CHATHAM AERONAUTS

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Battery Options

Choosing the right chemistry for the job

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Overview

- Multipart mini series on batteries.
- This month we’ll talk chemistry and application. Over the next few sessions we’ll cover:
  - Charging/care for each type
  - Battery specifics that effect performance, proper sizing, capacity, etc.
  - Choosing an appropriate charger (what to look for etc.)

Ok, so what are my options?

- There are 4 main types of rechargeable batteries we frequently see used.
  - NiCad – Nickel Cadmium. Older, but still used in high amperage cases.
  - NiMH – Nickel Metal Hydride. Still common in receiver packs, tools, glow ignitors etc.
  - LiPo –Lithium-Polymer. These are the current mainstay in battery tech for RC use. LiPo evolved from LiIon and, aside from the electrolyte used, are very similar.
  - LiFePO2 – Lithium Iron Phosphate. Most commonly known as A123. (Like how facial tissues are known as “Kleenex”)
- Yes, we do use Pb (Lead Acid) as well, but really only for your field box/starter and starting your car to get to the field.

NiCd

- Pros
  - Low internal resistance – Allows for high currents
  - Have a low self-discharge – holds charge longer while just sitting idle
  - More tolerant of cold than some technologies.
- Cons
  - Heavier than other options (aside from Pb)
  - Can suffer from voltage depression – known as the “memory” effect

NiCd – Continued

- By some accounts the “memory” effect has been overblown. This was first discovered by NASA when they noticed batteries in satelites, that get a precise amount of power from solar cells and known draw during the day, lost capacity down to the repeated use levels.
- Basically, if a cell is discharged to say 45% and recharged numerous times, eventually it will only hold that 55% that has been getting used.
- Frequent cycling, discharge and recharge, can help. Watch for over discharge. Without a balance lead one cell can go 0V then reverse polarity in the pack.

NiCd – Common uses

- Still used in some transmitters and receivers. Most due to low cost.
- Often still found where high currents are required and the weigh penalty isn't significant.
  - This is why they make good receiver packs. They respond quickly with current the servos are demanding.

NiMH.

- Pros
  - Higher capacity over NiCd and even some Lithium for the size. AA with 2700mah is common.
  - Solved the NiCd “memory” problem.
- Cons
  - Self discharge is higher that NiCd, which honestly wasn’t terrific. At best it was ok.
  - High capacity batteries can be delicate and are sensitive to how you charge them
  - Capacity sometimes questionable. They don’t develop voltage depression, but may never hold full values. 2700mah on the can, might only result in 2400 inside.

NiMH - Continued

- Unlike NiCd that run right from the box, MiMH requires a forming charge when new. If not, you likely won't get full capacity.
  - Forming charge is 1/10 of C rating. Best to use a wall wart charger are run it long enough to hit 120% of the packs capacity. The extra is blown off as heat, so don't let them sit and cook foverer.
- Larger packs (1400mah+) can see major voltage drop under load. So not ideal for receiver packs on anything larger than 40 size planes, unless you like resets and receiver brown outs.
- Larger packs (14-1600mah+) also aren't fans of high charge rates and can be damaged easily. Plan to not exceed 1Amp charge rates.

NiMH – Where to use

- Unimportant stuff like your starter (although NiCd will give better punch) and glow driver.
- Light amperage load aircraft, let’s say 40 size and below.
- Transmitters. Have moderate load and circuitry built in to watch the output voltage and warn you when it’s low. These are often high capacity packs, so best charged slowly.

LiPo.

- Pros
  - High capacity to weight ratio.
  - Much lower self-discharge due to lower internal resistance.
  - Can be more tolerant of cold than other technology, although expect to see a current reduction at low temps.
- Cons
  - Intolerant of over charge. Basically: Fire.
  - Intolerant of over discharge. Basically: Toast. Likely puffed. Won’t see full performance again.
  - High discharge rate (low internal resistance) means you have to be extra careful. Short a 7.2v NiCd pack and you get some sparks and heat. Short a 7.4V LiPo pack and you’ll be glad you had a bench fire extinguisher.

LiPo - continued

- Cons
  - All batteries will vent gas when abused. NiCd, NiMH, PB, and even LiFePO4 do this somewhat controlled. LiPo do it rapidly. This is why we see them in soft bags, to contain the gas quickly. In a hard case, we'd call this a bomb.
  - Require CC/CV chargers. No putting these on a wall wart.
  - Not huge fans of heat (over charge, over amperage).
  - Should not be charged hot. Let them go back to ambient temp before charging.
- Although not "strictly" required, balancing is recommended. This avoids over-charge. Without balance you can have one cell at 4.3 volts and the other at 4.1 (total 8.4, fully charged 2 cell pack) without knowing it.

LiPo – Where to use

- With such a high capacity to weigh ratio, we see them everywhere.
- For receiver packs, there may be other better options. If you use LiPo mount there somewhere easily accessible, you'll need access to them for
  - Special charging (balance)
  - Review for damage (puffed)
  - They can be pierced easily. (soft packaging)
- LiIon cells are offered in hard case (usually cylinders or small box). LiIon often not quite as high performing (there's a reason we moved to Polymer for high capacity and demand), but deliver same voltages and might be an option

LiPo

- Interesting side note on the packaging. LiPo cells perform better under some pressure.
- Pressure keeps components in contact and prevents delamination.
- The major “but” here is how they off gas when something goes wrong. LiPo blows off gases so quickly that unless very carefully engineered and carefully maintained, the hard case turns them into small bombs.

LiPo – What’s the deal with LiPo vs LiIon

- As far as the user is concerned, lithium polymer is essentially the same as lithium-ion.
- Li-polymer is unique in that a micro porous electrolyte replaces the traditional porous separator. Li-polymer offers slightly higher specific energy and can be made thinner than conventional Li-ion, but the manufacturing cost is higher by 10–30 percent.
- That’s it. Basically a LiPo is the new/better version of LiIon. The bulk of the difference, aside from above, is marketing. Would you be more likely to buy an “improved version LiIon” more than a “new technology LiPo”?

LiPo – What’s the deal with Graphene?

- Some manufactures have started adding a Silicon-Graphene additive, we’re seeing these online as “LiPo graphene”.
- Adding Graphene helps preserve the Anode (positive side) while discharging, increasing the longevity and cycle-life of the cells.
- Corrosion of the Anode has shown poor capacity (lower than expected mAh) and decreased lifespan of batteries.
- Graphene also raises the charged voltage of the cells to 4.35 in “High Voltage” packs leading to even higher energy densities.
- Treating HV batteries as standard LiPo (i.e not utilizing the extra 10% capacity) could further lead to longer life as some studies have show charging to 100% (and maintaining there for longer periods of time) can result in performance loses.

LiPo – So, what makes them puff up?

- LiPos have three components:
  - Anode (positive) – made of lithium, manganese, and oxygen, or lithium, cobalt, and oxygen.
  - Cathode (negative) – made of lithium and carbon held in a semi-liquid state
  - Separator - polymer soaked with a conductive electrolyte
- As they age (or are abused) the Anode degrades giving off Oxygen.
- Over charge, over discharge, and extreme load (short, over draw) accelerate that degrade.
- Some studies have show storing at full charge also causes oxygen to be released.
- Retailers say all kinds of things, but many believe the typical lifespan of a LiPo is around 100 cycles. After that expect deterioration.

LiFePO4

- Pros
  - High capacity to weigh. Similar to LiPo.
  - Low self discharge.
  - More tolerant of over/under-charge and over-discharge (high draw)
  - More tolerant of heat.
  - Package is hard case. They can out gas, but at a much slower controlled rate (like NiCd, NiMh)
  - 2S pack is similar voltage to 5S Nicd/NiMh (6 nominal, 7.3 fully charged)
- Cons
  - Limited sizes and capacities available.
  - They are heavier per Wh than LiPo (especially in larger capacities).
  - Often larger than similar sized LiPo (especially in larger capacities).

LiFePO4 vs A123

- Ok, I said they're pretty much the same but there is a major difference.
- A123 adds a nano-technology to increase current capacity.
- Where a standard LiFePO4 battery may have a rating of 3-5C, A123 can handle bursts to 100C.

LiFePO4 – Where to use

- Transmitter and Receiver packs. These (relatively) low current loads are the perfect place.
- As main power pack. Bundling (2S6P for example) can lead to decent main packs but as you go bigger the physical size and weigh can be an issue.
- As a main pack they (especially A123) have one major advantage, they handle heat better. Many users will recharge straight out of the plane/heli/drone whereas LiPo needs to cool first. This means fewer packs needed for a day of fly as you can recharge quickly.
- A123 also supports multiples or C charging. Making 15 minute charge (like NiCD) possible.

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