Electric Car

By

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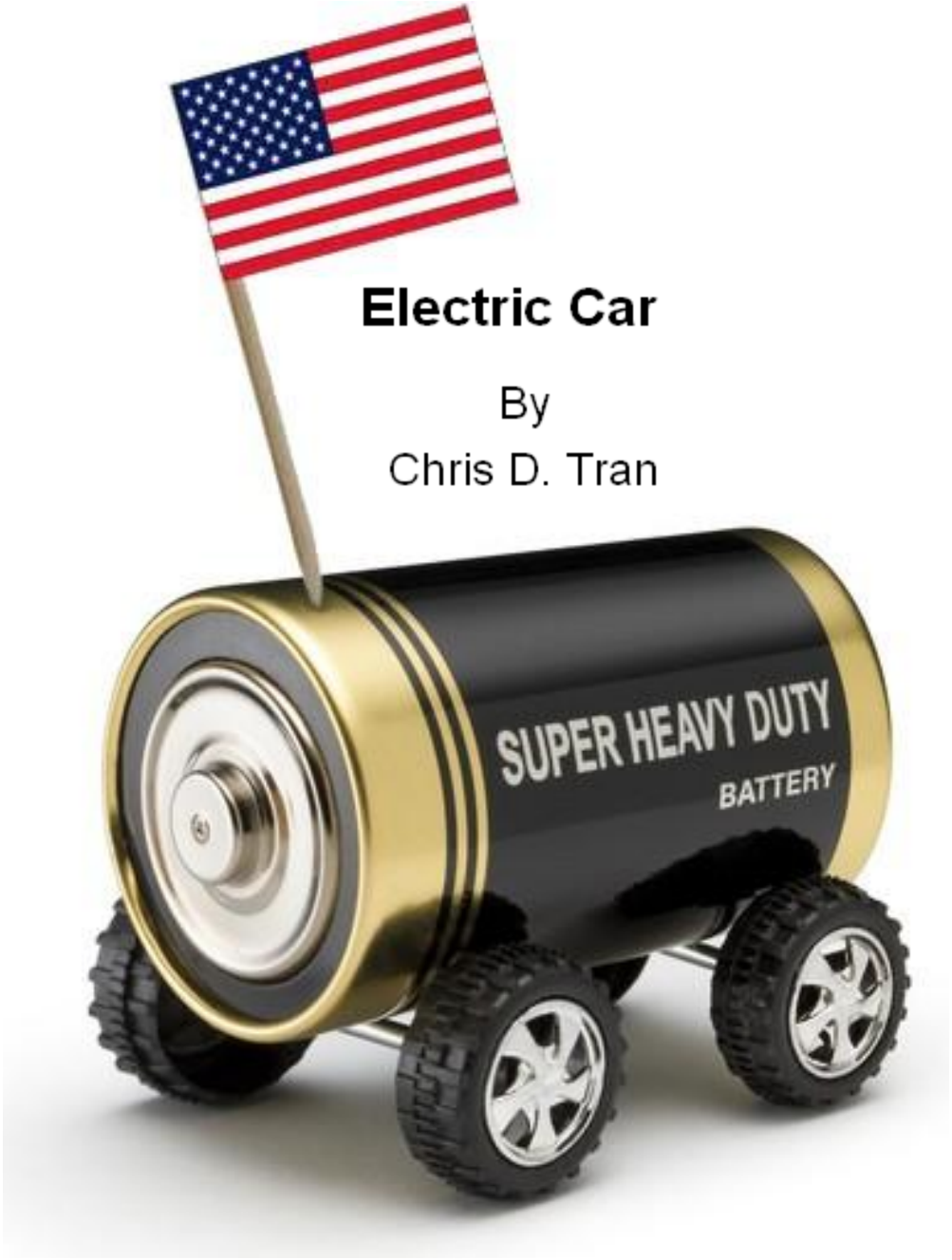


Outline

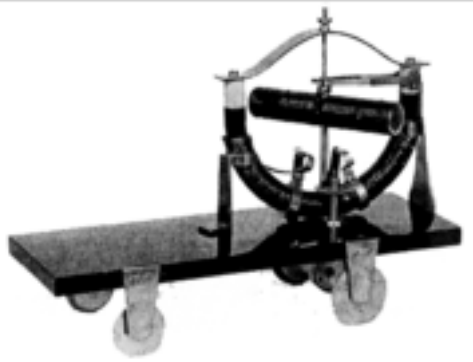
- **Introduction to electric car**
- **History of electric car**
- **How electric cars work**
- **Batteries of electric cars**
  - Lead Acid Battery
  - Lithium Ion Battery
  - Lithium Air Battery
- **Advantages and Disadvantages of electric cars**

Introduction to Electric cars

- Electric car is an alternative fuel automobile that uses electric motors and motor controllers for propulsion.
- Electric cars which store electrical energy in a capacitor or battery.
- Electric cars create less pollution than gasoline-powered cars, so they are environmentally friendly.
- Electric cars are zero emissions vehicles.
- Electric car did not have the vibration, smell, and noise associated with gasoline powered cars

History of Electric Cars

- **1828** The first electric car was developed in Hungary
- **1835** The first practical electric vehicle was built in America.
- **1859** France developed an electric car with a rechargeable lead-acid storage battery.
- **1891** The first successful electric automobile in the United States was produced.
- **1897** Electric cars were produced in New York city and used for taxis.
- **1902** Electric car has topped speed of over 14 mph, range of 18 miles/charging.



Electric vehicle model by Ányos Jedlik, the inventor of electric motor (1828, Hungary).

1902 Wood's Electric Phaeton

History of Electric cars

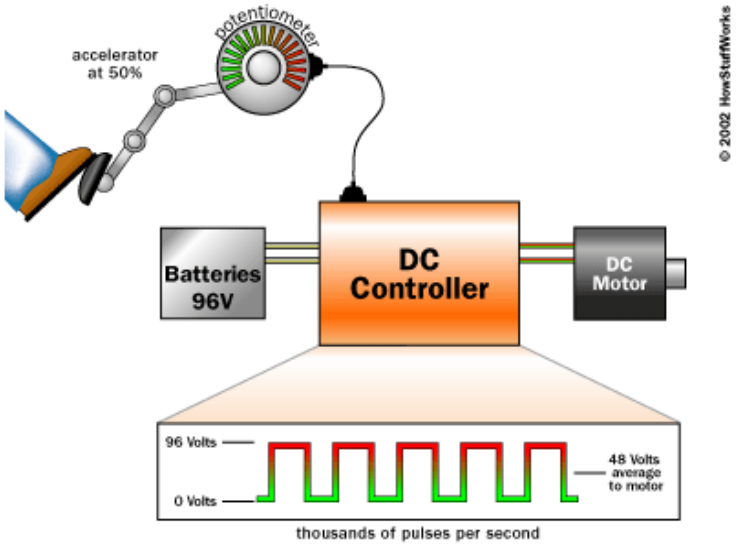
- **1974** Electric car has topped speed of over 30 mph, range of 40 miles/charging.
- **1997 - 2000** Electric cars are available for lease only.
- **2009** Few electric cars are available on the market such as Nissan LEAF, Chevrolet Volt, and Mitsubishi i MiEV with speed 70 mph, range of 300 miles/charging for lithium ion battery and 80 miles/charging for lead acid battery.

1974 Electric car model Vanguard-Sebring's CitiCar

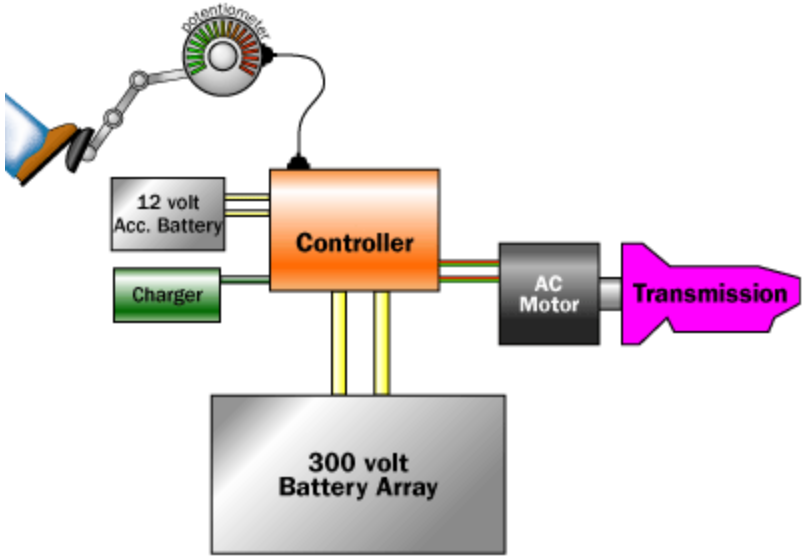
The tzero on the left can go up to 300 miles (480 km) at 70 mph (110 km/h) using Li-ion batteries, while the EV1 on the right has a range of 160 miles at 65 mph using NiMh batteries, or 80 miles (130 km) with lead acid ones.

How Electric Cars Work

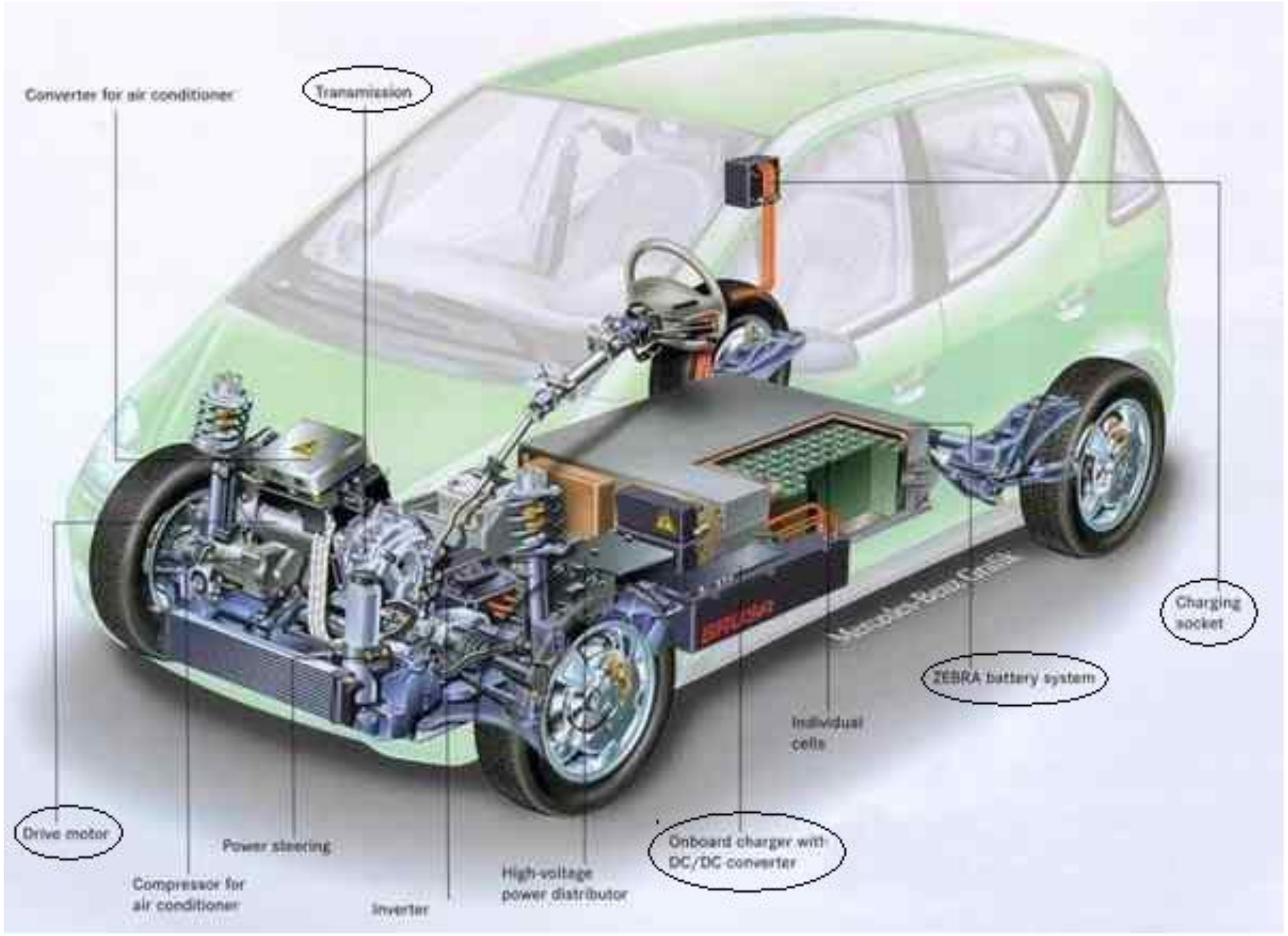
- The heart of an electric car is the combination of:
+ The electric motor
+ The motor's controller
+ The batteries



DC controlled motor may run on 96 to 192 volts.

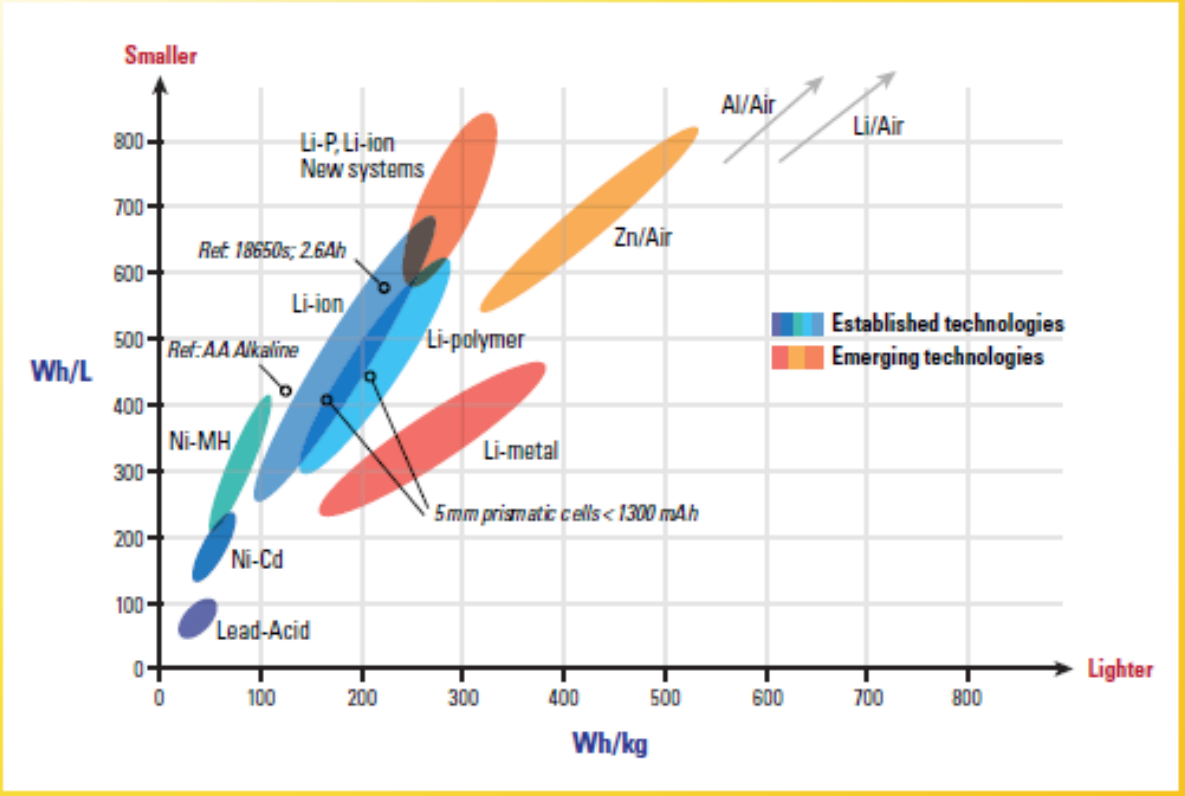


AC controlled motor usually runs at 240 volts AC using a 300 volt battery pack.


Converter for air conditioner
Transmission
Charging socket
ZEBRA battery system
Individual cells
Drive motor
Power steering
Compressor for air conditioner
Inverter
High-voltage power distributor
Onboard charger with DC/DC converter

nexergy

Comparison of Energy Densities for Various Chemistries



More information on battery chemistry and battery pack design can be found at the Nexergy Web site.

1-800-537-9602
www.nexergy.com

Lead-acid battery

lead acid car battery

Energy/weight	30-40 Wh/kg
Energy/size	60-75 Wh/L
Power/weight	180 W/kg
Charge/discharge efficiency	50%-92% [1]
Energy/consumer-price	7(sld)-18(fld) Wh/US$ [2]
Self-discharge rate	3%-20%/month [3]
Cycle durability	500-800 cycles
Nominal Cell Voltage	2.105 V

Lead Acid Battery Reactions

- Chemical Reactions for charge & Discharge

At the negative terminal the charge and discharge reactions are:

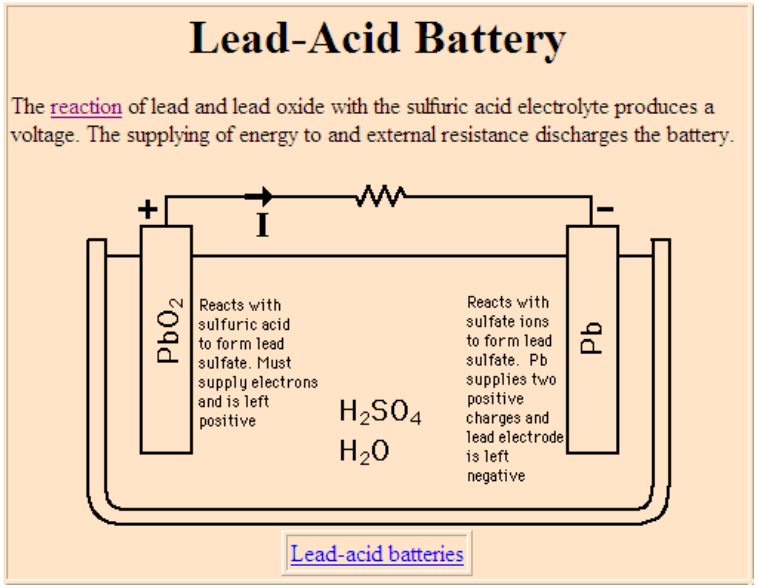
$$Pb + SO_4^{2-} \underset{\text{charge}}{\overset{\text{discharge}}{\rightleftharpoons}} PbSO_4 + 2e^-$$

At the positive terminal the charge and discharge reactions are:

$$PbO_2 + SO_4^{2-} + 4H^+ + 2e^- \underset{\text{charge}}{\overset{\text{discharge}}{\rightleftharpoons}} PbSO_4 + 2H_2O$$

The overall chemical reaction is:

$$PbO_2 + Pb + 2H_2SO_4 \underset{\text{charge}}{\overset{\text{discharge}}{\rightleftharpoons}} 2PbSO_4 + 2H_2O$$



Advantages & Disadvantages of Lead Acid Battery

- **Advantages of Lead Acid Battery**

- Inexpensive.
- Reliable.
- Rechargeable battery systems.
- Low maintenance requirements.

- **Disadvantages of Lead Acid Battery**

- Low energy density.
- Limited number of full discharge cycles.
- Environmentally unfriendly.
- Taking 12hr-16hr to recharge by standard outlet (110v).

Lithium-ion battery

Varta Lithium-ion battery, Museum Autovision, Altlußheim, Germany

Energy/weight	100-160 Wh/kg[1]
Energy/size	250-360 Wh/L[1]
Power/weight	~250-~340 W/kg[2]
Charge/discharge efficiency	80-90%[3]
Energy/consumer-price	**2.8-5** Wh/US$[4]
Self-discharge rate	5%-10%/month
Time durability	(24-36) months
Cycle durability	~1200 cycles *[citation needed]*
Nominal Cell Voltage	3.6 / 3.7 V

Lithium Ion Battery Reactions

- Chemical Reactions for charge & Discharge

Positive Electrode

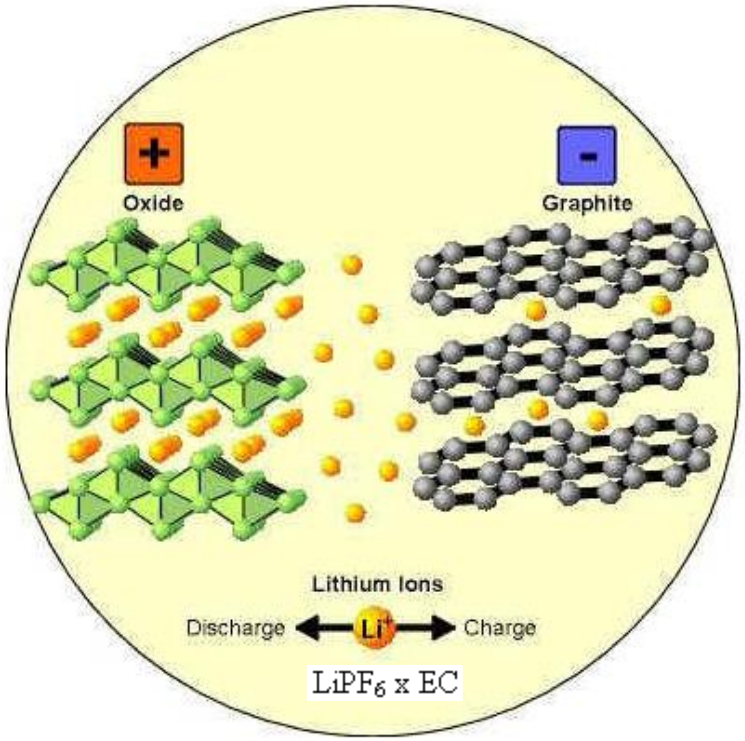
$$LiCoO_2 \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} Li_{1-x}\ CoO_2 + xLi^+ + xe^-$$

Negative Electrode

$$C + xLi^+ + xe^- \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} CLix$$

Battery as a Whole

$$LiCoO_2 + C \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} Li_{1-x}\ CoO_2 + CLix$$



Advantages & Disadvantages of Lithium Ion Battery

- **Advantages of Lithium Ion Battery**

- Higher energy density.
- Operate at higher voltages than other rechargeable.
- Lower self discharge rate than other rechargeable.
- Low Maintenance - no periodic discharge is needed; there is no memory.
- Specialty cells can provide very high current to applications such as power tools.

- **Disadvantages of Lithium Ion Battery**

- More expensive than other rechargeable ($10,000/battery).
- Lithium Ion Batteries are not available in standard cell size.
- Damage due to overcharging or undercharging.
- Highway speed, max 70 mph, taking 8 hours to complete recharge

Lead Acid vs Lithium Ion

Lead-acid battery

lead acid car battery

Energy/weight	30-40 Wh/kg
Energy/size	60-75 Wh/L
Power/weight	180 W/kg
Charge/discharge efficiency	50%-92% [1]
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Lithium-ion battery

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Self-discharge rate	5%-10%/month
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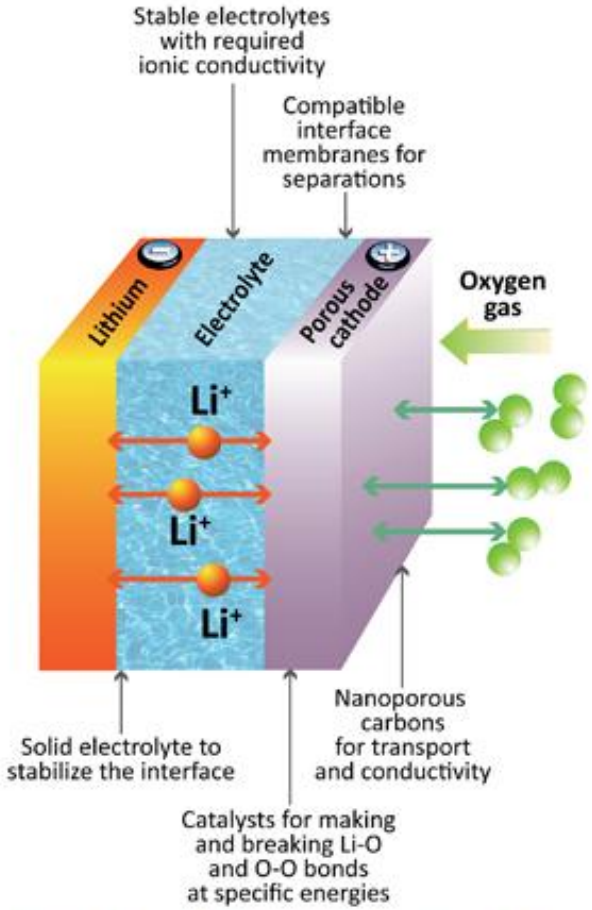
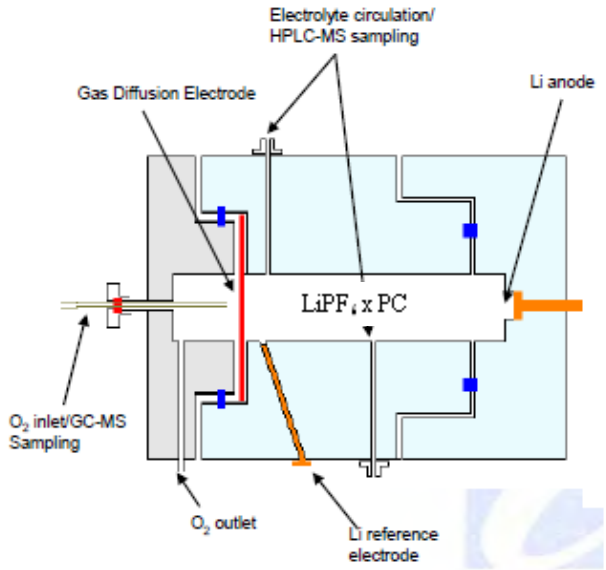
Lithium Air Battery Reactions



Li-air batteries hold the promise of increasing the energy density of Li-ion batteries by as much as five to 10 times. But that potential will not be realized until critical scientific challenges have been addressed.



Electrochemical cell for Li-air cell

The possible discharge cell reactions are:

$$2Li + O_2 \longrightarrow Li_2O_2 \qquad (Eo = 3.1\ V)$$

$$4Li + O_2 \longrightarrow 2Li_2O \qquad (Eo = 2.91\ V)$$

Advantages & Disadvantages of Lithium Air Battery

- **Advantages of Lithium Air Battery**

- Ten folds increase in energy capacity compared to lithium ion battery cell.
- Operate at higher voltages than other rechargeable.
- Lower self discharge rate than other rechargeable.
- Low maintenance requirements.

- **Disadvantages of Lithium Air Battery**

- It is easy to explode in contact with water.
- More expensive than other rechargeable.

Advantages & Disadvantages

- **Advantages of the electric car**
- Zero emission vehicle
- Lower cost of fuel (43 miles/dollar)
- Rechargeable batteries are recycle well
- Smooth running, No vibration
- Less maintenance
- **Disadvantages of the electric car**
- Takes time to charge battery (several hours)
- Low speed (max speed, 70 mph)
- Heavy battery (Lithium battery is 1000 pounds)
- Costly to replace new battery ($10,000/battery)

Electric Cars

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Green Technology