

Lithium-Ion Batteries: A Clean Source of Energy?

Barbara: Hi, Regis. Do you know what allows us to talk to our friends, stay in touch with the world, and save petroleum resources? Well, it's right there on the periodic table, element number 3.

Regis: You are right. Lithium (Li) is the major component of modern batteries. It powers our computers, iPods, cameras, electronic games, and hybrid (gasoline-electric) cars. I wonder if it is truly a clean energy source. Let's open this up for discussion.

B: The unique properties of this element make it just what we need to power tiny cell phones and electric cars. Lithium, with the lowest density of any solid element, can pack three times more energy per pound than older batteries.

What is involved in obtaining the pure element?

R: Lithium, like other alkali metals,

is too reactive to exist as a pure metal in nature. It is found combined in various minerals and in brine deposits that contain mostly salt. Lithium can be extracted by evaporating salty pools filled by rivers that have washed over lithium-containing rocks. As the water evaporates, the lithium crystallizes as ionic salts, usually lithium chloride and lithium carbonate.

As with other very active metals, pure lithium can be produced by electrolysis. In this process, an electric current is passed

through the molten lithium chloride to supply electrons to Li ions, reducing them to lithium metal and producing chlorine gas: $2\text{LiCl(s)} \rightarrow 2\text{Li(s)} + \text{Cl}_2\text{(g)}$.

Unfortunately, the mining and refining of lithium mars the landscape and produces wastes that could damage the environment, but since lithium atoms are light and can produce more energy per pound, less of the material is needed.

B: Another problem is that the majority of known lithium deposits are outside the United States. This may have some serious political implications. Some of the largest reserves are located in Bolivia, Chile, Australia, Argentina, and China. Does this mean that we will be dependent upon foreign sources? Will some of these countries become the next "Saudi Arabia of Lithium"? To address these questions, U.S. scientists and car manufacturers are looking at deposits within the United States.

R: Let's look at how lithium-ion batteries work. Compared to other batteries, they can store more energy for their size and weight and operate at a higher voltage and at a lower current than regular AA batteries. One Li cell can produce the same voltage as multiple AA cells. Lithium-ion batteries also have a lower self-discharge rate, so once they are charged they retain their charge longer. This is called having "high power density."

A lithium-ion battery operates using the process of oxidation-

reduction (Redox), in which one substance loses electrons (oxidation) to another substance that gains the electrons (reduction). By controlling the flow of these electrons, electricity is generated.

In a lithium-ion battery, the cathode (the place where reduction occurs) is generally made of lithium-cobalt oxide

(LiCoO_2), and the anode (where oxidation occurs) is coated with graphite (carbon).

A "separator" between the cathode and the anode allows ions to pass through. These components are submerged in a solution that conducts a current called electrolyte.

While the battery charges, the energy going in forces lithium ions to move through the electrolyte to the anode, where they attach to the carbon.

When the battery is in use, the lithium ions move back to the cathode, stranding electrons on the anode. These electrons must take the long way back through the circuit, creating an electrical current.

B: It is important to remember that the recharging of the batteries requires electricity produced by burning coal in power plants. This produces carbon dioxide (CO_2), a greenhouse gas, so using batteries is not completely emission-free.

R: I agree, but battery-operated cars have no direct emissions. Since electric cars are not burn-



ing gasoline, a fossil fuel, they do not directly produce CO_2 . And since they do not burn fossil fuels, they are not consuming a nonrenewable resource. This helps reduce our dependence on foreign oil.

B: Having said that, there are always environmental issues to consider, even in what is described as clean energy. Mining and refining lithium certainly have hidden environmental issues, ranging from destroying the landscape during the mining process to producing emissions during refining.

R: So, all energy has a cost. As we look to the future and scientifically evaluate new technologies, should we consider the actual "cleanliness" of each energy source? What do you think? Let us know by contacting us at: chemmatters@acs.org.

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