

Prelithiated Carbon Anode for Lithium-ion Battery Applications Using Electrode Microlithiation Technology (EMT)

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Introduction

We have previously reported(1) that a Li-ion battery can be made with a non-lithium containing cathode coupled with a pre-lithiated carbon anode, utilizing our electrode microlithiation technology (EMT). This technology removes the limitation on the choice of cathode materials to only those containing a source of lithium, and paves the way for enhancing Li-ion batteries with more choices of materials. For example, we have shown as a concept cell a Li-ion cell made with a prelithiated carbon anode and a V_6O_{13} cathode (see Fig.1). In this presentation, in addition to its use in the new concept cell, we will demonstrate that our EMT technology can also be utilized to combat the irreversible capacity in today's Li-ion cell design that utilizes $LiCoO_2$ or other lithium metal oxides as cathode, and thereby increase the cell capacity/energy without any system change.

We have developed a method of fabricating a fully or partially lithiated carbon anode (2) that can be combined with a non-lithiated cathode or lithiated cathode to produce a Li-ion cell.

This novel technology utilizes a stabilized lithium metal powder (SLMP) developed by FMC Corporation (3). Composite carbon electrodes have been fabricated, using a slurry containing the stabilized lithium metal powder, graphite powder and a binder coated onto a copper current collector. There are several advantages of using the stabilized lithium metal powder incorporated into the electrode:

- 1 The quantity of lithium powder added can be adjusted and controlled.
- 2 The lithium powder is uniformly distributed throughout the electrode.
- 3 The stabilized lithium metal powder can be handled safely in dry air.
- 4 The powder reacts when electrolyte is added to the cell, producing an SEI layer and lithiated carbon.
- 5 After formation, there is no residual lithium metal - a Li-ion cell is produced.

This technique is much safer than chemical lithiation methods, e.g. butyl lithium in hexane (4). It is simpler than using a sacrificial third electrode (5), and the reaction is quicker than with lithium foils.

Results

Partially lithiated carbon electrodes were produced and tested in 3 electrode cells containing a $LiCoO_2$ counter electrode and a lithium reference electrode. After 2 hours the voltage of the carbon electrode with respect to the lithium reference electrode was approximately 0.19V, indicating that partial lithiation of the carbon electrode had occurred.

Figure 2 shows the first charge and discharge curves for a cell containing a partially lithiated carbon electrode and a control cell. It can be seen that the initial OCV of the cell

containing the partially lithiated electrode is much higher than the control cell. In addition, the cell containing the partially lithiated electrode required less capacity on initial charge and provided more capacity on discharge than the control cell, leading to improved first cycle efficiency.

As shown, the lithium loss due to the SEI formation during the 1st cycle can be compensated by the stabilized lithium metal powder through anode prelithiation, and the cell capacity is increased without having to change the anode/cathode active materials. We believe a greater benefit can be realized when our EMT technology is applied to emerging anode materials that have both larger reversible and irreversible capacities than that of graphite used today.

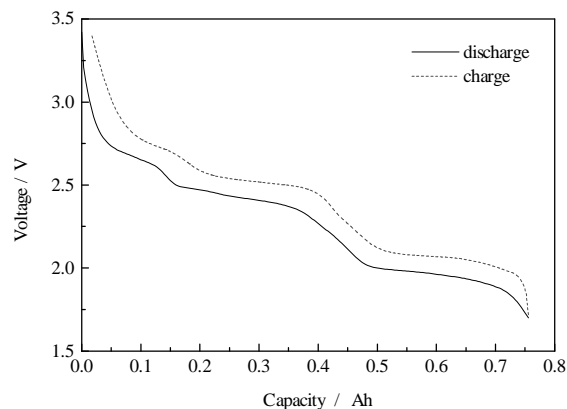


Figure 1 First discharge and charge curves for a lithiated carbon - V_6O_{13} cell

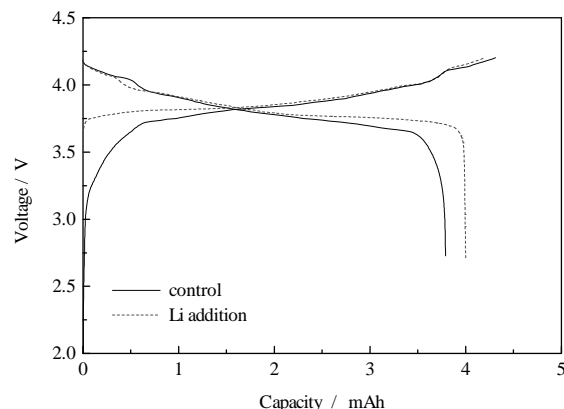


Fig. 2 First charge and discharge curves of carbon - $LiCoO_2$ cells, with and without lithium addition to carbon electrode

References

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