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Preserving Battery Longevity

Discover the facts and debunk the myths about maximizing portable energy storage.

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Finding ways to improve the storage of electrical energy is currently one of the hottest topics in science. This drive stems primarily from the increasing demand for batteries in portable devices such as personal electronics (mobile phones, watches, tablets, or laptops), from the rising demand for electric vehicles, as well as from the growing ecological awareness of societies and the increasing push to make greater use of renewable energy sources like solar and wind power, tidal energy, etc. It is no wonder, therefore, that the market is awash with diverse types of new energy storage solutions.

Fundamentally, all batteries (more accurately termed *electrochemical cells*) generate energy by exploiting chemical reactions of oxidation and reduction. Some of these reactions are irreversible, meaning once the cell is depleted, it cannot be reused – these are known as *primary* or *single-use* cells, like the AA or AAA batteries familiar in everyday life. Some other cells are rechargeable – these are technically known as *accumulators*. Note that the size or shape of a cell does

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not determine whether it is rechargeable: for instance, there are some AA/AAA cells that are rechargeable. Each cell's type is usually indicated on its casing.

From the user's perspective, rechargeable cells are generally preferable because they can be reused multiple times. However, replacing single-use cells with rechargeable ones is not always cost-effective. For example, in traditional watches where the primary cell can last two years or more, switching to rechargeable cells might not be necessary. In contrast, today's smartwatches, which have numerous power-hungry features, essentially require rechargeable cells. The choice of cell depends on the device's functions and expected usage time.

A conspiracy theory

All batteries age. However, there is increasing speculation among the public that certain manufactured products, including batteries, are being purposefully designed by their manufacturers to age prematurely, in order to boost sales. Although from a chemical standpoint such manipulations could be attempted, due to safety concerns and the potential for triggering uncontrolled discharge processes, it is nevertheless clear that no reputable manufacturer engages in such practices. The mechanisms responsible for the aging of batteries – or more precisely, the loss of their operational properties – are the subject of extensive investigation. This research aims specifically to slow or minimize the rate of degradation. Factors like temperature, humidity, load type, and charging practices can significantly affect a battery's lifespan, and so careful and conscientious battery use can help prolong their "youth."

An electrochemical cell is a small chemical reactor where many processes occur. A fully charged cell, which stores energy, can be likened to a wound-up spring. At full charge, this reactor operates at full capacity, providing a sufficient amount of energy (often expressed in watt-hours, *Wh*), and the voltage (expressed in volts, *V*) reaches its maximum value. Drawing energy from the cell naturally decreases the voltage (similar to what happens with a gradually unwinding spring). The first step towards ensuring that this reactor operates for a long time and efficiently is to avoid charging it fully when doing so is unnecessary. In this regard, manufacturers sometimes recommend charging a cell to a specified voltage if it

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will not be used for some time. This is also a common practice for cells used in laptops when operating on mains power, and it applies universally to most cells during storage.

Proper temperature

What else can be done to prolong the lifespan of power cells? Remember that their operation is based on specific chemical reactions, which have preferences regarding both operating temperature and conditions for charging and discharging. As concerns temperature, it is important to note that low temperatures usually harm batteries – cells should never be deliberately frozen. One can sometimes encounter theories advocating that freezing batteries can "repair" them due to alleged electrode material recrystallization, but apart from certain exceptions, these theories are unfounded and can even lead to dangerous and irreversible changes in the cell.

High temperatures are equally harmful – while a phone battery may seem to operate longer in summer, this is generally the result of multiple factors. In widely used lithium-ion cells (and their derivatives), the maximum safe operating temperature is no more than 60°C – above this value, dangerous reactions can occur, potentially leading to cell explosion. Therefore, on hot days, devices powered by such cells should be shielded from direct sunlight and generally kept away from any heat sources. The safe operating temperature for cells with aqueous electrolyte is slightly higher, theoretically not exceeding 100°C, as above this temperature, electrolyte evaporation, increasing inner pressure, and explosion can occur. Naturally, devices designed to operate at higher temperatures are equipped with special cells able to endure such conditions safely.

Proper charging

When it comes to extending cell longevity, the most crucial issues are proper charging and usage conditions. Energy accumulation in a cell involves specific chemical reactions, which are limited by both reaction kinetics and mass transport. This means that effective charging requires sufficient time and a current of specified intensity. These parameters are usually strictly defined, and manufacturers specify that the properties of the supplied cell are guaranteed only under these conditions. Cells should be charged using original chargers or with as low a current as possible. So-called fast charging may be suitable occasionally, but it should not be used in ordinary, daily charging practice. Why? Chemical reactions proceed at a certain rate, and forcing them with high current intensity causes the cell to convert energy into heat rather than store it, essentially making it work like an iron. Each time a charging cell heats up, this indicates that some energy is being lost as heat and so will not be stored, hence the charging process is too aggressive. Incidental fast charging is unlikely to destroy a battery, but it certainly has a negative impact on its longevity.

Today's power cells are equipped with numerous electronic safeguards that simply halt the charging process if the current exceeds safe limits, but these mechanisms can be unreliable, and an overheating battery can cause irreversible changes in its operation, posing a serious risk to the user.

It is also worth remembering that a battery is a working chemical reactor – in this sense, one should also prioritize personal safety. A cell that is being charged should not be left unattended – just as one would not leave unattended a kettle on a gas burner or an open faucet when filling a bathtub. Of course, many electronic safeguards used in batteries and personal devices today have significantly reduced the number of incidents related to battery overcharging, but unexpected changes (e.g., frequently carrying a phone in one's back pocket, exposing it to unnecessary mechanical stress) can sometimes occur too quickly for these protective mechanisms to kick in.

The quest for new energy storage materials is a fascinating scientific endeavor. While we haven't yet achieved eternal battery life, we have made significant strides in understanding and improving their longevity and efficiency. By adhering to best practices in charging and usage, and by continuing to explore advanced materials and technologies, we can ensure that our batteries will increasingly last longer and perform better. ■

Further reading:

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