ENHANCING LITHIUM-ION BATTERY ELECTRODES: THE ROLE OF [60]PCBM IN CARBON NANOFIBERS FOR ENERGY STORAGE IMPROVEMENT

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In the modern automotive industry, electrochemical batteries, particularly lithium-ion batteries, are becoming increasingly important. The objective of this research is to enhance the quality of these batteries by improving the electrodes, which typically consist of various types of carbon. A promising approach for this purpose is to convert carbon into nanofibers through electrospinning, thereby increasing the surface area available for the adhesion of lithium ions. Since a purely electrical two-layer capacitance (EDLC) has energy density limitations, adding pseudo-capacity using Faraday reactions allows for a significant increase in stored energy while maintaining a high charge/discharge rate. This can be achieved by including various components, such as electron donors and acceptors, which can undergo oxidation or reduction. For example, Ayaganov Z. with colleagues compared various carbon additives, including pure fullerene (C_{60}). Their results obtained showed that C_{60} was unpromising, since its effectiveness was minimal. Whereas, in another ongoing study by Dr. Ferraris J.P. and Haque S.F.B. from the University of Texas at Dallas (USA), a fullerene derivative [6,6]-phenyl-C_{61}-methyl butyric acid ester (PCBM) was used as a conductive additive. This additive differs from pure fullerene C_{60} in that PCBM has an alkyl side chain (Fig. 1). PCBM is a soluble material and is widely used in the photovoltaic industry. Therefore, for this reason, Dr. Ferraris J.P. and Haque S.F.B., incorporated 5 % PCBM into polyacrylonitrile (PAN) and subsequently pyrolyzed the resulting nanofibers. It was suggested that during pyrolysis, the PCDM side chain could separate and pure C_{60} remained, which, according to the conclusions in [1], should not have a significant effect. However, in a study by Dr. Ferraris J. with colleagues, there was a significant increase in specific capacity and energy density.

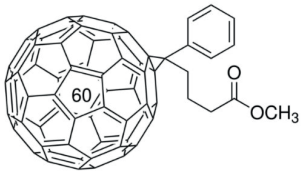

Fig. 1. Structure of [6,6]-phenyl-C_{61}-butyric methyl ester (PCBM)

Currently, another study is underway to investigate electrospinning solutions prepared under similar conditions using both pure C_{60} and PCBM. This research is ongoing. The authors of the present study propose that during the pyrolysis of the resulting fibers, the alkyl side chain is not simply detached from the PCBM; rather, it is activated and integrated into the common carbon polymer chain. This process plays a crucial role in charge accumulation, facilitating the flow of electrons into the external circuit and enhancing conductivity. Moreover, the structural reorganization that occurs during pyrolysis may result in the formation of additional defect sites and π-conjugated domains, which can further enhance the electrochemical performance of the material. Additionally, the presence of functional groups derived from PCBM may influence the wettability of the electrode surface, thereby optimizing ion diffusion and improving overall battery efficiency.