

ANODE MATERIAL FOR LI-ION BATTERIES

Jaromír Makovička

Doctoral Degree Programme (2), FEEC BUT

E-mail: xmakov05@stud.feec.vutbr.cz

Supervised by: Marie Sedlářiková

E-mail: sedlara@feec.vutbr.cz

ABSTRACT

This article is aimed on preparing and measuring the negative electrode base on expanded natural graphite.

1. INTRODUCTION

In the last decades, many kinds of carbon materials have been investigated as anode materials for Li-ion batteries [1]. Among them, natural graphite appears as a promising candidate due to its advantages such as high capacity at low electrode potential relative to lithium metal. However was found that raw natural graphite from mines cannot deliver satisfactory electrochemical performance [2], [3]. From this information results that larger specific surface leads to better electrochemical behaviour (reversible capacity). In this paper will be discussed the expanded graphite which is the natural graphite with expanded surface (approx. 200x).

2. EXPERIMENTAL

The negative electrode was prepared in the following way: The electrode material was prepared by mixing the expanded graphite (specific surface approx. $50\text{m}^2\cdot\text{g}^{-1}$, Bochemie s.r.o, fig.1 [4]) with PVdF at weight ratio of 95:5. A small amount of isopropanol was added to the mixture for making the proper paste. The resultant paste was coated on the nickel mesh. The coated mesh was pressed and dried at $150\text{ }^\circ\text{C}$ for 1 h.

The three electrode cell was assembled to examine galvanostatic charge/discharge behaviors. A piece of lithium metal (purity 99.9 %) was used as a counter and reference electrode. The working (negative) electrode is described above. 1 M LiClO_4 (purity 95 %, dried at $110\text{ }^\circ\text{C}$ for 50 hours in vacuum oven) in EC-DEC [ethylene carbonate, diethyl carbonate (anhydrous, purity 99 %)] was used as electrolyte. The electrode was discharged to 0 V (vs.Li) at a constant current of 100 mA/g. Then the electrode was charged to 1.5 V (vs.Li) at the same constant current. Fifteen cycles were measured. The AUTOLAB PGSTAT 30 was used for the measurement.

The negative electrode was also measured in the three electrode cell by using cyclic voltametry. The potential step and scan rate were set for 1mV resp. 0,5mV/s. The sample was evaluated in the potential window from 0 V to 1,5V.

The assembly of the electrode cell was done under argon atmosphere ($\geq 95\%$) in the basic acrylic glovebox (fig.2). The electrolyte, solvents and metal lithium were stored here, too.

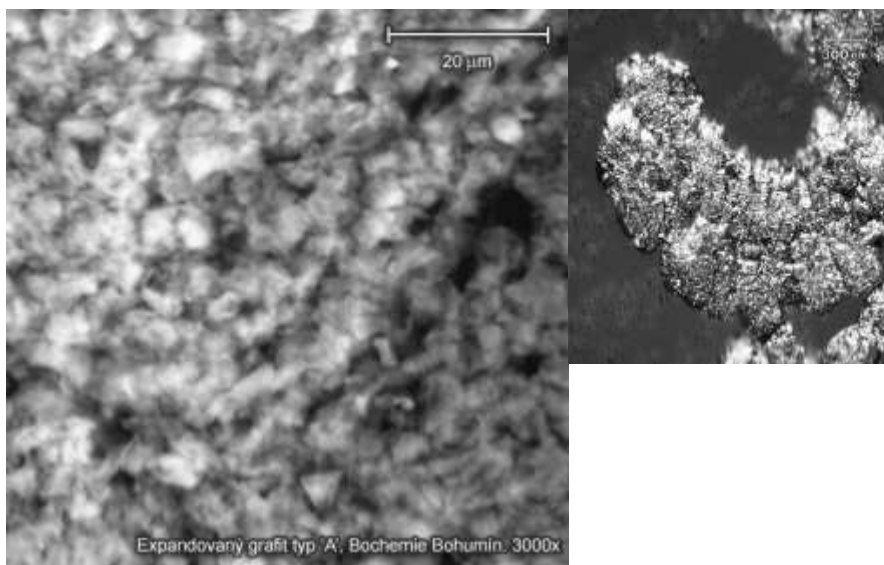


Fig 1: SEM pictures of the expanded graphite – the smaller picture(magnification 200x)

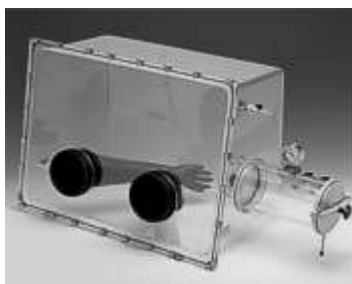


Fig 2: Basic acrylic glovebox

3. RESULTS AND DISCUSSION

The results are shown in the figures 4,5 and 6. The 1st discharge cycle demonstrate high irreversible capacity (over 300mAh/g) and low coulombic efficiency due to SEI (solid-electrolyte-interface) formation on the graphite surface.

3.1. SOLID ELECTROLYTE INTERFACE

SEI is a thin film (several nm) consists of decomposition products of electrolyte solvents such as EC (eq.1, 2) [5] which are permeable to Li^+ cation, but are electronically insulating and prevent further electrolyte decomposition. The stability of SEI determines safety, power capability and cycle life of batteries.

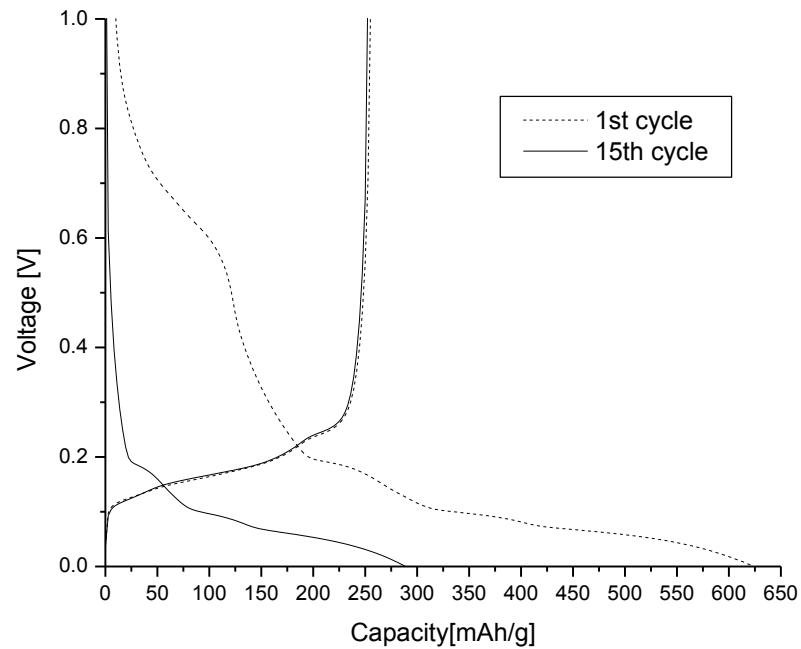
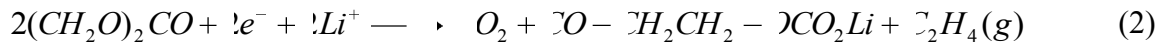
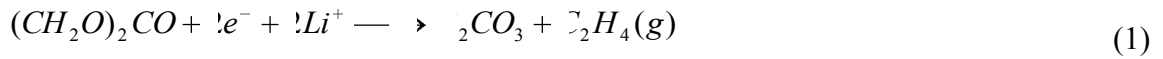


Fig 3: Charge and discharge characteristics of the expanded graphite

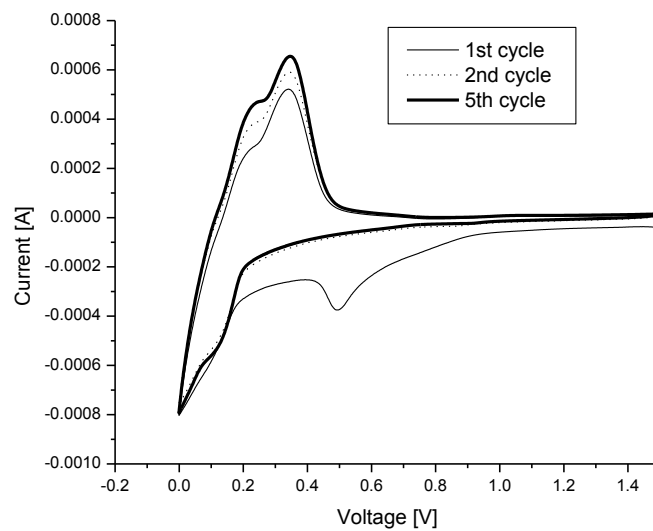


Fig 4: Cyclic voltammogram of the expanded graphite at 0.5mV/s

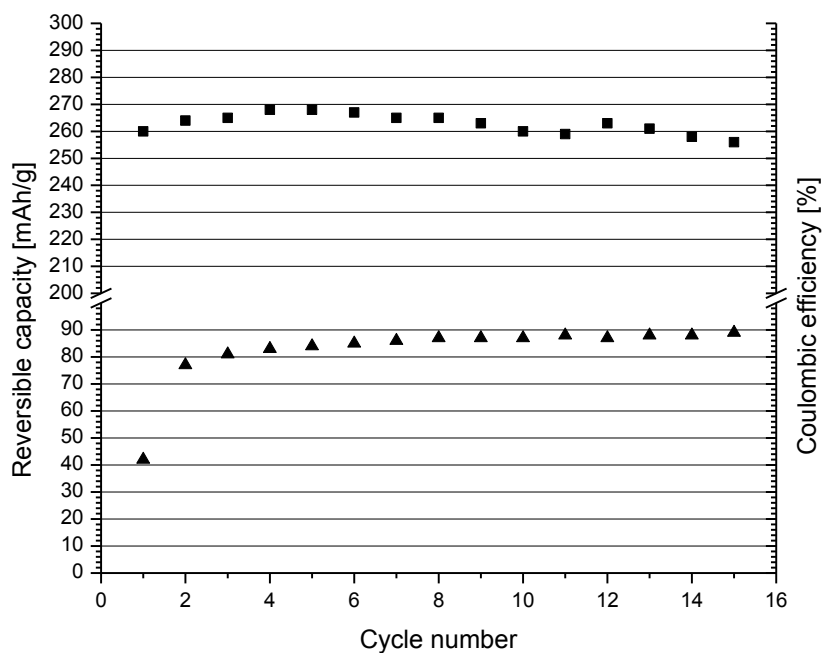


Fig 5: Dependence of reversible capacity and coulombic efficiency on the cycle number

The following cycles reveal acceptable reversible capacity around 260 mAh/g which is approximately 70 % capacity related to the composition of LiC_6 (372 mAh/g). The reversible capacity also strongly depends on current rate [6]. On the other hand coulombic efficiency hardly reached 90% and it means either same impurities in electrolyte (probably H_2O) or additional SEI forming. The H_2O or additional SEI forming were not registered by the means of cyclic voltammetry. The fig.4 shows only one irreversible peak caused by SEI formation around 0.5 V in the first cycle and no peak around 1.2 V (water decomposition) can be seen.

4. CONCLUSION

The results illustrate that the expanded graphite is a promising candidate for anodes in Li-ion batteries but some obstacles have to be removed.

ACKNOWLEDGEMENT

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