Research on Lithium Ion Battery Performance

Why in News

Researchers from IIT Guwahati have developed a technique to improve the performance of rechargeable lithium-ion batteries, which power most of the portable devices used today.

Key Points

- **Lithium Ion Batteries:**
  - **Development:**
    - The **2019 Nobel Prize in Chemistry** was jointly awarded to **Stanley Whittingham, John Goodenough and Akira Yoshino** for work that led to the development of **lithium-ion batteries.**
    - The **foundation of the lithium-ion (Li-ion) battery was laid during the oil crisis of the 1970s**, around which time Whittingham started working on developing methods that could lead to fossil fuel-free energy technologies.
    - The **first commercially viable Li-ion battery** was created by Yoshino **in 1985.**
  - **Utility:**
    - Li-ion batteries provide portable electricity, powering electronic gadgets such as mobile phones, laptops and tablets.
    - Today, most **Electrical Vehicles (EV) use Li-ion batteries** as well, but are slowly reaching their theoretical limits of being able to provide roughly up to **300-watt hour per kilogram** of energy.
    - These batteries can also be used to **store solar and wind power**, which means that with their widespread use it may even be possible to **live in a fuel free society.**
  - **Disadvantage:**
    - Some of the disadvantages of Li-ion batteries include their **susceptibility to overheating** and their **being prone to damage at high voltages.**
      - Since they are made with **flammable and combustible materials.**
    - Such batteries also start **losing their capacity over time**—for instance, a laptop battery in use for a few years does not function as well as a new one.
- **New Research:**
  - Researchers **from IIT Guwahati** have developed a technique which can **precisely estimate** one of the most important battery internal states known as **SOC, state of charge.**
  - **SOC reflects the remaining capacity of the battery**, that is how much more charge can be withdrawn from the battery before it gets fully discharged.
  - The knowledge of remaining capacity helps to optimize battery's capacity utilization, prevent overcharging and undercharging of the battery, **increases its lifespan, reduces cost, and ensures safety of the battery and its surroundings.**

- To improve a battery's lifespan and optimize its capacity, it is **important to predict its various states accurately. One of these states is the SOC**, which has so far been difficult to estimate.
- Through their work, the **researchers have proposed** an approach that avoids overestimation and therefore helps in **taking accurate measurements.**

State Of Charge

- The state of charge (SOC) of a cell denotes the capacity that is currently available as a function of the rated capacity.
- The value of the SOC varies between 0% and 100%. If the SOC is 100%, then the cell is said to be fully charged, whereas a SOC of 0% indicates that the cell is completely discharged.
- In practical applications, the SOC is not allowed to go beyond 50% and therefore the cell is recharged when the SOC reaches 50%.
- Similarly, as a cell starts aging, the maximum SOC starts decreasing. This means that for an aged cell, a 100% SOC would be equivalent to a 75%–80% SOC of a new cell.

- **Related Developments:**
  - The **Johns Hopkins Applied Physics Laboratory** developed **a Lithium-ion battery that does not catch fire.**
  - Earlier in January 2020, researchers from **Australia** claimed that they developed the world's most efficient **lithium-sulfur (Li-S) battery**, capable of powering a smartphone for five continuous days.
    - While the materials used in the **Li-S batteries** are not different from those in **Li-ion batteries**, the Australian researchers **reconfigured the design of the sulfur cathodes** (a type of electrical conductor through which electrons move) to accommodate higher stress without a drop in overall capacity.
  - India, through a newly-floated state-owned company **Khanij Bidesh India Ltd**, has **inked a pact with an Argentine firm** to jointly prospect lithium in Argentina, a country that has the one of the largest reserves of Lithium in the world.
- **Potential Alternatives to Li-ion Technology:**
  - **Lithium-Sulfur Batteries:**
    - **Li-S batteries** are generally considered **the successors of Li-ion batteries** because of their **lower cost of production, energy efficiency and improved safety.**
      - Their cost of production is lower because sulfur is abundantly available.
    - Even so, there have been some difficulties when it comes to commercialising these batteries, mainly **due to their short life cycle** and poor **instantaneous power capabilities.**
  - **Graphene Batteries:**
    - Graphene batteries may be an important alternative to lithium-ion batteries, with the latter having limitations due to the frequency with which lithium requires charging. Graphene is a newly stabilized and isolated material.
  - **Fluoride Batteries:**
    - Fluoride Batteries have the potential to last eight times longer than lithium batteries.
  - **Sand Battery:**
    - This alternative type of lithium-ion battery **uses silicon** to achieve three times better performance than current graphite Li-ion batteries. The battery is still lithium-ion like the one found in a smartphone, but it uses silicon instead of graphite in the

anodes.

- **Ammonia-powered Batteries:**
    - Ammonia-powered batteries may not be coming any time soon, but the chemical commonly known as a household cleaner is still an alternative to lithium in the way it can power fuel cells in vehicles and other equipment.
    - If scientists can figure out a way to produce ammonia without creating the greenhouse gas emissions that result right now, they can ship it anywhere in the world to be converted into hydrogen to power those fuel cells.
- **Vertically Aligned Carbon Nanotube Electrode:**
    - These are good candidates for lithium-ion battery electrodes which require high rate capability and capacity.
- **Solid-state Batteries:**
    - It uses alternatives to aqueous electrolyte solutions, an innovation that could lower the risk of fires, sharply increase energy density and potentially take only 10 minutes to charge an EV, cutting the recharging time by two-thirds.
    - These cells can extend the driving distance of a compact electric vehicle while maintaining legroom - a quantum leap in battery tech.

Source: IE

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