# Application of Electrochemical Impedance Spectroscopy for Characterization of Post Li-Ion Batteries

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In the last decades, the investigation of new secondary cells has been increased considerably. Very promising battery systems are the so called "Post Li-ion batteries" with metal anodes: metal-sulfur and metal-air (oxygen) batteries, in particular Li-sulfur and Li-air batteries.
Li-sulfur battery is a promising system, due to its high theoretical capacity (1675 mAh/gsulfur), energy density (2500 Wh/kg), the low cost and non-toxicity of sulfur. Nevertheless, some of the drawbacks of lithium-sulfur batteries are the poor rechargeability and high self-discharge rates. Due to the low electrical conductivity of sulfur, electrical conductive material has to be added in order to encourage the electrochemical reaction. Furthermore, polysulfides of high order ($Li_2Sn$ with $2 \leq n \leq 8$) dissolve in the electrolyte and can diffuse to the anode and react directly with lithium metal. This so-called shuttle mechanism causes irreversible loss of sulfur.
Metal-oxygen cells exhibit highest theoretical energy densities. State-of-the-art metal-oxygen cells mainly suffer from severe cyclic aging and low Coulombic efficiency. One of the major challenges is the development of suitable electrolytes and electrocatalysts for the oxygen reduction and gas evolution reactions. One of the major limiting factors on performance and round-trip efficiency is the catalyst used. Today´s Lithium-air batteries still suffer from high charge- and discharge overpotentials caused by insufficient catalysts. The major goal is to reduce overpotentials by using bifunctional catalysts catalyzing both the oxygen reduction reaction (ORR) as well as the oxygen evolution reaction (OER). Noble metal catalysts show good performance on both reactions but with increasing prices of noble metals metal oxides have drawn attention recently.
In the presentation new results from the production and characterization of Lithium-sulfur batteries [1] and bifunctional cathodes for Li-air batteries [2] will be shown.

**Keywords:** Electrochemical Impedance Spectroscopy, metal-air batteries, metal-sulfur batteries, OER, ORR

**References:**
[1 N.A. Cañas, A.L.P. Baltazar, M.A.P. Morais, T.O. Freitag, K.A. Friedrich, N. Wagner, Electrochim. Acta, 157 (2015) 351-358.
[2] D. Wittmaier, N. Wagner, K. A. Friedrich, H.M.A. Amin, H. Baltruschat, Journal of Power Sources, 265 (2014) 299-308.