E-Tec 90 mAh
A new LiPoly Cell for Ultra-Micro Planes

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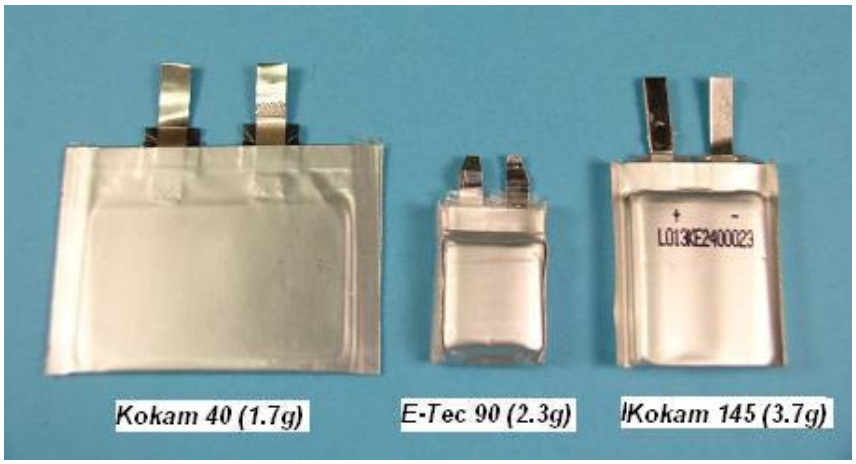
As a micro enthusiast I have an interest in trying to find new LiPoly cells that will suit our needs for ultra-micro planes. For some time I've been looking for a cell that is smaller in capacity and weight than the Kokam 145 but with more capacity and discharge capability than the Kokam 40. A few months ago I spotted some new cells by the Korean battery manufacturer E-Tec that were listed as intended for Bluetooth consumer electronics applications. The cell that caught my attention was one listed as having 90mAh capacity and weighing approximately 2.3 grams This is 1.4 grams lighter than the Kokam 145 and only 0.5 grams more than the Kokam 40. I enlisted Bob Selman to help me get a sample of the cell. Unfortunately the cell was not yet in full production. Two months later, with the help of the US importer, we managed to obtain three cells to test. Matt Keennon has access to better discharge equipment than I do and kindly offered to test the cell. Within days we knew we had the cell we had been looking for. By the time you read this you should be able to purchase this new LiPoly cell and a charger designed to accommodate it from Bob Selman Designs.



The E-Tec 90mAh cell is between the Kokam 40 and 145 in terms of capacity. But its size is more compact than either and will be a breeze to fit inside a small fuselage.

The picture above shows the ET-90 cell, flanked by the Kokam 145 and 40 mAh cells. The first thing we notice is its diminutive size. Its 15x20mm footprint is just 53% that of the Kokam 145, and considerably smaller than the very thin but large footprint Kokam 40. This will be a real advantage when placing the cell in a fuselage, or on the side of a micro plane. The ET-90's max discharge rate relative to its capacity, its "C-Rate", is not as high as the Kokam 145 we are used to for many of our smaller planes. Still, it is high enough for the lower amp draw of pager motors we might expect to use in an ultramicro or room flyer plane. Read on and see what this little cell can do and how to put it to use in a plane.

Constant Discharge Tests

The results of Matt's discharge tests are shown in Figures 1 and 2. Figure 1 shows volts over time at various discharge rates. The first thing to note is that at a constant 5.5C discharge rate (0.5 amps or 5.5 times the cell's stated capacity) the voltage drops below the 3 volts safe minimum after 4.75 minutes. This half amp discharge rate probably represents the upper limit for what the ET-90 can do for our purposes. For comparison, a Kokam 145 is generally acknowledged as being able to be discharged

continuously at up to 7C, or about one amp, and the Kokam 40 can be discharged at only about 0.25 amp. In contrast, the 3.3C, 0.30 amp, discharge rate doesn't result in the volts dropping below 3 until 14.5 minutes have passed. This is a pretty long flying time for most of our models. So, we will probably want to use this cell in applications that have amp draws of between a quarter and half an amp. Below a quarter amp the Kokam 40 would be a lighter alternative, although with less capacity and a less convenient size.

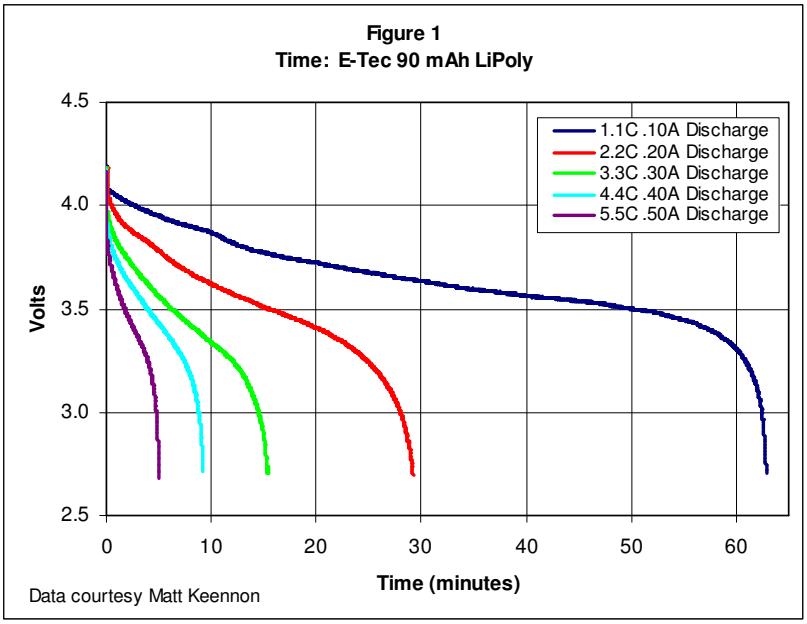
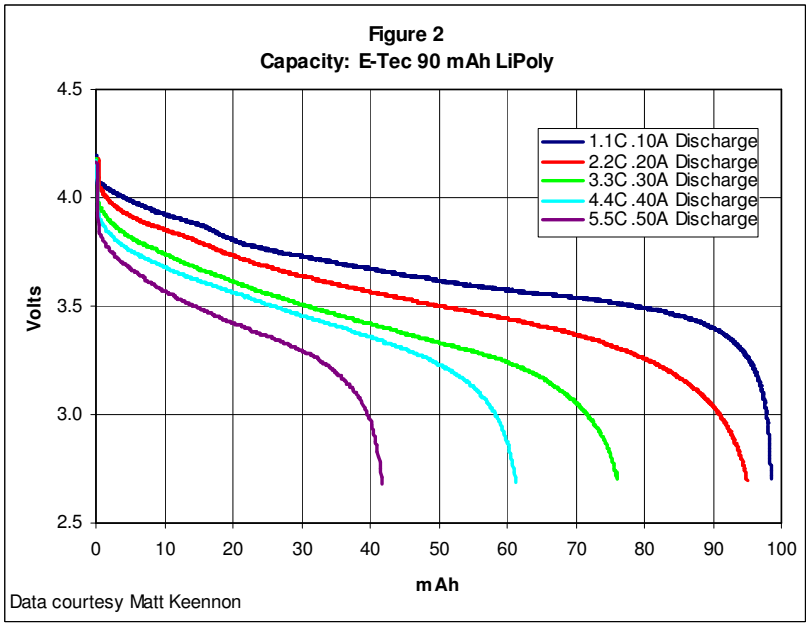


Figure 2 shows the capacity in mAh that can be pulled out of the cell at each of the same discharge rates. First, we see that at the 3.3C discharge rate the cell delivers 80 percent of its stated 90mAh capacity, down to the 3 volt cutoff we normally observe for LiPoly cells. At the 5.5C rate it delivers just 44 percent of the stated capacity, and hence the significantly shorter discharge time. The manufacturer lists this cell as 80mAh minimum and 90mAh typical. Based on these discharge tests it's clear we should use the typical rating.



Charging The ET-90

Bob Selman Designs has developed a LiPoly charger that charges at three different rates — 40, 90, and 140 mA. The middle 90mA rate is specifically tailored for this cell. To be on the safe side I charged my cell only at this rate. Other chargers can charge at rates moderately higher. But, charging at rates greater than 1C should be avoided to prolong battery life. Bob's charger is simple to operate. Two jumpers allow selecting which of the three charge rates to use. With one jumper in place it charges at the 90mA rate for this cell. When the charger is connected to a 12V power supply a green light comes on to indicate the cell is charging. When a battery is connected to the charger a red light comes on. When, the red light goes out the battery is charged. It generally took approximately an hour to charge the ET-90 cell.

The Bob Selman Designs LiPoly charger is perfect for the E-Tec 90 cell, and the Kokam 40 and 145 cells as well by changing jumpers.

Appropriate Propulsion Sets

For very light and somewhat larger floater type of planes the selection of the appropriate propulsion set for the ET-90 cells is very simple. A pager motor with a very high gear ratio like 21:1 and a relatively large prop like the Westechnik 16cm or larger can be used. Amp draw will be very low and this cell although heavier than the Kokam 40 at 1.7g, will be able to provide extremely long flight times.

For small semi-scale planes the propulsion set choice is considerably more complicated. We can't use a prop which is too large or it won't look scale or it will hit the floor. And, with smaller props a very high gear ratio won't yield as much thrust. So, my focus here is on solutions for small semi-scale and similar planes.

Propulsion Set Comparison				
		Didel 6x15mm 10 ohm pager		Didel 6x12mm
	KP00	Straight LiPoly	Voltage Booster	4.5 ohm pager
PERFORMANCE				
Volts	3.5V	3.5V	5.0V	3.5V
Amps (motor)	0.77	0.14	0.22	0.33
Amps (power source/VB)			0.40	
Watts (motor)	2.70	0.49	1.10	1.16
Thrust (g)	13.30	7.00	10.60	11.30
Rpm	1,470	2,550	3,210	3,300
DETAILS				
Gearing	2.7:1	6.7:1	6.7:1	6.7:1
Prop	U80	CF 4.8x3.1	CF 4.8x3.1	CF 4.8x3.1
LiPoly Used	Kokam 145	E-Tec 90	E-Tec 90	E-Tec 90
WEIGHTS				
Motor	3.80	1.60	1.60	1.32
Gearbox	1.00	0.73	0.73	0.73
Prop	*0.79*	0.45	0.45	0.45
LiPoly cell	3.70	2.30	2.30	2.30
Voltage booster			0.30	
Total weight	9.29	5.08	5.38	4.80
Thrust/Weight ratio	1.4	1.4	2.0	2.4

Amps power source are from the power supply at 3.5V with a 5V voltage booster

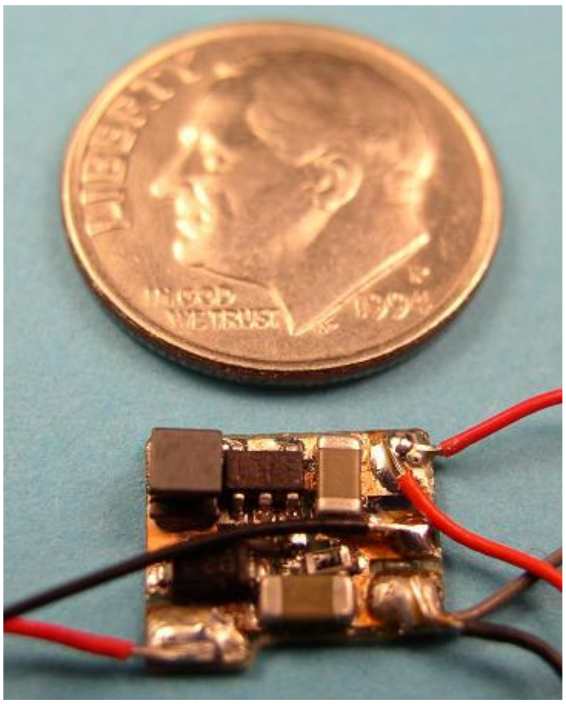
One of the most commonly used micro propulsion sets is the KP00, which is a Mabuchi M20-LV motor geared 2.7:1 with a U80 prop. This setup pulls approximately 0.77 amps (8.6C) and is clearly too much for the ET-90 cell. A more appropriate use of the ET-90 cell would be in an application with a lighter motor so weight savings could be realized from both the motor and the battery. Pager motors come in a variety of diameters and lengths, and from a number of manufacturers. Those in the 6mm diameter are particularly worth considering as their weights are generally in the 1.3 to 1.6 gram range. At 3.5 volts the thrust that can be obtained from a 6mm pager motor is considerably less than from the KP00. However pager motors tend to perform better at moderately higher volts, but are quite efficient in terms of their amp draw. A good solution is to use a DC-DC voltage booster to boost voltage to 5.0 volts. The one I use is from Graham Stabler (www.indoorflyer.com) and will soon be available in the US from Bob Selman Designs (http://users.joplin.com/~bselman/).

The table above shows static tests for a KP00 and a Didel 6x15mm 10 ohm pager motor. To be fair, the M20-LV motor used in the KP00 can generate more thrust if it is geared higher and a larger prop is used than those in the standard KP00 setup. But, the KP00 in its standard form is widely used on small planes so the comparison is appropriate for our purposes. Let's first look at the thrust delivered by the KP00 and the pager motor without a voltage booster. The pager motor even with a larger prop and higher gearing generates only about half the 13g thrust of the KP00. However, its 0.14 amp draw is less than one fifth that of the KP00. Turning now to the pager motor at 5 volts we see that its thrust increases to just over 10 grams. Now it is within shouting distance of the KP00.

Another possibility is to use a pager motor with a "hotter" low-ohm wind. Most surplus pager motors have about 10 ohms resistance. However, Didel has 6x12mm pager motors in 3 ohm, 8 ohm, and as I was writing this article they added a 4.5 ohm motor. The 3 ohm motors tend to run hot and have high amp draws. The 8 ohm motor put out about the same thrust as the 6x15mm 10 ohm, but with a higher amp draw. The 4.5 ohm motor cannot be powered at 5 volts as it would overheat. I wondered if this new 4.5 ohm motor might be a good choice for the ET-90 cell. The last column in Table 1 shows static thrust for

this motor. Amp draw at 0.33 amps is considerably higher than the 15mm long motor at 3.5 volts, but less than the voltage boosted pager at 5.0 volts. The static thrust, however, is slightly higher than the voltage boosted solution. Lower resistance pager motors tend to run hotter and I don't know how this one will hold up over time. However, I did run it in this setup at 3.5 volts for 15 minutes and at the end it was barely warm. Based on that I think it should hold up fairly well. The 4.5 ohm pager propulsion system is also 420mg lighter since the motor is shorter and no voltage booster is needed.

A consideration when choosing a propulsion set is amp draw and its effect on flying time. The voltage boosted solution will have the shortest run time, followed by the 4.5 ohm pager, and then finally the no-boosted 10 ohm pager. The table show, for the 6x15mm motor, amps at the motor at 5 volts and also amps at the battery when the VB is boosting to obtain that 5 volts. At the beginning of the discharge the amp draw is about 0.40 amps. As the discharge progresses the cell's voltage drops, so the booster must boost the voltage higher to achieve 5V at the motor. As a consequence the amp draw increases to about 0.50 amps. At full throttle the run time is about 4.5 to 5.0 minutes. However, the volts to the motor is 5 volts the entire time, so thrust does not diminish.



The Indoor Flyer DC-DC Voltage booster boosts voltage to 5 volts, and weighs just 300mg without wires. The extra wires in the picture go to the voltage monitor.

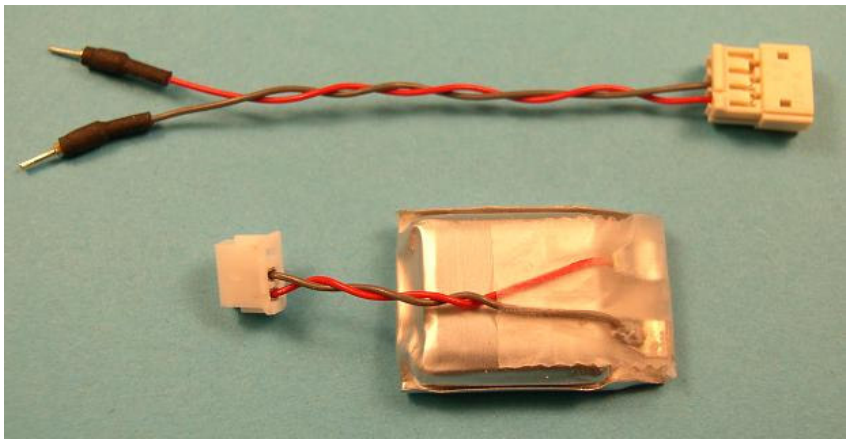
Just as important as thrust is the total weight of the propulsion set and battery. Table one shows that the pager/DC-DC/ET-90 solution is 4.4g lighter than the KP00/Kokam-145 package. This means any plane the voltage boosted pager setup is used in won't need as much thrust since the weight will be lower. In addition, the boosted pager setup has a thrust to weigh ratio of 2.0 compared to the KP00 setup at 1.4. The 4.5 ohm pager setup has an even higher thrust to weight ratio at 2.4.

Appropriate Planes

What kind of planes are suitable for use with a pager motor and ET-90 based propulsion system? In short, very light. To test this cell I built a small stick plane, the Quick Junior. I have a family of "Quick" planes that all use foam wings and tail surfaces with a carbon fiber fuselage for a quick build and easy repair. The Quick Junior is by far the lightest at 15.5g. It uses Bob Selman's hot-wire cut 3.5-inch chord foam wings. These wings have a nice undercamber airfoil that performs better than the usual curved flat plate airfoil. The fuselage stick is 1.3mm carbon fiber tube from Dave Lewis. Tail surfaces are 2mm Depron sanded to 1mm to save weight. Wing span is a diminutive 12.5 inches. The receiver is RFFS-100 with DU actuator coils in Bob Selman housings. I used a Homefly voltage monitor, mounted on the front of the wing pylon, as I want to make sure I don't discharge the battery below 3.0 volts. The stick design has the advantage of allowing easy swapping of components including different pager motor propulsion sets with various gearings and with and without voltage boosters. The gearbox is one that my friend Carl Martin has made for me that allows easy swapping of various motors for testing purposes. I molded my own carbon fiber prop to save weight. A kit with the necessary materials for molding the same kind of prop off commercially available plastic props can be purchased from Bob Selman Designs. If you are interested in building a similar plane, the weight breakdown is given in the table below.

Quick Junior	
Weight Breakdown	
Total Weight (g)	**15.50**
Airframe	5.90
DU/BSD MiniAct actuators	2.00
RFFS-100 receiver	1.90
6mm motor/GB/CF Prop	2.80
Indoor Flyer voltage booster	0.30
E-Tec 90 cell	2.30
Wires	0.30

To wire the ET-90 cell up for this plane I went with my usual JST micro connectors from Dave Lewis. He now carries these in two wire gauges and I use the 32 gauge size for my micro planes Three inches of wire and both plugs as shown in the picture below weigh a total of 360mg. The pins and shrink tubing add a bit more weight. One thing I like about the JST connectors is there are no exposed connections to worry about coming in contact with something metal on a workbench and shorting out, which can ruin a LiPoly cell from the fast discharge. The ET-90 with the JST connector and wire and a bit of cellophane tape as shown below weighs just 2.39g.



After soldering it up with the 32 gauge JST plug and wires the ET-90 weighs just 2.39g.

For the first flight I used the combination of the 6x15 10 ohm pager motor with the voltage booster (which can be seen mounted just in front of the RFFS-100 in the picture above) With 10 grams of static thrust this propulsion set is perfectly matched to this tiny plane. With this setup the Quick Junior has a wing loading of 1.8 oz/sq.ft. Had it been built with a KP00 propulsion set and the Kokam 145 cell, its weight would have been ~19.5g and its wing loading would have been ~2.4 oz/sq.ft. This would have been acceptable but the version here weighs 23% less and would fly slower since flying speed decreases as weight decreases.

My Quick Junior weighs just 15 grams using readily available equipment like the RFFS-100 radio, Bob Selman MiniAct's, and a pager motor propulsion system optimized for the E-Tec 90mAh cell.

When I flew the Quick Junior for the first time I found it had plenty of power. I ended up flying it at about 60% throttle. But, I had more power when needed for more aggressive climbs if I wanted. Because of the low throttle level flying time was about 7 or 8 minutes. Next time I fly it I'll try the non-boosted 4.5 ohm Didel pager motor. That's what I like about my "Quick" planes, they are easy to swap equipment on.

Conclusion

The E-Tec 90 mAh cell is one that should appeal to anyone who has wanted to build a sub 18 gram or so airplane. Its shape fits well in a fuselage and its discharge capability is more than adequate for motors appropriate for sub 18 gram models. I'm still learning about this cell. But, I'm sure I'll be getting more of them. The E-Tec 90 should help bring very light pager motor powered planes within reach of more modelers.