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A Review on Different Types of Lithium Batteries and Their Impact on Enviroment

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ABSTRACT
As the globe accelerates its technological developments and moves closer to an industrial revolution, there is an increasing need for portable, environmentally friendly energy sources for a wide range of applications. Everyday devices are all around us, and they either require energy to operate continuously or something to store the energy so that it may be used on-the-go. A popular subject among researchers is the development of batteries and ongoing studies to improve the electrochemical performance of current battery chemistries. It became clear that Li-ion batteries were the most dependable and appropriate energy-storage technology. These have a range of uses, from tiny ones like smart phones to larger ones like electric cars. With a lower electrochemical potential of −3.04 V compared to a normal hydrogen electrode, Li metal anodes are an appealing option because to their highest theoretical capacity, lightweight design, high energy density, and numerous other attributes. When using advanced batteries in larger applications, they must meet certain requirements, such as being able to store more energy, taking up less space, and having improved cycle and rate capability. Currently, scientists are searching for substitute materials for the anode and cathode. A range of anode chemistries have been studied, together with diverse structural cathode materials. The ten-fold greater specific capacity of silicon additive anodes makes them a viable replacement for conventional graphite anode material. The many types of lithium batteries, electrical cars, and their effects on the environment are reviewed in this paper. In order to gain insight into the material's efficiency as well as the numerous obstacles and possible paths for future research in the development of anode materials for Li-ion batteries, a comparison of the material with several metal-ions batteries is also presented. The possible effects of utilizing electric car batteries for energy storage in the context of an energy system are investigated in this research.

Keywords: lithium battery, types of lithium battery, environmental impact of lithium batteries.

I. INTRODUCTION

The improvements in technology that surround us have a significant impact on us. Since most tasks are now completed using devices, there will be a greater need for energy in the future as a result of the majority of tasks being completed with these devices. Furthermore, in order to continue using these technologies smoothly and effectively for a long time to come, we will need dependable energy sources. As a result of our continued reliance on non-renewable energy sources including natural gas, fossil fuels nuclear power, and crude oil, black carbon is produced as a byproduct that endangers human health and the environment [1].

As the offspring of our forebears, we must devise strategies to get past these issues. Numerous renewable energy sources, including wind, solar, hydropower, and many more, are now in use. More focus should be placed on the issue of energy storage, which is necessary for a steady flow of electricity. Electric automobiles, culinary appliances, digital device charging, and other everyday uses for electrical appliances are driving up the number of new products entering the market. Energy storage systems are desperately needed right now so that energy can be stored for later, more extensive use.

It is impressive to see that Li-ion batteries represent a key component of the majority of commercial batteries on the market. The lead-acid battery is the source of history, yet it is unreliable, heavy, and large [2]. Scientists are encouraged to continue their study in order to identify better materials with enhanced features such as volumetric capacity (VCC), specific capacity

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(SCC), energy density (Ed), power density (Pd), etc.

By the fundamental understanding of the chemistry of Li ions batteries.

Today's commercialized Li-ion batteries are helpful, but they are not dependable enough to provide us with long-term results due to a number of concerns, such as low electrochemical parameter values (e.g., VCO, VCI, VSH, coulombic efficiency, rate capacity, removable ability, shelf life, etc.) [3]. Li-ion battery applications in energy storage will contribute to the expansion of the electrical device and automobile markets. Researchers are gravitating toward studying Li-ion batteries to further improve their properties due to its appealing qualities, which include high theoretical capacity (δ), lightweight, cyclic stability (CC), and high $\mathbf{D}D$. Different lithium ion battery chemistries have been tested, such as Li-iron phosphate (LFP), Li-manganese oxide (LMO), Li-titanate oxide (LTO), Li-cobalt oxide (LCO), Li-nickel cobalt aluminium (NCA), Li-nickel manganese cobalt (NMC), etc. The chemistries are known by different names. Of these Li-ion batteries, LCO is the most widely used and produced [4].

Several approaches have demonstrated improved outcomes to raise SC, such as creating 1D, 2D, and 3D material structures that can endure chemical changes that occur while the system is operating.

In order to combat the climate catastrophe, the US developed a clean and just energy economy. According to their plan, net-zero emissions must be reached by 2050 and carbon-pollution-free electricity must be produced by 2035 [4]. As compared to the US spending 120 billion dollars, China's energy transformation investments reached a peak of 297 billion dollars in 2021 [5].

Stakeholders need to find alternatives for essential resources, gain access to raw and refined commodities, and incorporate recycled materials into the circular economy in order to have a piece of this significant market [6]. It is important to stress that the effect on the environment is primarily dependent on where the electricity used to charge the battery comes from. According to well-to-wheels (WTW) studies, battery electric vehicles (BEVs) that run on electricity from nuclear power plants or energy from renewable sources perform better environmentally [7].

LITHIUM BATTERIES

The lithium battery that can be recharged was developed by numerous researchers. At the start of 1970, the first lithium battery made using Li/Li+/Lix TiS2 technology was quickly taken off the market because lithium dendrites formed and caused the cell to short circuit. In 1991, after twenty years, stony correlation introduced a new type of lithium batteries called Li ions batteries (Lix C6/Li-x co2). Lithium ion batteries are currently largely produced in large quantities by Japanese manufacturers.

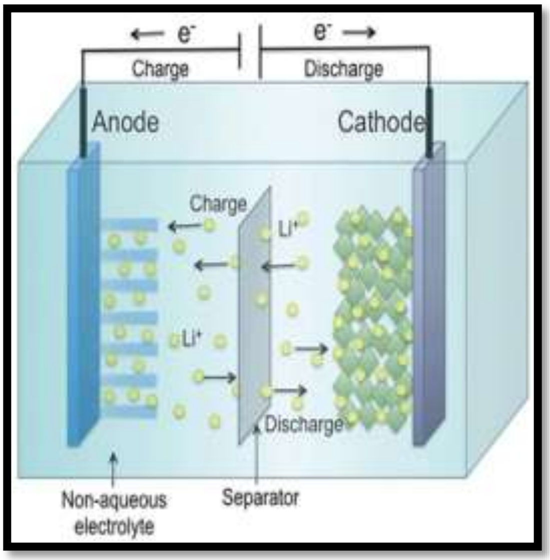

Figure 1. Lithium batteries

Li-ion batteries are the preferred technology for power tools, portable devices, and hybrid and fully electric cars due to their exceptional energy and power density [1]. Li-ion batteries will dramatically lower greenhouse gas emissions if most gasoline-powered transportation is replaced by electric vehicles (EVs) [8]. Because of Liion batteries' exceptional energy efficiency, they may be used in a variety of electric grid applications, such as enhancing the quality of energy obtained from renewable sources like solar, wind, and geothermal energy. This would encourage the use of Liion batteries more widely and help to create an economy that is energy-sustainable. As a result, Li-ion batteries have drawn a great deal of attention from financing organizations in the business and government, and there has been a lot of study in this area recently. As Li-ion batteries are the preferred option for portable electrochemical energy storage, increasing their efficiency and cost-effectiveness will enable new energy-storage-dependent technologies and significantly increase the range of applications for these batteries. Electrode materials have been the focus of a significant amount of Li-ion battery research to date. Li batteries can have higher energy and power densities, be smaller and less

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expensive, and have higher rate capability, higher charge capacity, and (for cathodes) a sufficiently high voltage when their electrodes are optimized. This is only true, though, if the material in question isn't extremely scarce or costly.

THE TYPES OF LITHIUM-ION BATTERIES

- Lithium iron phosphate (LFP) LFP batteries are the best types of batteries for ESS. ...
- Lithium Nickel Manganese Cobalt (NMC) ...
- Lithium Nickel Cobalt Aluminum Oxide (NCA) ...
- Lithium-Ion Manganese Oxide (LMO) ...
- Lithium-Ion Cobalt Oxide (LCO) ...
- Lithium Titanate Oxide (LTO

1. LITHIUM COBALT OXIDE($LiCoO_2$) — LCO

Its high specific energy makes Li- cobalt the popular choice for mobile phones, laptop and igital cameras. The battery consists of a cobalt oxide cathode and a graphite carbon anode. The cathode has a layered structure and during discharge, lithium ions moves from anode to the cathode. The flow reverses on charge. The drawback of Li- cobalt is a relatively short life spam, low thermal stability and limited load capabilities (specific power). Figure 2 illustrates the strucute.

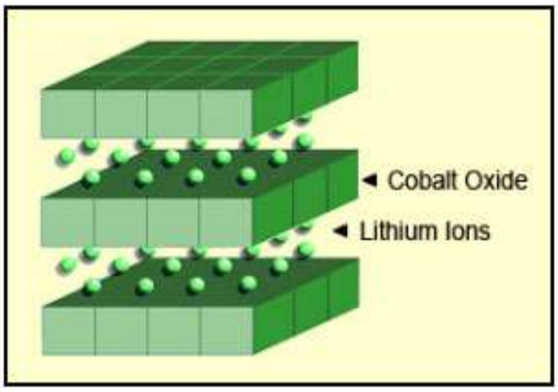

Figure 2: Li-cobalt structure

The drawback of Li-cobalt is a relatively short life span, low thermal stability and limited load capabilities (specific power). Like other cobalt-blended Li-ion, Li-cobalt has a graphite anode that limits the cycle life by a changing solid electrolyte interface (SEI), thickening on the anode and lithium plating while fast charging and charging at low temperature. Newer systems include nickel, manganese and/or aluminum to improve longevity, loading capabilities and cost. Li-cobalt should not be charged and discharged at a current higher than its C-rating. This means that an 18650 cell with 2,400mAh can only be charged and discharged at 2,400mA. Forcing a fast charge or applying a load higher than 2,400mA causes overheating and undue stress. For optimal fast charge, the manufacturer recommends a C-rate of 0.8C or about 2,000mA. (See BU-402: What is C-rate). The mandatory battery protection circuit limits the charge and discharge rate to a safe level of about 1C for the Energy Cell.

2. Lithium Nickel Manganese Cobalt Oxides

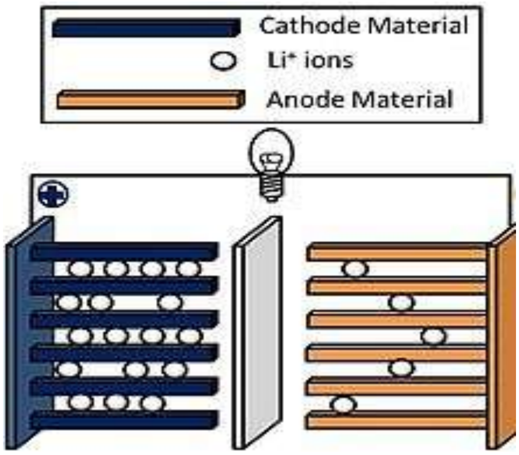

Figure 3: lithium nickel manganese cobalt oxides battery

Often used as the positively charged cathode in lithium-ion batteries for mobile devices and electric vehicles, lithium nickel manganese cobalt oxides (abbreviated NMC, Li-NMC, LNMC, or NCM) are mixed metal oxides of lithium, nickel, manganese, and cobalt with the general formula LiNixMnyCo1-x-yO2. An overall illustration of a lithium-ion battery. During charging and discharging, lithium ions intercalate into the cathode or anode. Because of the material's high energy density and operating voltage, optimizing NMC is especially important for electric vehicle applications. Reducing the cobalt content in NMC is also a current goal because of the moral dilemmas associated with cobalt mining and the high cost of the metal. [1] Additionally, higher nickel content offers more capacity within the stable operation window. [2]

3. LITHIUM IRON PHOSPHATE (LFP OR LIFEPO4)

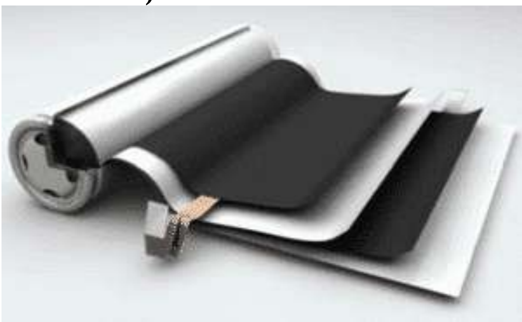

Figure 4: lithium iron phosphate battery

Since its introduction in 1996, Lithium Ferro Phosphate (LFP or LiFePO4) technology has replaced other battery technologies due to its many technical benefits and extremely high level of safety. This technology is used in heavy-duty traction applications (marine traction, industrial vehicles, etc.) or medium-power traction applications (robotics, AGV, E-mobility, last mile delivery, etc.) because of its high power density.

LiFePO4 can be used in energy storage applications (stand-alone applications, Off-Grid systems, self-consumption with batteries, and stationary storage in general) due to the extended service life of the LFP and the capability of deep cycling.

Major advantages of Lithium Iron Phosphate:

• Very safe and secure technology (No Thermal Runaway)
• extremely low environmental toxicity (from iron, graphite, and phosphate use)
• Lifespan on calendar > 10 years
• Cycle life: from several thousand to 2000 (see chart below)
Up to 70°C is the operational temperature range. Very low internal resistance. Stability or even a downturn over time.
• Easy recycling; • Power that remains constant throughout the discharge range

4. Lithium Nickel-Cobalt-Aluminum Oxide (NCA)

Most lithium ion secondary batteries are made of lithium nickel-cobalt-aluminum oxide (NCA), which is primarily utilized in electric vehicles. Owing to the company's high nickel content in its Lithium Nickel-Cobalt-Aluminum Oxide (NCA) products, batteries have a greater capacity, which extends the amount of distance that can be covered between charges. The company's comprehensive production process, which starts with nickel raw material and ends with battery material, is its main strength.

5. LITHIUM TINTATE BATTERIES

The lithium-titanate, also known as lithium-titanium-oxide (LTO) battery, is a form of rechargeable battery that has a lower energy density than other lithium-ion batteries but has the advantage of charging more quickly [8].

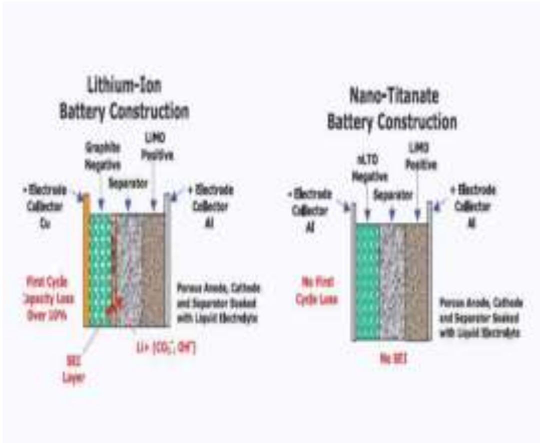

Figure 5: lithium tintate battery

The technology known as lithium titanium oxide (LTO) batteries has several benefits, and it is revolutionizing the battery industry as a whole. The LTO is opening up new avenues for energy storage with a variety of financial and environmental benefits. Essentially, the Lithium-Ion (li-ion) battery technology serves as the foundation for the LTO, which is a rechargeable battery that has undergone modifications. In the anode of a standard Li-Ion battery, graphite is swapped out for lithium titanate oxide (LTO), which crystallizes the materials into a spinel three-dimensional structure. It discharges a high current that is ten times the capacity of other types of lithium batteries, with a nominal cell voltage of 2.40V. Lithium Titanate uses lithium-titanate nanocrystals on its surface as opposed to conventional lithium batteries' use of carbon particles.

6. A LITHIUM ION MANGANESE OXIDE BATTERY (LMO)

A lithium-ion cell that employs manganese dioxide as its cathode material is known as a lithium-ion manganese oxide battery (LMO). They operate using the same intercalation/de-intercalation process as other secondary battery technologies that are commercially available, like $LiCoO_2$.Inexpensive, non-toxic, readily available, and offering superior thermal stability are cathodes utilizing manganese oxide components [9].

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Advantages

As well as having a high working voltage and energy output, LMO batteries are renowned for their quick charging and discharging times. In addition, their strong thermal stability lowers the possibility of overheating and improves safety measures.

LMO batteries are also reasonably priced since manganese, the primary component, is comparatively cheap.

Disadvantages and Limitations

A few disadvantages of LMO batteries include that their capacity fades quickly due to the loss of electrical contacts between the nanoparticles and the current collector.

Furthermore, their potential for large-scale energy storage may be hindered by their potential lower energy density in comparison to specific lithium-ion chemistries.

LMO batteries have a fair degree of thermal stability, yet they can still be vulnerable to high temperatures.

USE OF LITHIUM-ION BATTERIES IN ELECTRIC VEHICLES

For usage in high-performance electric vehicles, lithium-ion (Li-ion) batteries offer a compelling option. Li-ion batteries have a very high specific energy and a high number of charge-discharge cycles when compared to other rechargeable batteries. It's also reasonably priced. Li-ion batteries are therefore the better option compared to other technologies like nickel-metal hydroxide and silver-zinc. But at the moment, Li-ion batteries are limited to tiny sizes in the commercial market. Consequently, in order to obtain the requisite battery sizes, a significant number of cells must be assembled in series/parallel arrangements. Making extremely dependable and efficient battery packs for use in electric vehicles is a difficulty brought on by safety concerns as well as this.

THE ENVIRONMENTAL IMPACT OF LITHIUM-ION BATTERIES

Materials including nickel, copper, and lead that have the potential to be harmful are found in lithium batteries. When batteries are kept improperly, they might explode, which can be disastrous for the environment. On the other hand, lithium-ion battery trash is an important resource. Since Li-ion battery components are hard to find and scarce, their availability is crucial in the modern world. All of the components in Li-ion batteries can be recovered through recycling. Because electric vehicles are thought to produce fewer greenhouse gases than gasoline-powered automobiles, the green movement is pushing electric vehicles on the American people. Nevertheless, the lithium-ion batteries used in electric vehicles have problems with greenhouse gas emissions both during the extraction and processing of the raw materials and during the batteries' eventual disposal. As the sales of electric vehicles rise, so do the challenges associated with mining and disposal.

The proposed car regulations and purchasing incentives included in the Inflation Reduction Act, popularly known as the "climate bill," are forcing the people to buy electric vehicles in the United States. As more and more electric vehicles are driven on the roads of the globe, there is growing concern over the environmental impact of producing lithium-ion batteries, which power electric vehicles, which emit more carbon dioxide during production than gasoline-powered cars do. Additionally, the disposal of these batteries after their useful lives is a problem. The mining and processing of the necessary minerals accounts for about 40% of the climatic effect associated with the production of lithium-ion batteries. Significant amounts of energy are needed for the mining, refining, and manufacture of battery components, which results in the emission of greenhouse gases during the production of cells, modules, and battery packs. Nearly 60% of China's electricity comes from coal, a fuel that emits a lot of greenhouse gases. China is the country that leads the global EV battery production chain. The Wall Street Journal claims that the mining and manufacturing of lithium-ion batteries has a greater negative impact on the environment than that of fossil fuel-powered car batteries. It takes three times as much cumulative energy demand (CED) to produce an average lithium-ion battery as it does an ordinary battery.

Figure 6: Environmental Impacts of Lithium-ion Batteries

Renewable energy sources like sun, wind, tidal currents, biofuels, and hydropower can all be stored as energy in lithium-ion batteries. When we use renewable energy, we acquire our fuel from naturally replenishing sources, which emits fewer greenhouse gases than fossil fuels, for our homes and communities. When natural disasters pose a threat to the power supply, stored energy, similar to that found in battery systems, can prove advantageous. Reserving energy in transportable containers makes us more resilient, enabling us to bounce back from adversity like natural disasters. Similar to battery systems, stored energy can be helpful in the event of emergencies that endanger the power supply. Our ability to bounce back from adversity, like natural disasters, is enhanced when we have stored energy in portable containers.

II. CONCLUSION

The results show that using an electric vehicle battery for energy storage through battery swapping can help decrease investigated environmental impacts; a further reduction can be achieved by using retired electric vehicle batteries. Using an electric vehicle battery for energy storage through a vehicle to grid mechanism has the potential to reduce environmental impacts if the impact of cycle degradation is minimal compared with calendar degradation. Natural resource extraction, processing, and battery manufacture are energy-intensive processes that require three times as much energy as internal combustion vehicle batteries. These techniques are needed to produce the batteries for electric vehicles. Moreover, batteries that have reached the end of their useful lives are typically disposed of as e-waste in landfills, where they may leak dangerous compounds into the ground and ignite big fires that are very challenging to put out because of the quantity of combustible waste they are mixed with. Governments are working to recycle batteries, but the process is costly because battery designs are not standardized and they are challenging to disassemble.

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