cells. The areal capacities of the electrodes were around 5 μAh cm^{-2} with stable performance for more than 30 cycles. Further, three solutions for the anode, separator (containing polymer only) and cathode were electrospun successively on top of each other. As a result, a flexible, bendable and semi-transparent membrane containing all three components (*i.e.*, cathode, separator and anode) was fabricated. The membrane was then soaked into the liquid electrolyte and assembled into a quasi-dry full-cell battery.

After activating pouch cell by adding the liquid electrolyte, the "all-in-one" battery was tested for bending resistance. The initial voltage of the as-assembled "all-in-one" battery was observed as 0.177 V and after 20 bends it dropped to 0.146 V. During further 20 cycles of bending and folding the battery demonstrated 0.125 V potential.

The developed "all-in-one" membrane assembled within copper and nickel meshes acting as anodic and cathodic current collectors demonstrated semi-transparency. It is enabled by the swollen polymer fibers network, which provides transparent substrate for nano-sized particles of active materials. The thin metallic mesh used as current collectors could maintain the overall transparency of the cell. This work opens the opportunity for developing a new generation of flexible and transparent batteries, since various nanosized active materials can be loaded into the conductive nanofibrous structure.

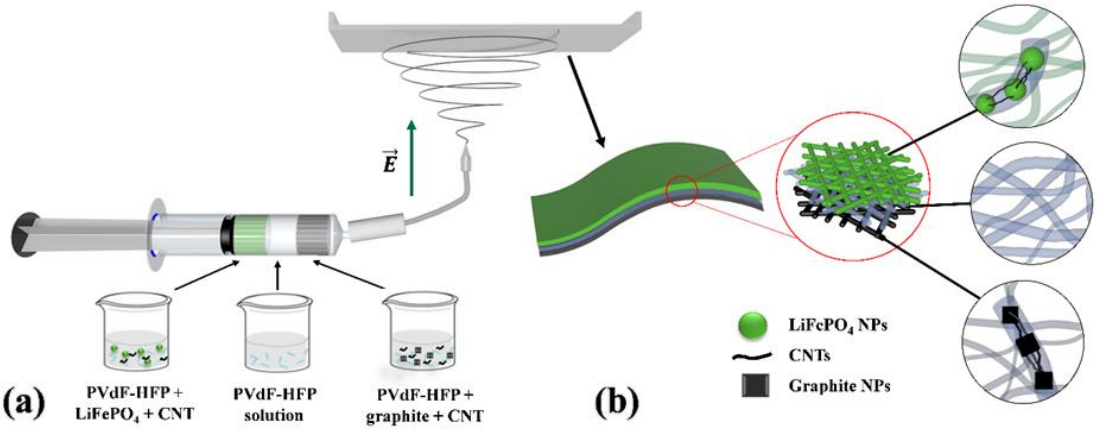

Figure 1 (a) Scheme of one-stage preparation of flexible lithium-ion battery by electrospinning, (b) Schematic illustration of "all-in-one" nanofibrous membrane and its composition

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