



Li-EcoSafe – more efficient and safer batteries for electric vehicles

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The range and performance of electric vehicles depends directly on the batteries used. Lithium-ion batteries are currently considered very promising for use in alternative vehicle propulsion systems due to their high energy density and low capacity loss when frequently, but incompletely, charged and discharged. In the joint project 'Li-EcoSafe', battery experts at the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) are working together with the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg; ZSW) and the University of Ulm because lithium-ion batteries are more efficient, less costly and safer to manufacture. The scientists wish to contribute to their everyday practicality, thus improving consumer acceptance of electric vehicles. In the course of the project, the researchers will consider the entire development process, from materials to suitable operating strategies. The network is a Centre of Excellence for Battery Research, which is funded under the 'Excellent Battery' programme by the German Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung; BMBF).

Diversity is the key – different types of lithium-ion batteries

The term lithium-ion battery refers to a type of battery in which lithium ions are used as charge carriers. These ions usually migrate between the two electrodes in a liquid medium, the electrolyte. Depending on the design and materials used, special variants can be created, such as lithium cobalt oxide or lithium iron phosphate batteries, which sometimes have different characteristics. "To further develop the concept of the lithium-ion battery, the chemical reactions at the interface between electrodes and electrolytes are especially interesting for us, because they affect the properties of such a battery," explains Norbert Wagner, who supervises the project at the DLR Institute of Technical Thermodynamics in Stuttgart. With this knowledge, new materials for use in lithium-ion batteries can be developed or the surface of the electrodes can be made in such a way that the batteries exhibit the most desirable properties and can be operated safely.

Overcharging and high temperatures – the 'acid test' for batteries

DLR experts are playing a key part in the joint project – they build lithium-ion batteries and subject them to extensive laboratory testing. Based on specific requirements geared toward standard test cycles in the automotive industry, the batteries are repeatedly charged and discharged in test cabinets. The scientists observe the evolution of the battery's storage capacity as well as its behaviour under differing boundary conditions such as during overcharging or at high temperatures. Specific recommendations are important to guarantee safe operation, since strict safety requirements are necessary for vehicle applications. "In this context, we are interested in finding out under what conditions and at which locations heat build-up inside the battery leads to damage, mostly due to undesirable side reactions," says Wagner, describing the work. Heat build-up leads to decomposition of the electrolyte, which produces oxygen at the cathode. The pressure inside the battery increases, which can cause rupture or combustion.

Novel measurement methods for science and user

To record and understand events such as voltage or capacity losses as accurately as possible, the DLR researchers are also working on novel measurement techniques. To do this, they systematically divide the surface of the electrodes into individual segments, and track the

reactions occurring there. Another method, referred to as in-situ diagnostics, allows the Stuttgart experts to virtually view the inside of the battery and make measurements while the battery is in operation. These advances in the field of measurement methodology could also contribute to the development of more complex battery management systems in the future. For example, these methods could provide the driver of an electric car with immediate feedback about the battery's charge, condition and life expectancy at the touch of a button.

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Battery research for sustainable mobility in the future



In the joint project 'Li-EcoSafe', researchers at the DLR Institute of Technical Thermodynamics, together with their partners, are developing and testing lithium-ion batteries.

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Lithium-ion battery undergoing laboratory tests



Overcharging or high temperatures – during extensive laboratory experiments, DLR experts build different lithium-ion batteries and subject them to an 'acid test'.

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