SPECTRUM BATTERIES INC.

Passivation

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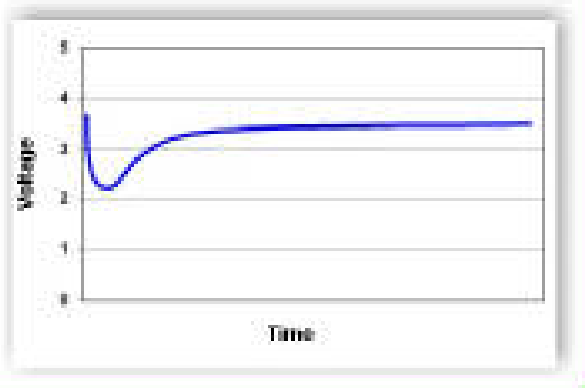
Passivation

Lithium batteries are affected by a phenomenon known as passivation. Passivation is a film of lithium chloride (LiCl) that forms on the surface of the lithium anode, and it serves to protect the lithium from discharging on its own when the load is removed from the cell. The film of LiCl, which is essentially a high resistance layer between the electrodes, is primarily responsible for the long shelf life (>10 years) of lithium cells.

Passivation may cause voltage delay after a load is placed on the cell as illustrated in the following drawing:



After a load is placed on a cell, the high resistance of the passivation layer causes the cell's voltage to dip. The discharge reaction slowly removes the passivation layer thereby lowering the internal resistance of the cell. This in turn causes the cell's voltage to reach a peak value which should remain steady if other discharge conditions do not change. If the load increases after the cell's voltage stabilizes, then it may dip again until the passivation layer is sufficiently removed.

Once the load is removed or lowered, the passivation layer will reform, and voltage delay may be a factor when subsequent loads are applied.

Several different factors may increase passivation thereby influencing the length and depth of voltage delay. They are:

- Current capability of cell - High loads on cells may cause voltage delay to increase. Conversely, voltage delay may be unnoticeable with very small loads.
- Chemistry - Different variations in chemistry may influence passivation.
- Length of storage - Generally, the longer a cell is in storage, the more passivation is formed on the anode surface. Thus, voltage delay may be higher for older cells of a given cell type.
- Storage temperature - Higher storage temperature increases the amount of passivation. Essentially, storing cells at high temperature for short periods will have the same result as storing cells for long periods.
- Discharge temperature - The effect of passivation is more apparent at lower discharge temperatures.
- Prior discharge conditions - Partially discharging a cell and then removing the load increases the amount of passivation relative to when the cell was new. Voltage delay may increase after each use.

In many cases, voltage delay caused by passivation does not affect users of lithium cells. However, we recommend that you evaluate the effect of passivation very carefully when selecting lithium batteries. Users of lithium cells should refer to each cell manufacturer's specific information on this subject.

PASSIVATION NOTES FROM ELECTROCHEM

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