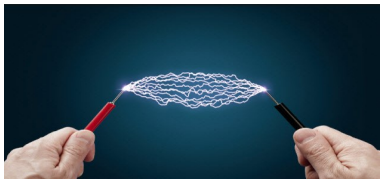
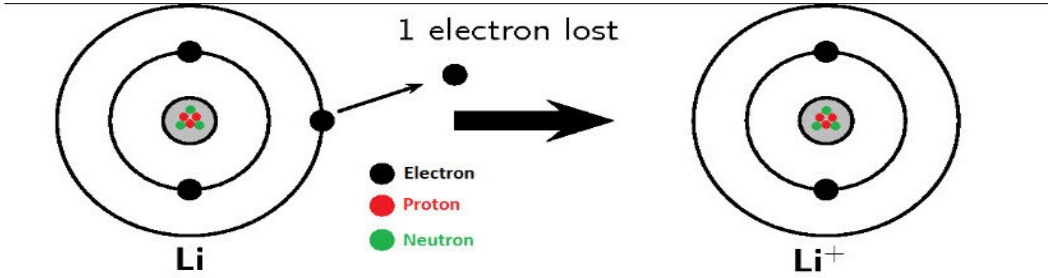


WATTS UP!

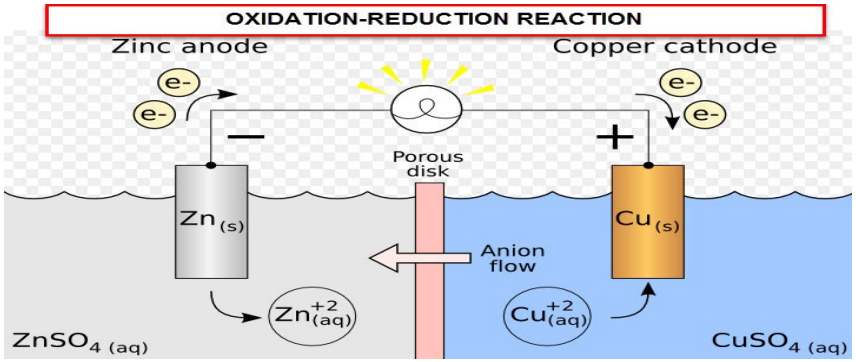
All About Batteries—LIPO Chemistry

All the material we see is made up of atoms. **Atoms** are made up of **protons** and **neutrons** in the center, called the **nucleus**, and electrons on the outside. In **Lithium (Li)**, there are three protons, three neutrons and three electrons. If one electron leaves the atom, with only two electrons remaining, it is called a **lithium Ion (Li+)**. Electrons occupy "**shells**" and "**orbits**" around the nucleus and these states correspond to various "**energy states**." If an electron can move to a lower "energy state," it will do so, and this explains chemical reactions.



Li atom with 3 electrons and 3 protons

Li^+ ion with only 2 electrons and 3 protons



Oxidation-Reduction Reaction:

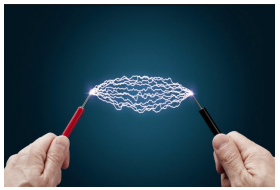
In an Oxidation-Reduction reaction, one atom or molecule gives up an electron. We see this most often as rust as in rusty metal. However, this happens in batteries as well. In a battery, the atom or molecule giving up an electron becomes an "anion" and flows into a solution. Its corresponding electron flows through a wire in the form of electric current. The electrons separate from their respective atom because the separating electron moves to a lower energy state at the cathode. The lower energy state is correlated with the "Standard Electrode Potential" or volts.

ANODE: $\mathrm{Li_{1-x}CoO_2 + xLi^+ + xe^- \leftrightarrows LiCoO_2}$

CATHODE: $\mathrm{xLiC_6 \leftrightarrows xLi^+ + xe^- + xC_6}$

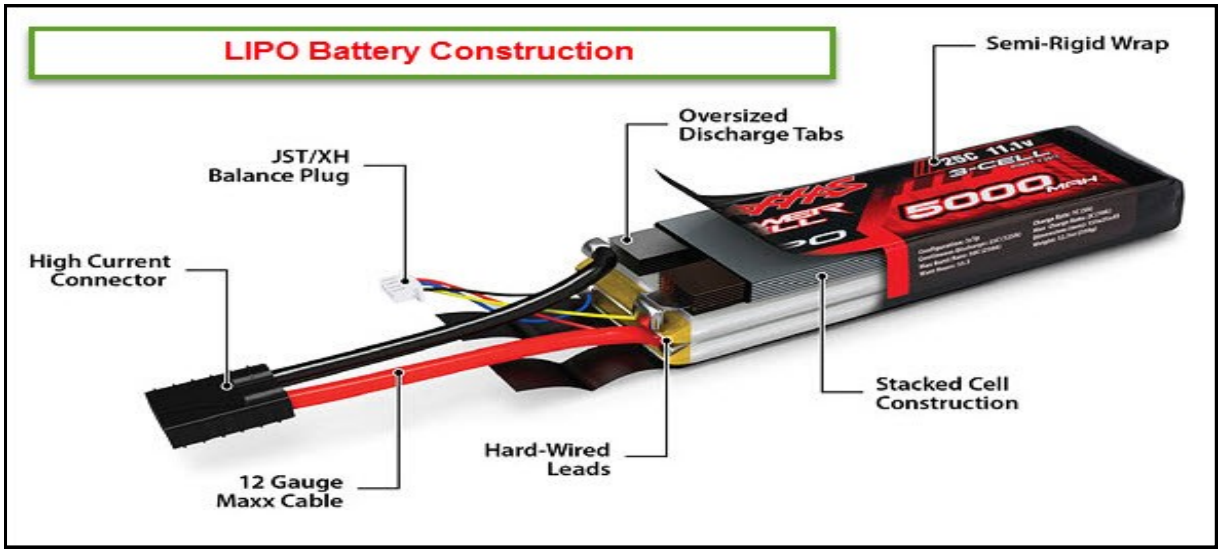
OVERALL: $\mathrm{Li^+ + e^- + LiCoO_2 \rightarrow Li_2O + CoO}$

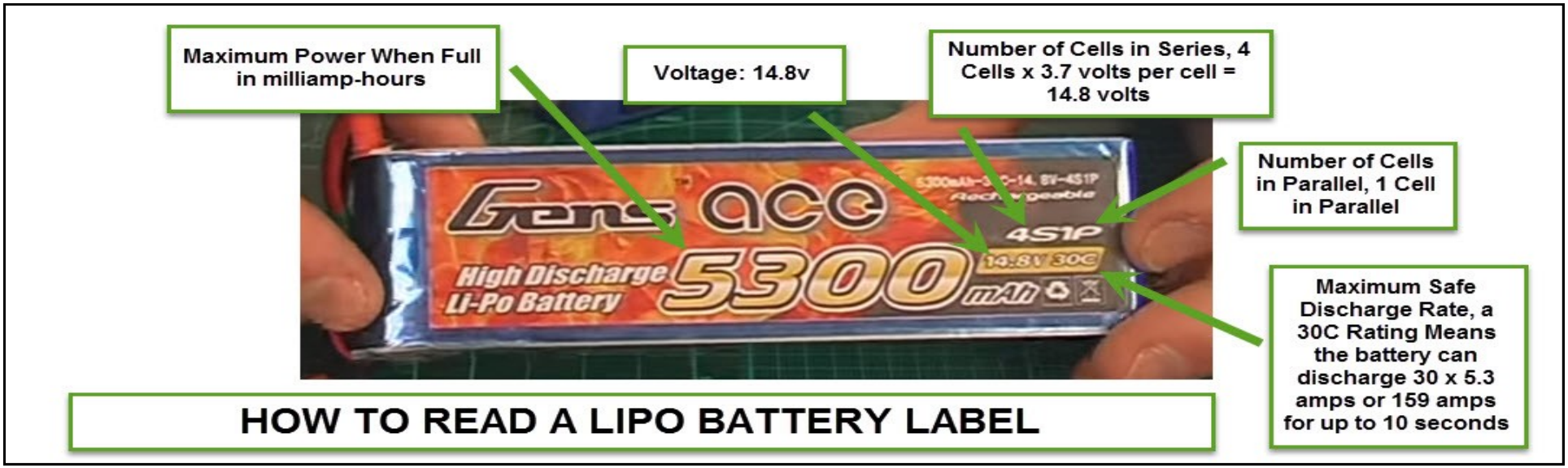
To the left are the half-reactions for the LIPO battery. At "**discharge**," the half reactions occur from left-to-right; while charging, the reactions flow from right-to-left. The **Anode** is the charged positive plate; the plate that collects the **electrons**. The **Cathode** is the charged negative plate; the plate that emits the **electrons**. **Li** is the symbol for Lithium. $LiCoO_2$ is Lithium-Cobalt-Oxide, **Co** is the symbol for Cobalt; and **CoO_2** is Cobalt Oxide. C_6 is a special form of Carbon called "graphite." Between each plate, there is a polymer separator and an electrolyte solution which allows the ions to flow. The reaction voltage is 3.7 volts.

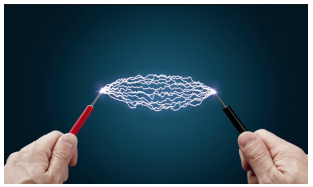


WATTS UP!

All About Batteries—Reading the Label & Construction

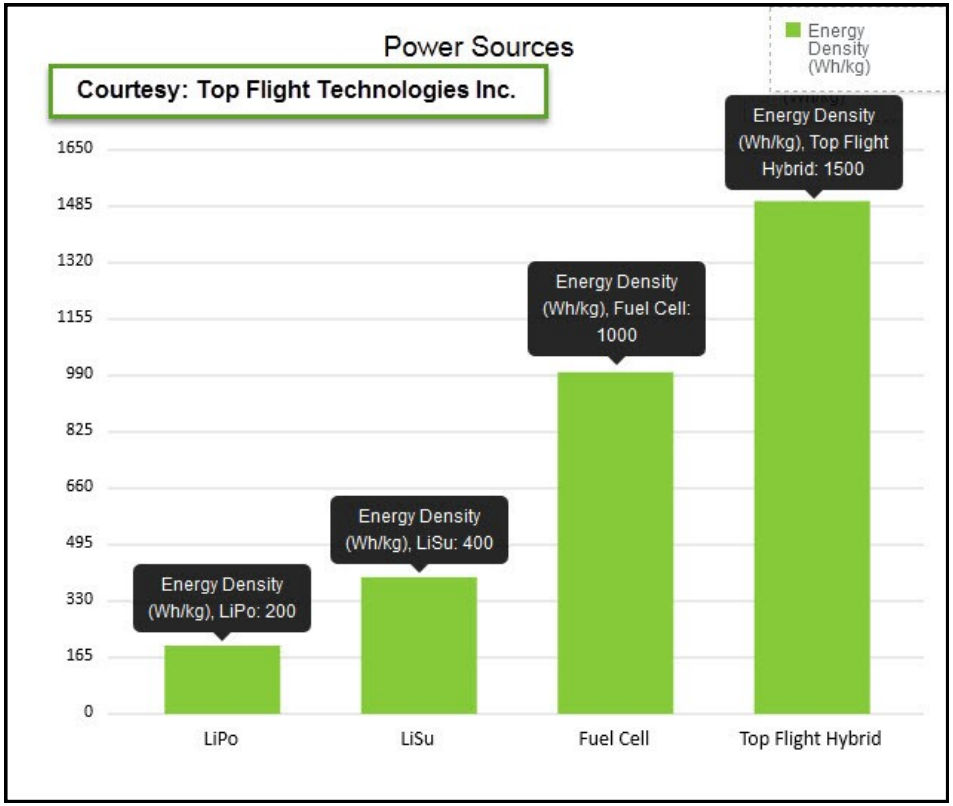






WATTS UP!

All About Batteries—Additional Considerations



One way to evaluate batteries is to consider their "Energy Density." **Energy Density** is the amount of energy stored in a system compared to its volume or weight. Even though today's LIPO batteries have improved significantly, they have a long way to go compared to some liquid fuels. In the "personal drone market," we may see "hybrid" drones in our near future; where liquid fuels are used to replenish the electricity used by the electric motors while in flight.

We are aware that the number of jobs in the Unmanned Aerial Vehicle (UAV) market is growing rapidly. However, a better consideration may be to think about how this "job market" will continue to grow. One way it could grow is if the **range and endurance** of drones is enhanced.