Mechanisms Panel Abstract & Speaker Biography

Viscosity Depending Ion Transport in High Energy Lithium-Sulfur Batteries

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The lithium-sulfur battery is one of the promising systems for the future generation of rechargeable batteries. Its main advantages are the high theoretical capacity (1672 Ah/kg), high gravimetric energy density (2455 Wh/kg) and natural abundance. This facts promise a three-to five-fold increased specific energy and greatly reduced costs compared to lithium-ion technology. So far, the commercial application of this battery has been hindered by the reduced cycle live. The insulating properties of sulfur as well as the formation of polysulfides in a complex reaction mechanism, which is not yet completely understood, are the main causes for battery degradation.

In lithium-ion batteries lithium ions intercalate from one crystalline matrix electrode to another. In lithium sulfur batteries lithium reacts directly with sulfur, but in a more complex way. Reaction takes place via electrolyte soluble polysulfide intermediates. After assembling of a charged cell sulfur exists mostly in the orthorhombic crystalline form as cyclo–sulfur and a low percentage is dissolved in the electrolyte. During discharge, the partially dissolved sulfur reduces to polysulfide ions with progressively lower states of oxidation. As the discharge proceeds, the dissolved sulfur in the electrolyte is consumed by electrochemical reactions, the concentration of sulfur decreases, while the concentration of shorter chain polysulfide is increasing. While lithium sulfide precipitates during discharge, the intermediate polysulfides are soluble in the electrolyte and are able to increase the electrolyte viscosity. During discharge the viscosity has reached its maximum at the endpoint of the first voltage plateau.

Efficient ion transport is an important parameter for fast rechargeable batteries. Ion conductivity or transport determines the performance of the rate capability of the secondary cells. Ion transport depends on two solvent properties: the viscosity and the dielectric constant. As shown by the Stokes-Einstein equation, ion mobility is inversely proportional to the viscosity. As stated above lithium-sulfur battery reaction takes place through electrolyte soluble polysulfide intermediates effecting electrolyte viscosity. It is important to highlight that the high reactivity of lithium sulfide is a problematic issue during measurements, because it hydrolyses easily in ambient air, producing hydrogen sulfide and lithium hydroxide. Therefore electrolyte viscosity of a polysulfid-containing-electrolyte cannot be measured in ambient air.

In this work we show a method to measure electrolyte viscosity in an argon-filled glovebox with sample quantities as small as 100 µL. We furthermore observe the degradation mechanisms of lithium-sulfur batteries by enhancing the active loading of cathode while keeping constant the quantity of electrolyte for1000 cycles.

Speaker Biography:

Brigitta Sievert (née Pascucci) is currently pursuing her Ph.D. degree at the department of Electrochemical Energy Technology at the German Aerospace Center in Stuttgart. Concerning the cycle-stability of lithium-sulfur batteries her scientific investigations include polysulfide retention, cathode slurry formulation and preparation, cathode layer application techniques and electrochemical testing, cathode characterization techniques, such as AFM.

After a general apprenticeship at the Dr. Binder Institute in Stuttgart, Germany from 1997 till 1999 Brigitta Sievert worked as a chemical-technical assistant in an additive company in Heilbronn, Germany until 2007. Within her employment she was responsible for implementation and evaluation of test series in a wide field of additive applications in aqueous and non-aqueous systems. Within her seven-year's working experience she gained knowledge in paint formulation and coating technology.

In 2006 Brigitta Sievert started a Bachelor of Science (BSc) in Chemical Engineering/Colors and Coatings at Esslingen University of Applied Sciences. Her investigations in the development of advanced battery technologies started in the context of her bachelor thesis: “Preparation and characterization of novel lithium iron phosphate cathodes for lithium ion cells" in 2010.

From 2008 to 2012, she was awarded with a scholarship from the “Studienstiftung des deutschen Volkes”. Inspired through the opportunity to contribute to the development of novel batteries Brigitta Sievert acquired additional knowledge during her master's degree program: “Applied Surface and Material Sciences” at Esslingen University of Applied Sciences in conjunction with Aalen University of Applied Sciences. In 2012 she graduated with her master's thesis "Cycle stability of lithium-sulfur high energy batteries for electric mobility" at the German Aerospace Center in Stuttgart.