

**Tuesday, 10/24/23**

## **Other Types of Rechargeable Batteries for Use in Stand-Alone PV**

- 1) Nickel-Cadmium (Ni-Cd) Batteries
- 2) Nickel-Metal-Hydride (NiMH) Batteries
- 3) Lithium-Ion (Li-Ion) Batteries

This battery technology is currently the most likely to replace Pb-acid batteries.

### a. Battery Construction

Negative electrode (anode): carbon (usually graphite).

Positive electrode (cathode): one of three materials:

- (1) A layered oxide such as lithium cobalt oxide.
- (2) A polyanion such as lithium iron phosphate.
- (3) A spinel such as lithium manganese oxide.

Electrolyte: typically, a mixture of organic carbonates:

They must be non-aqueous.

Pure Li is highly reactive with water, forming lithium hydroxide and hydrogen gas.

The nominal cell voltage is 3.6 V.

The cell is sealed for safety (to prevent exposure to moisture).

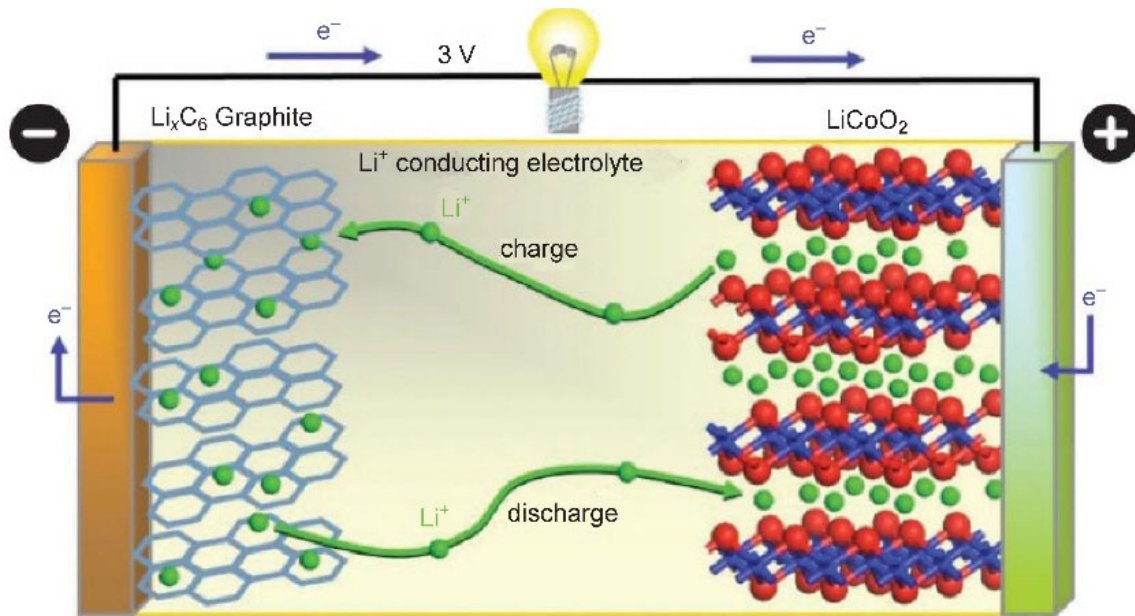
Lithium presents a safety risk for explosion or fire. Therefore, you must prevent:

- (1) Over-charging
- (2) Over-discharging

- (3) Over current
- (4) Short circuit
- (5) High temperatures
- (6) Charging below 0°C
- (7) Rupturing the sealed container

Compared to Pb-acid batteries, Li-ion batteries:

- (1) use no toxic Pb, a heavy metal
- (2) may last longer
- (3) may weigh less
- (4) may cost less (over a PV system's lifetime)



Courtesy: <https://www.technology.matthey.com/article/59/1/4-13/>.

Li ions move from the anode to the cathode through the non-aqueous electrolyte as electrons flow through the external load.

#### 4) Pb-acid : Li-ion battery comparison (12V 200 AH batteries)

##### Universal 12V 200 AH Deep Cycle Sealed AGM Battery - UB4D



Length: 20.75 in  
Width: 8.11 in  
Height: 8.43 in  
Terminal Height: 9.65 in  
Weight: 132 lb  
Shipping Weight (lb.): 137  
DC Output Voltage: 12 V

\$381.95 (was \$387.95 spring semester 2022)

<https://www.batterystuff.com/search.html?q=deep+cycle>



## 12V 200AH Lithium Ion Battery

Product: CX200 SKU: 12-LIB-200 Weight: 60 lbs  
\$1749.99 (was \$1,999.99 spring semester 2022)

<https://www.lithiumion-batteries.com/products/12-volt-lithium-batteries/group-31-12v-200ah-lithium-ion-battery>

## 5) Charge Controller for Li-ion Batteries

Consider the SCM25 MPPT (12V/24V 25S solar charge controller):

Cost: \$249.99



(<https://www.lithiumion-batteries.com/products/product/12v-or-24v-25a-solar-charge-controller>)

It is both an MPPT and a charge controller.

Stated characteristics:

- Very high efficiency for faster charging.
- Stable, accurate Mastervolt Maximum Power Point Tracker.
- Up to 30% faster charging compared with PWM technology.
- Suitable for inexpensive 60-cell panels.
- Capacity for solar panel configurations from 200 to 700 Wp.
- Suitable for all battery types, including Mastervolt Lithium Ion.
- Automatic 12/24 V detection.
- Flexible charging characteristics.
- Battery temperature sensor for long lifespan.
- Large and bright display.
- Secure switchable output.
- Safe operation, audio signal in case of malfunctions.
- Very quiet operation.
- Robust casing, suitable for humid environments (IP23).

#### 4) Sodium-Ion Batteries

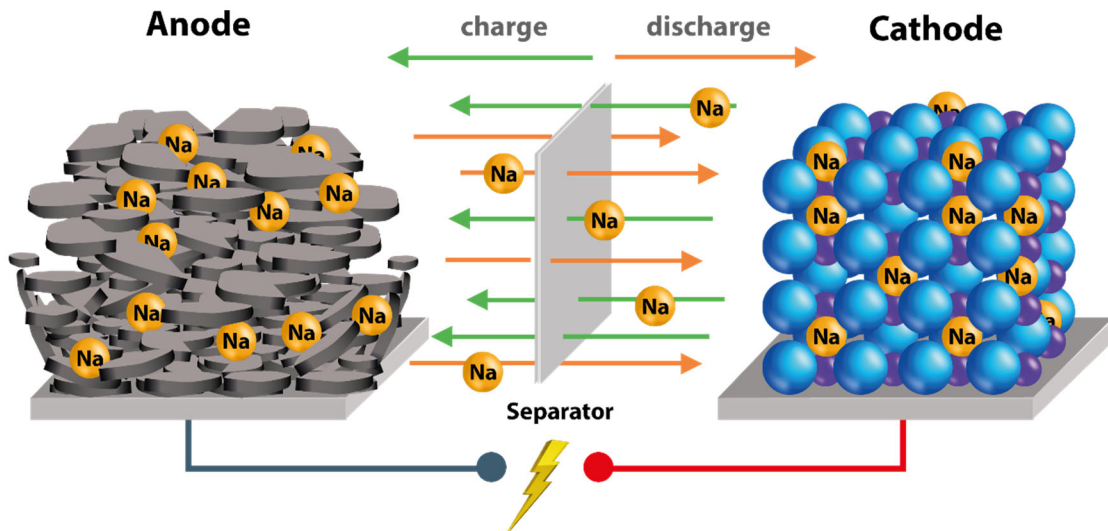
Na-ion battery development began in the 1970s and extended into the early 1980's. However, further development was supplanted by Li-ion battery development at that time, until the early 2010s. At that point, there was a resurgence of interest in Na-ion batteries.

Li and Na are in the same column of the periodic table and therefore have similar chemical properties.

Na can replace the Li in the cathode. Na is much more readily available than Li and is much more environmentally friendly to obtain: from seawater for example. This could also reduce battery cost, compared to Li-ion batteries. Also, Co, Cu, and Ni are not required for some types of Na-ion batteries: Fe can be used in some cases with Na-ion batteries (Fe does not work with Li-ion batteries).

Fe is also less expensive than Co, Cu, or Ni.

Na-ion batteries have some drawbacks.  $\text{Na}^+$  is larger (ionic radius) than  $\text{Li}^+$ , and  $\text{Na}^+$  is a more massive ion than  $\text{Li}^+$ . This results in poorer performance and heavier batteries. Na-ion batteries are beginning to come onto the market though.



<https://www.flashbattery.tech/en/sodium-batteries/>

Similar to Li ions in Li-ion batteries, Na ions move from the anode to the cathode through the electrolyte as electrons flow through the external load.

The larger ionic radius of Na<sup>+</sup> compared to Li<sup>+</sup> results in much slower ion movement in the crystal lattices.

Commercially available 12.4 V 100 AH Na-ion battery:



[https://www.alibaba.com/product-detail/France-New-Sodium-ion-battery-Storage\\_1600918738369.html?spm=a2700.7724857.0.0.58771b23KhIQYM](https://www.alibaba.com/product-detail/France-New-Sodium-ion-battery-Storage_1600918738369.html?spm=a2700.7724857.0.0.58771b23KhIQYM)

\$220/ea (Quantity of 2): more than Pb-acid but less than Li-ion equivalent capacity batteries.