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Exploiting neutron techniques to reveal the hidden secrets of batteries

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Nowadays, increasingly sophisticated methods are applied for more and more complex battery materials in order to gain a better understanding of the complex processes in electrochemistry. A particular challenge here is to investigate electrochemically relevant processes that occur on different length and/or time scales in such a way that these processes are not influenced by the method. One often looks for probes that can measure a sufficient volume of the sample non-destructively and at the same time are sensitive to the important small charge carriers.
Such challenges are often solved with neutrons because they are ideal for these tasks. Neutrons have a relatively high sensitivity to light chemical elements such as lithium, sodium, hydrogen and they can easily distinguish neighboring elements of the periodic table. The large cross section of the incident neutron beam together with the large penetration depth of neutrons into materials open up unique measurements, including the examination of entire large batteries in the beam.
This contribution gives an overview of how dedicated neutron techniques are applied for specific questions on a wide variety of length and time scales [1]. The main applied neutron method is neutron diffraction (ND) to understand at the atomic level changes such as phase transformations or the intercalation processes. Often measurements are carried out operando, particularly on complete cylindrical cells [2]. The neutron depth profiling method (NDP) is suitable for lithium distribution determination on the surface of electrodes [3]. Neutron imaging (NI) techniques, including neutron radiography or neutron tomography, is an ideal tool for studying and monitoring the wetting process during electrolyte filling of prismatic hard shell cells or pouch bag cells on the macroscopic length scale [4]. Further methods as quasi-elastic neutron scattering (QENS), small-angle neutron scattering (SANS), prompt gamma activation analysis (PGAA) or positron methods are suitable tools.

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