Poly-N-vinylformamide as a binder for lithium-ion batteries

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One of the most significant challenges facing the modern world of science is to provide reliable and efficient energy storage systems for ever-evolving industry. Nowadays the major role in this field is played by Li-ion batteries. However, there is still a need for dynamic progress in improving the operation parameters of the cells, hence even this popular Li-ion technology is constantly optimized [1].

One of the key issues to meet the expectations of industry in accomplishing Li-ion batteries is a properly designed electrode. It is commonly known that apart from active materials, the integral parts of electrode are additives such as conductive components and binders. Binders are necessary in order to form an electrode with suitable mechanical properties. Binders exhibit good adhesion to electrode materials and current collectors, high electrochemical stability over a wide range of potentials, high melting point and good ionic and electron conductivity. The most typical one is poly(vinylidene difluoride) (PVDF) which is dissolved in an organic solvent such as N-methyl pyrrolidone (NMP). However the main disadvantage of PVDF is its instability at high temperatures and its tendency to swelling in ionic liquids. Moreover using NMP as a solvent is directly connected with negative environmental impacts and higher cost of electrode production [2,3].

Therefore, mainly for environmental issues as well as lowering manufacturing cost there is a necessity for developing the water soluble binders for Li-ion batteries. In this work we propose the hydrophilic binder- poly-N-vinylformamide (PNVF). The PNVF was obtained by free radical polymerization of N-vinylformamide (NVF) in aqueous solution. The polymer was characterized in terms of electrical and physicochemical properties by i.a. rotational rheometer (RR), size-exclusion chromatography (SEC), electrical conductivity (EC) etc. The stability and the aging process of the PNVF in contact with liquid electrolytes were examined using thermal analysis (TGA/DTG/SDTA/DSC) and inductively coupled plasma- optical emission spectrometers (ICP–OES).

During these studies the binding potential of PNVF in Li-ion technology was investigated. The galvanostatic charge-discharge cycling measurements (GCDT) were conducted using selected cathode (e.g. $LiCoO_2$, $LiMn_2O_4$, $LiMn_2O_{3.99}S_{0.01}$, Li_2MnSiO_4 $LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$) and anode (e.g. graphite, carbon aerogels) materials in lithium-ion cells for verification their electrochemical behaviour. These research aimed to improve the performance of the electrode for its better operation along with the cost reduction and environmental friendliness.

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