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Review of Challenges in Various Electric Vehicle Batteries

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Abstract - *Electric vehicle batteries had become very privileged nowadays our world is moving towards a green environment. The lithium-ion battery (Li-IB) currently rules the EV market but the dark side of a lithium-ion is not so popular, to make Li-IB material needed nickel and cobalt which are the most toxic materials and those batteries also explode as the temperature crosses 40-45 degrees Celsius, with Li-IB world is not heading towards a so-called green revolution. To overcome the disadvantages of Li-IB many researchers and scientists have developed alternative batteries for Li-IB. In this review paper, different battery types are discussed with their challenges and how to enhance the performance of electric vehicle batteries.*

Key Words: Electric vehicle, green environment, lithium-ion, explode, nickel and cobalt, temperature.

1. INTRODUCTION

The ultimatum for battery and clean energy has pursued the evolution in the world of electric vehicles. The lithium-ion is ruling the battery market and is growing on a large scale, there is an extensive application of Li-IB with further demand. All-electric vehicle present today (the year 2022) is powered by a Li-IB. However, many questions arise about Li-IB like they are harmful to our environment and expensive because of their rare presence. Whereas, Li-IB uses harmful components such as nickel and cobalt which cannot be decomposed or recycled. To overcome most problems of Li-IB researchers and scientists are discovering different resources which could replace lithium-ion batteries, the most prominent and efficient replacement could be sodium-ion batteries (NA-IB) because of affordability, the long-life cycle can be easily recycled and sodium is found in all over the world. Although NA-IB also have major disadvantages like low energy density, NA-IB is heftier than Li-IB. Li-IB have Ultra-Fast charging technology up to 5C, which is not the same as the charging time of Na-IB.

As well as researchers are also seeing enough opportunity in lithium iron phosphate (LiFePO4) batteries to replace current lithium-ion batteries. Lithium iron phosphate batteries have more life cycle and are safer than lithium-ion batteries. LiFePO4 is low cost, has stable thermal and chemical chemistry, good energy density, and no thermal. Lithium-ion batteries are harming our environment through their toxic component and are too costly due to there is specific location for mining lithium and rare components. But, lithium-ion batteries are more efficient and more powerful. Whereas Na-IB and lithium iron phosphate are good for the environment and are low cost, they are not as efficient as lithium-ion batteries due to less research.

2. CHALLENGES OF LITHIUM-ION BATTERY

Li-IB are famously used in mobile phones, laptops, and computers. Li-IB first started in the 1990s as a result of thorough research and the offering of many scientists and engineers. In the endeavour of developing and improving the performance of Li-IB with the increasing demand for energy storage, for electric vehicles, escalate research is required for better and non-toxic Li-IB which will improve performances, including specific energy, life cycle, and protection from heat. There are many further improvements to be made in Li-IB for superior performance.

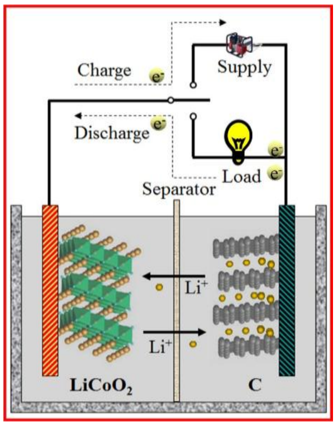

Figure 2.1 (Li-ion Construction) [1]

The Li-IB is made by connecting Lithium-ion cells parallel or in series figure 2.1 show the detailed construction of a Lithium-ion battery. Multiple battery cells can be put together. A Li-IB have cathode and anode as their positive and negative electrode respectively. Both anode and cathode are differentiated by separator [1].

Li-IB is currently being produced in million per month and it replaces the heavy nickel-cadmium and nickel-metal hydride batteries in, such as mobiles and computers [10].

It is important to note that when Li-IB is fully charged, combustible lithium negative materials pose the greatest safety hazards [9].

When 24-volt life cycle tests were done on ten cells held in series at 4C and at a discharge rate of C/2 then it had minor degradation in Amp-hours capacity for 1000 cycles [8].

The challenge is to evolve a new battery to supplant today's Li-IB. The most famous lithium phosphate battery has minimum capacity. The challenge is to make minimum carbon electrode materials [1].

The cost of a Li-IB pack for EVs is Rs.50, 000. The price of Li-IB is expensive and also the performance of Li-IB degrades at a higher temp as well, charging at minimum temp is not a safe decision. So, to safeguard the circuits protection is used and these protective circuits add weight which minimizes the energy density. Figure 2.3 the energy densities of various batteries and neatly shows the advantages of Li-IB over others. Li-IB has more energy density but they have disadvantages of low recharge ability and risk of fire or explosion [1].

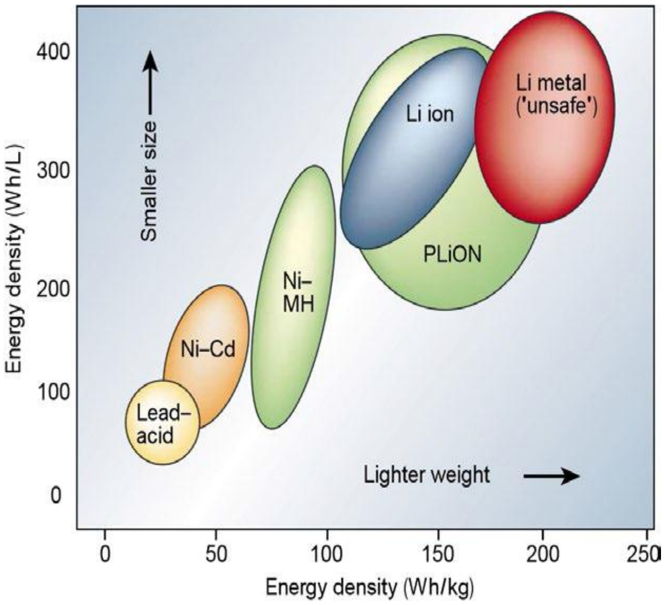

Figure 2.3 (Comparison of various batteries) [1]

3. CHALLENGES AND MATERIALS OF NA-IB

Na-IB is famous for its ample resources at minimal cost, Na-IB is promising subsequent technology electricity garage structures for large-scale packages, which include smart grids and minimum-velocity electric-powered automobiles. Li-IB had caused many to combust we know that being safe should be the first priority. The main cause of the fire is temperature and heat as Lithium-ion batteries cannot tolerate temperature above 40 degrees Celsius whereas, Na-IB can stay calm till 60 degrees Celsius [2].

Having a huge abundance and minimal price of Na-IB, it additionally has comparable electrochemistry to Li-IB. Figure 3.1 shows the construction of a Sodium battery where its chemistry is similar to a Li-IB, Na-IB has influenced considerable people. In the last 10 years, though extraordinary efforts were made to encourage making Na-IB, notable research has been made, and other development is required for energy-enhancing, power density, and more cycle life [3].

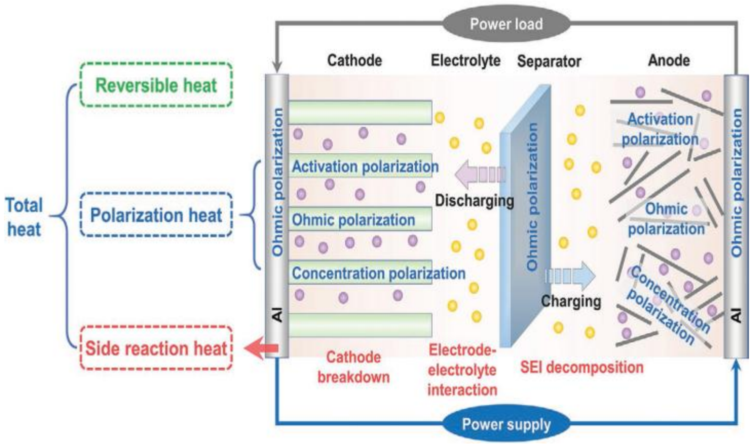

Figure 3.1 (Construction of a Sodium battery) [2]

The cathode material of a Na-IB determines the energy density of a battery, developing cathode materials is the key challenge for making more energy in Na-IB. Many substances had given brilliant storage capacity because of their acceptable structure. The sodium storage for Sodium-ion is indistinguishable from that of Li-IB [3].

As shown in figure 3.2 construction of Na-IB consists of heaped transition metals with Na as '+' whereas carbon being '-'. When charging ions moves from '+' to '-' [5]

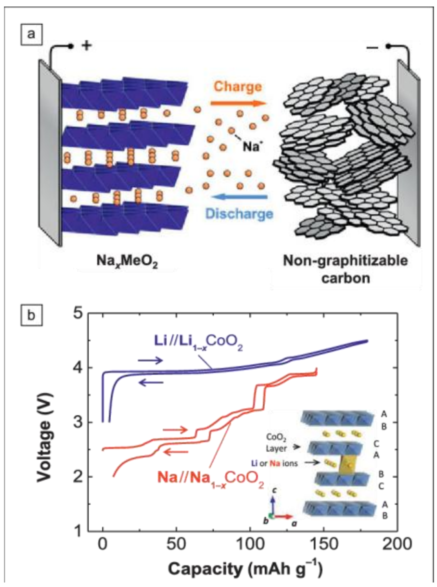

Fig.3.2

(Na-IB with a heaped transition having metal oxide as '+' and carbonaceous material as '-') [5]

More existence and minimal cost of Na have made him a good exchange to Li-IB. Scientist has given us many Sodium chemistries which were suitable for Na-IB. Some Sodium substances with the same structure as Lithium are electrochemically active where the latter has not. In the future scientists should work on '-' materials of Na-IB. The concern of an electron and additional supplements on solid electrolyte interface heaped formation can be determined properly. [5]

4. LITHIUM PHOSPHATE BATTERIES

Nowadays popular battery is Lithium iron phosphate (LiFePO4) where Lithium Phosphate is used as a Graphite carbon electrode with cathode material and metal substrate as an anode. Lithium iron phosphate batteries are popular in vehicles due to factors such as minimum cost, safer, minimum toxicity, and more life. LiFePO4 is popular in vehicles [6].

Suitable for EVs, HEVs, Bicycles, and heavy tools, it has become a very promising choice among phosphate-based cathode materials. It has a minimal cost, is less hazardous, and environmental friendliness set it apart. Lithium iron phosphate battery has great thermal and cyclic stability. Due to these properties, it attracts greater attention as a new cathode electrode material for lithium-ion batteries [13].

Figure 4.1 shows the advanced Li-IB with graphene Nano flake ink anode and iron phosphate lithium cathode. The battery is designed to stabilize the configuration of the cell and subdue the initial irreversible behaviour of the anode over a few cycles [6].

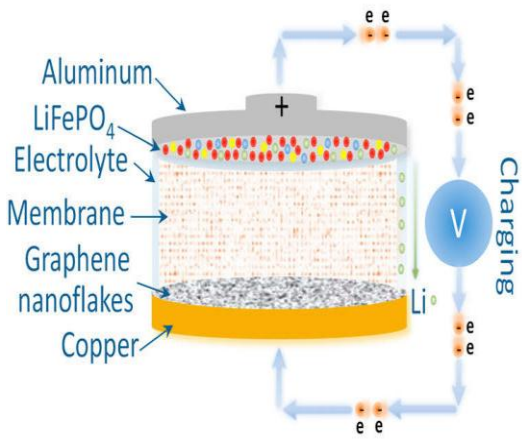

Figure 4.1(Construction of LiFePO4) [6]

Lithium phosphate is extremely safe as compared to Li-IB, also improves charge efficiency, and has a longer life span, and begin lightweight lithium phosphate is becoming a new option for electric vehicles. They have the ultimate edge on a lithium-ion battery that is lithium phosphate has zero maintenance.

Lithium iron phosphate batteries are thermally stable and their chemical properties are likely to be widely used in the future. Hence the circuit designers design a circuit with a battery model which predicts performance with high precision to control usage and enhance safety during use. [17]

Lithium iron phosphate batteries have a considerable reversible capacity of up to 3.5 Voltage and because of a small volume change of (6.8%), they have long cycle life. Because of their low inherent electron conductivity and minimum ion scattering rate of Lithium they do not reach up to their theoretical capacity.

LiFePO4 batteries are also distributed as a crystal olivine construction as shown in Fig 4.2

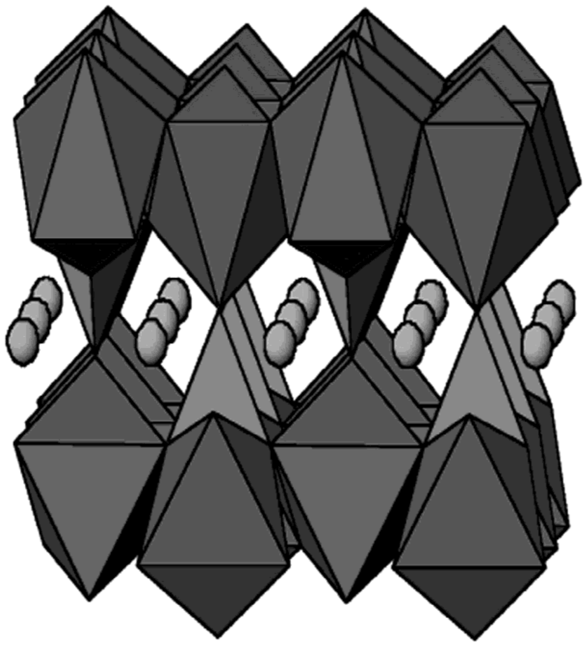

Fig 4.2 (3-D crystal structure of Li FePO4) [13]

Not all chemistry allows fast charging of Li-IB because it impairs battery function and boosts its continuous mechanism. But for the commercialization of EVs, quick charging methods will become a major thing. Reducing the timing for battery charging is an important factor [16].

5. NICKEL MANGANESE COBALT (NMC) BATTERIES

NMC is a combination of nickel, manganese, and cobalt this battery has high specific energy. The high-capacity batteries are today's evolving movement. For making a good battery design, some characteristics should be learned and considered. Different types of battery capacity at various temperatures have been performed. Through these test data, the electrical characteristics of various parameters, such as capacitance data, internal resistance data, OCVSOC characteristic relationship curve, and temperature data. These results can be used to compare different data. Its estimation of battery state, and enhance the standard of development [11].

However, NMC batteries are hazardous to our environment because of their component used for cathode material [12].

In NMCs the possibility of stable high voltages cannot be reached by balancing the cathode electrolyte, accessing this high voltage by optimizing the crystallographic orientation of the cathode is important. [14]

The capacity of the NMC cell decreases with the clock and decreases rapidly at high storage temp. At higher temp and more SOC, acceleration resistance increases over time and it is determined by the current pulse test. [15]

6. EFFECT OF $LiNaFePO_4$

LiNaFePO4 is another promising material that could replace Li-IB, whereas it is not possible to mix lithium with sodium but to do it has to go through the solvothermal process, the compound of cathode materials was combined with the easy solvothermal method. Sodium doping had a negligible result of replaced particles that gives a promise for its great electrochemical performance.

The Li0·99Na0·01FePO4 upgrades Lithium conductivity and manifests with the finest electrochemical performance [7].

7. CONCLUSIONS

In the current situation for the development of new-generation electric vehicle batteries, with improved performance and less harmful effect on the environment, there is a need of noticing the challenges of batteries accessible in our present market i.e., Li-IB. By adding some materials which are similar to Li-IB according to their chemical structure and properties. It can reduce major harmful effects and make them environment friendly.

The challenges of Li-IB and Na-IB is the use of certain materials which improve the performance of batteries. by studying various parts of the battery their functions and required properties deeply i.e., anode, cathode, and electrolyte materials which are major components in battery and total battery performance are dependent on these components, some challenges may get reduced. Many researchers have found several materials for anode-cathode and electrolytes suitable for batteries to get the best performance.

Li-IB degrades at high temperatures and it is not safe to charge faster at low temperatures also in Li-IB, low carbon electrode materials are difficult to develop. And in Na-IB development of cathode materials is difficult to create high-energy. As Na-IB and Li-IB have the same working properties, both may give similar output.

There are many more challenges related to batteries of lithium and sodium ions hence instead of using only lithium or sodium, adding other materials with them helps to improve battery performance. Such as now day lithium phosphate batteries are more popular now a day which are lower in cost and safer to use than lithium-ion batteries. Their weight is less and maintenance requirements are less.

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