Aleksandra Piotrowska Wrocław, 22.03.2018.

Abstract

The present PhD thesis is devoted to nongraphitizable “hard” carbons for use as the active material of the negative lithium-ion cell electrode. Analysis of the present state of art in the field of the thesis, indicates that this is a scientifically attractive and practically important area of research. Despite abounding research works, the problem of full exploitation of the disordered carbon potential in the lithium insertion/deinsertion has not yet been solved.

As raw materials for the research were used natural and synthetic polymers and oxidized pitch. The study has been focused on the impact of the organic precursor modification, thermal treatment conditions, pyrolytic carbon coating and mild activation on the composition, structure and porous texture of obtained carbons in the relation to their behavior in the electrochemical lithium insertion/deinsertion process.

The methods applied to characterize the structure and texture of carbon materials included elemental analysis, X-ray diffraction (XRD), adsorption of nitrogen and carbon dioxide, infrared spectroscopy (FTIR) and SEM. Lithium insertion/deinsertion behavior of the carbons was assessed in a coin-type half-cell with lithium metal cathode. Electrochemical tests were carried out using galvanostatic charging/discharging to determine the contribution of reversible and irreversible capacity, cycling stability and to analyse the voltage profile.

The study shows, that carbons from oxidized pitch, cellulose and polyacrylonitrile only represent higher or similar to graphite capability of reversible lithium insertion during standard discharging with the current of C/20. The discharge using two-stage constant current + constant voltage (CC+CV) mode instead of simple constant current one appeared to be profitable, to increase the reversible capacity by 15-25 %. Moreover, the pyrolytic carbon deposition under strictly defined conditions resulted in reducing the irreversible capacity by about 20%, without any reversible capacity loss.

Cellulose-base carbon produced at 1000°C represents, after 1,5 h CVD treatment, the best lithium insertion/deinsertion performance amongst developed materials. Anode of the carbon demonstrates, using CC+CV mode, high reversible capacity of 458 mAh/g with a moderate irreversible capacity of 139 mAh/g and acceptable cycling stability during 55 charge/discharge cycles (capacity loss of 5%). Durability test in a full Li-ion cell confirmed that this is a promising, alternative to graphite, anode material of „hard carbon” type.