Improved Lithium-Sulfur Batteries with a Protective Electrode Surface Layer Based on Graphene Oxide

Tomáš Kazda[a], David Škoda[b], Pavel Čudek[a], Kamil Jaššo[a],

[a] *Department of Electrical and Electronic Technology, Faculty of Electrical Engineering and Communication, Brno University of Technology, Technická 10, 616 00 Brno, Czech Republic*

[b] *Centre of Polymer Systems, Tomas Bata University in Zlin, Tř. T. Bati 5678, Zlín 760 01, Czech Republic*

E-mail: *kazda@feec.vutbr.cz*

Lithium-sulfur (Li-S) batteries are one of the most promising post-lithium battery systems because of their high theoretical energy density (about 3000 Wh/kg) and low cost because sulfur is one of the most abundant element in the earth crust. [1] However, many problems are connected with this system. Li-S batteries work on the basis of a conversion reaction which is accompanied by volume changes. Formation of polysulfides (Li_2S_8, Li_2S_6, Li_2S_4 etc.) occurs during conversion reaction. These polysulfides are soluble in the electrolyte and they are subsequently deposited on the anode (shuttle effect). [2] This process leads to the decrease of capacity and cycle life of the battery. Another crucial issue is the fact that sulfur and lithium sulfide are isolators, thus it is necessary to add conductive additives into electrode. [3] There are several ways how to solve these problems: encapsulation of sulfur with carbon, coating of sulfur by polymers, changes of electrode design like 3D cathode structure with enclosed sulfur. [4] Other techniques to prevent shuttle effect are special active layers on the surface of separator. [5] Here, we show the role of the protective surface layer based on graphene oxide (GO). Three types of electrode was prepared. The first was a standard electrode based on sulfur (Sigma-Aldrich, 99.5%), conductive carbon Super P and polyvinylidene fluoride (PVDF) in the weight ratio of 60:30:10 dispersed in N-methyl-2-pyrrolidone (NMP). The second electrode was a standard electrode coated by GO-MnO composite. Weight of the protective layer was 4% of the weight of electrode. Sulfur loading of both electrodes was 1.9 mg/cm^2. These electrodes were cycled at various C-rates up to 2 C and compared with the standard electrode. The electrode with the protective layer showed higher stability than the standard electrode - capacity retention after 60 cycles at different C-rates was 95.2% compared to 71.2%. This electrode shows also higher capacity even at a high rate: 2 C – 349 mAh/g compared to 191 mA/g in the case of standard electrode.

This research has been carried out in the Centre for Research and Utilization of Renewable Energy (CVVOZE). Authors gratefully acknowledge the financial support from the Ministry of Education, Youth and Sports of the Czech Republic under NPU I programme (project No. LO1210), program NPU I (LO1504) and Operational Program Research and Development for Innovations co-funded by the European Regional Development Fund (ERDF) and national budget of Czech Republic, within the framework of project CPS - strengthening research capacity (reg. number: CZ.1.05/2.1.00/19.0409) and BUT specific research programme (project No. FEKT-S-17-4595).

References:

[1] J. Kim, D. Lee, H. Jung, Y. Sun, J. Hassoun, B. Scrosati, Adv. Functional Materials. 23 (2013) 1076-1080.

[2] N. Nitta, F. Wu, J. Lee, G. Yushin, Materials Today. 18 (2015) 252-264.

[3] S. Evers, L. Nazar, Accounts of Chemical Research. 46 (2013) 1135-1143.

[4] X. Zhao, J. Tu, Y. Lu, J. Cai, Y. Zhang, X. Wang, C. Gu, G, Electrochimica Acta. 113 (2013) 256-262.

[5] H. Yao, K. Yan, et.all, Energy Environ. Sci. 7 (2014) 3381-3390.