Thermal Analysis for Fire Safety of Lithium-ion Batteries

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Research introduction

Paper describes graphite lithiation proces, the process produces pre-lithiated graphite material with low irreversible capacity. This way treated graphite provides approx. 2 % an irreversible capacity (initial graphite around 24 %). The comparison between initial and treated (lithiated) graphite is shown on Figures 1 and 2. STA (Simultaneous Thermal Analysis) was made for investigation of lithim presence in graphite, see Figure 3. STA provides two bacis lines, DSC (Differential Scanning Calorimetry) and TG (Thermogravimetry).

The principle DSC with power-compensation

DSC wit power-compensation is also called as „reverse“ DTA (differential thermal analysis). In comparison, DTA measures differences in temperature between a sample and a reference (when they are both put under the same heat), whereas essence of power-compensation DSC is keep both the reference and the sample at the same temperature. This type of DSC is characterized by two separate measuring boxes (furnaces) and by two heat sources. DSC measures electric power, that is needed to maintain constant temperature of both samples. The result of a DSC experiment is a curve $dQ / dt = f(t)$, where Q is heat energy and this curve has peaks as well as the curve generated from DTA. Distinction from DTA lies in their opposite („reverse“) orientation relative to the x-axes. For endothermic process in DTA is value of the temperature difference negative, while to endothermic process in DSC corresponds positive value of heat energy.

The principle of TG

TG is one of the basic methods of thermal analysis and belongs to dynamic analytical methods. The basic principle is to measure the weight change of analyzed sample during its continuous heating or cooling.

The weight changes are expressed

in relation to temperature $m = f(T)$

or in relation to time m = f (t).

Weight changes of substances during their heating can be expressed by equation:

$$mAB_{(s)} = mA_{(s)} + mB_{(g)}$$

Upon heating gaseous component is released, causing a decrease in weight of the test substance. We meet with these changes for example during thermal decompositionof calcium oxalate monohydrate.

It may occur reversal phenomenon, where the substance reacts during heating with gas, and thereforeincreases its own weight.

$$mA_{(s)} + mB_{(g)} = mAB_{(s)}$$

An example could be oxidation of non-noble metals, where arises oxide or hydroxide of the respectivemetal.

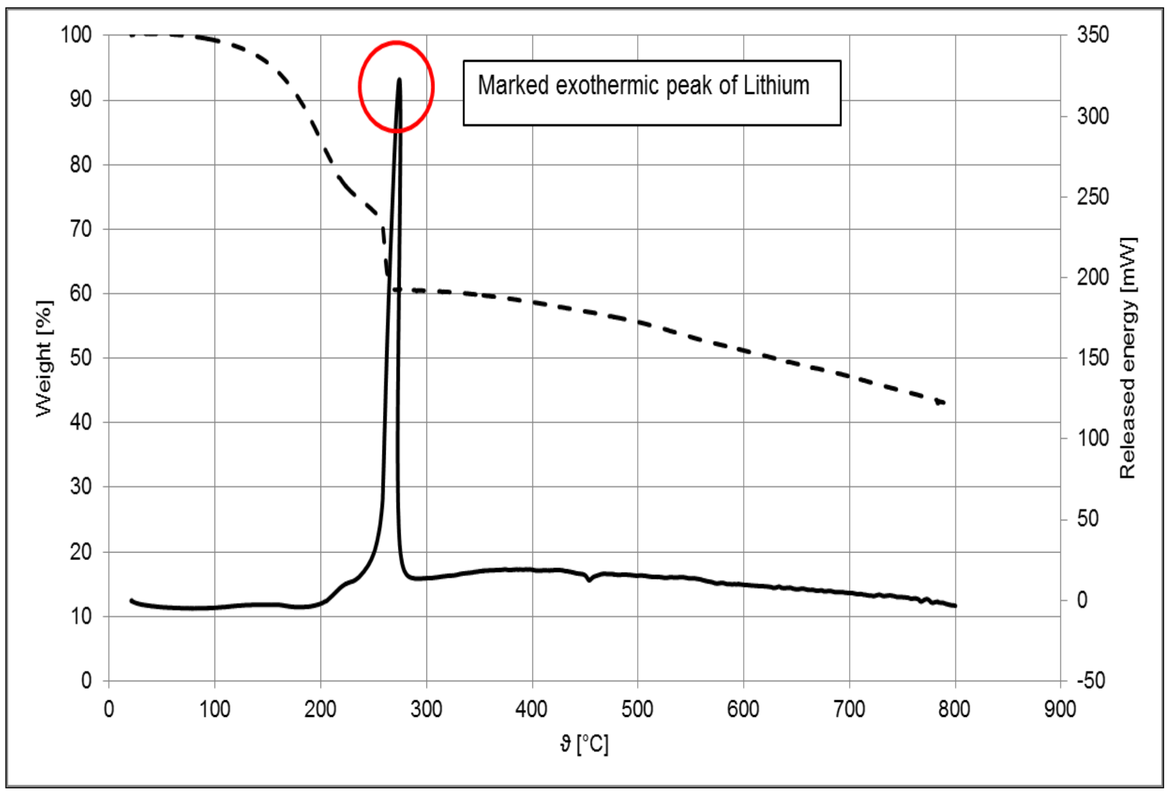

Figure 3. *Energy released by oxidation of lithium.*

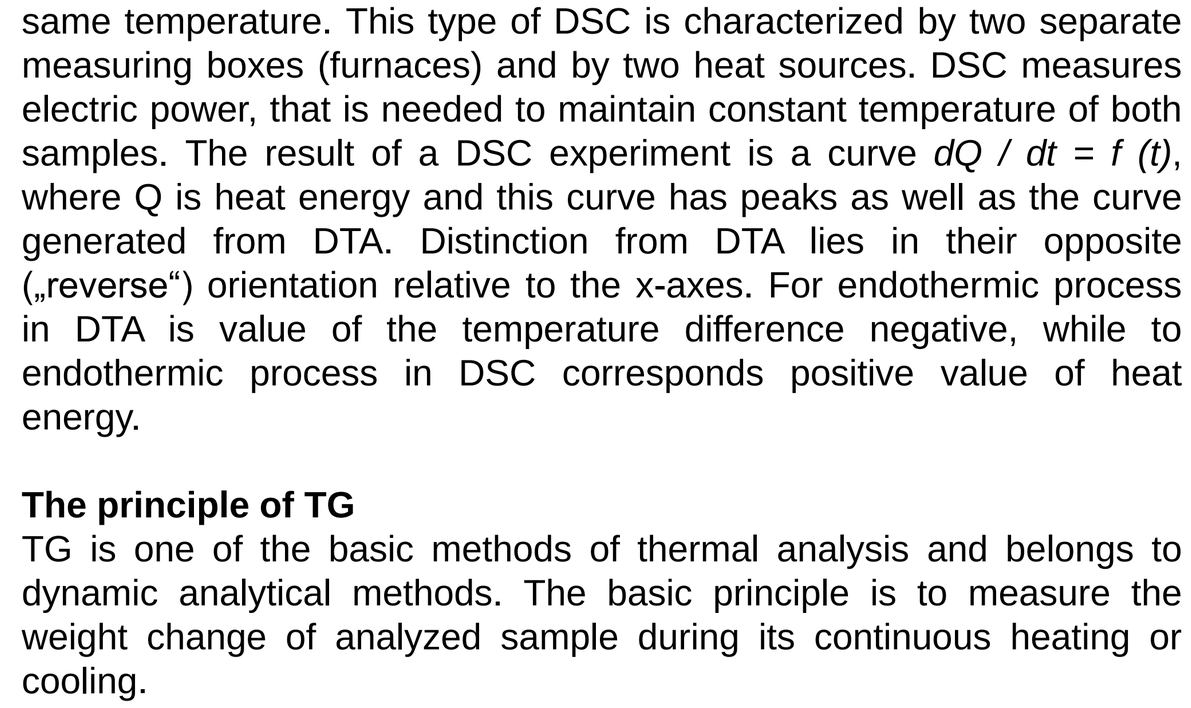

Figure 1. *Initial graphite capacity characteristics.*

Figure 2. *Lithium dopped graphite*.

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