Environmental issues and Chemistry behind major Electric vehicle batteries: Challenges in India

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Abstract:

In order to cut down its dependency on increasing import bills of oil, India has to reduce down its consumption of oil, and Electric vehicles (EV) running on rechargeable batteries can be a good option.

The nature of EV batteries, which contains a considerable amount of rare metals like lithium, cobalt, and nickel, necessitates battery repurposing and recovery in the long run. Lithium, cobalt, and nickel reserves are concentrated in a few countries and this poses a serious challenge to India. The present paper tries to depict the chemistry of these batteries and the solution to challenges posed by electric vehicle batteries.

Key words: Lithium-ion batteries. Nickel, Cadmium

Increased desire for an alternate energy source for transportation has been fueled by environmental pollution and high gasoline costs. Alternative cars will rely heavily on batteries. Used electric vehicle batteries could be an important and low-cost component of the solution. The environmental performance of electricity storage is examined in this study utilizing a life cycle assessment technique to examine the effects of each system's construction, disposal/end of life, and use.

Batteries have been highlighted as a waste stream concern material. To power their reactions, batteries are produced from a variety of substances. Nickel and cadmium, for example, are exceedingly poisonous and can cause cancer (1)

One of the most common types of energy storage technologies is the battery, which stores energy as chemical energy and transforms it to electrical energy as needed. Primary and secondary are two types of batteries. Their operation should be clearly understood.

As the electrochemical reactions in primary batteries are irreversible, they are not rechargeable.

The majority of alkaline and dry cell batteries are primary batteries.

Secondary batteries, on the other hand, are rechargeable and can be used indefinitely by recharging them once the charge has been depleted.

Some examples of secondary types of batteries are Lead acid batteries, lithium ion batteries, nickel cadmium batteries.

Wet batteries, commonly known as lead acid batteries, are electrolyte-based batteries that store electrical energy. It has a positive plate with lead dioxide, a negative plate with lead, and an electrolyte solution in a charged state with a high concentration of aqueous sulfuric acid. Each cell is capable of producing an EMF of 2.1 volts. To provide the requisite voltage, the battery is made up of multiple cells connected in series. In order for the battery to create voltage, it must first be charged.

Environmental concerns: Lead acid batteries pose a significant environmental risk. Both lead and sulfuric acid have the potential to pollute soil.

Lithium batteries have a lithium anode and are used as primary batteries. This type of battery, often known as a lithium-ion battery , is most typically employed in electric cars and electronic devices. The electrolyte transports positively charged lithium ions from the anode to the cathode and vice versa through the separator. The mobility of lithium ions in the anode produces free electrons. A charge is created at the positive current collector as a result of this. The electric current then passes from the specified charge collector to the negative charge collector via a supplied device. When lithium ions flow between the anode and the cathode, the battery charges and discharges in cycles, providing electricity. The amount of energy stored in the battery is affected by the number of times it is used. . The most common cathode material in lithium-ion batteries is lithium cobalt oxide, while the most common anode material is graphite. Other typical cathodes are lithium magnesium oxide and lithium iron phosphate. The electrolyte in lithium-ion batteries is ether. (2) Lithium mining and lithium-ion production are both extremely labour intensive, despite the fact that they are both safe for landfills. Furthermore, the majority of batteries are not adequately recycled, resulting in severe environmental consequences (3)

The presence of two liquid electrolytes in place of electrolyte plates distinguishes flow batteries from other rechargeable batteries. An ion selective membrane separates these liquid electrolytes, allowing ions to pass through and react chemically under charging and discharging conditions. Because the electrolytes can be easily replaced, they are regarded a better alternative to lead-acid, solid-state, and lithium-ion batteries. Two distinct tanks of electrolyte (mainly vanadium) with various charges are connected to a centrally placed fuel cell stack inside the flow batteries. After that, the electrolyte is pushed through the fuel cell stack, where an ion exchange process takes place across a membrane. During this exchange, a reversible electrochemical reaction occurs, allowing the electrical energy to be transferred. As there are no phase transitions from one solid to another, they, too, have a lengthy cycle life. The demand for and application of flow batteries is predicted to rise in tandem with the expected increase in the share of renewables in the overall global primary energy mix in the coming years.

The main benefit of a flow battery is that it produces no hazardous emissions.

The electrolyte of high temperature batteries is molten salts, while the electrodes are two liquid metals. Based on immiscibility and density, the electrolyte is further divided into three layers. To solve grid-scale electricity storage difficulties, these batteries have a unique mix of high energy, extended life, high power density, and low-cost materials. These high-temperature batteries' components are solid at ambient temperature and can be stored dormant for a long time. Because of their immiscibility and relative densities, the anode, cathode, and electrolyte layers spread during activation at high temperatures. The electrolyte has a high ionic conductivity, and while the charging and discharging process occurs, the ionic species pass through the electrolyte.

The total reliability of the ageing power infrastructure should be improved even more by these batteries. These batteries have high working temperatures, which are kept constant by self-heating during charging and discharging cycles. (4)

Nickel Cadmium battery is a rechargeable battery which uses Nickel Oxide hydroxide and metallic cadmium as electrodes. Nickel cadmium batteries consist of a metal case and a sealing plate which is further equipped with a self-sealing safety valve. Cadmium layer acts as the cathode terminal. The separator layers (provide OH ions) are kept above it. It is also soaked with water to provide for the initial reactions. When Nickel combines with water and Cadmium, it forms

Cadmium Oxide and Nickel Oxide. This reaction is followed by the flow of electrons causing potential difference between two terminals. This battery has a jelly roll design wherein the positive and negative electrodes are isolated using the separator and rolled into a spiral shape. This construction helps Ni-Cd batteries to deliver higher maximum current as compared to alkaline batteries of similar size.

Toxic to the environment: Cadmium is a toxic and heavy metal, hence discarding these batteries will damage the environment

Nickel metal hydride (NiMH)is one of the most advanced and commercially available rechargeable battery. It uses Nickel Oxide Hydroxide in its positive electrode and hydrogen absorbing alloy in the negative electrode. The electrodes are separated by a permeable membrane which allows for ionic and electron flow between them. The membrane is made up of aqueous potassium hydroxide and is immersed in the electrolyte. There is no significant change to this membrane during the battery operation. They are used as substitutes for alkaline batteries due to their compact size, compatible cell voltage, leak, and explosion resistant. The battery has a resettable fuse which breaks the circuit if the current or the temperature is too high. They are much safer as compared to NiCad and give a higher output. However, their performance is not superior when compared to Lithium-Ion battery (5)

Metal air batteries have metal anodes with aqueous or nonaqueous electrolyte. It creates voltage from the availability of oxygen molecules (O2) at cathode which reacts with positively charged metal ions to form oxide and generate electric energy. These batteries hold great potential to resolve future energy and environmental issues. In these batteries, the electrolyte can be aqueous or nonaqueous depending on the nature of the anode employed; the air breathing cathode often has an open porous architecture that permits continuous oxygen supply from surrounding air. Metal-air batteries holds great potential to resolve future energy and environmental issues. It creates voltage from the availability of oxygen molecules (O2) at cathode which reacts with positively charged lithium ions to form Li2O2 and generate electric energy23. During discharge, metal is oxidized at the anode; O2 from the surrounding air is reduced

Conclusion and Recommendation .

Electric vehicle (EV) adoption is increasing in India, thanks to the government's promises to combat climate change and its ambition of decarbonizing the transportation sector. This would result in a significant increase in the need for traction batteries. Aside from the need for batteries, the battery chemistry technological environment is rapidly changing. New market entrants and the government are boosting the growth of innovative enterprises like battery swapping. Lithium-ion, the preferred chemistry for EV batteries in India, necessitates a set of minerals that aren't plentiful in the country. As a result of this situation, there is a large reliance on imports. As a result, it's critical to encourage battery circularity in order to reduce supply chain reliance and recycle battery materials. However, depending on the amount of electricity required to operate them, their composition and size vary from vehicle to vehicle. A battery pack is made up of cells and modules that are stacked together. Lithium, cobalt, nickel, iron, copper, and aluminium are the main components of these batteries. According to industry experts, the life of an EV battery is between six and eight years, and it needs to be replaced when its capacity falls below 80%, entrepreneurs and professionals working in the field of battery assembly, and the life of a battery is also dependent on the frequency of EV use. Lithium-ion batteries are rechargeable batteries that store energy. From two-wheelers to commercial vehicles and public transportation buses, the batteries utilised in these vehicles are virtually the same.As per industry sources , a lithium-ion battery can perform between 500 and over 10,000 cycles of charging and discharging, depending on the chemistry, size, configuration and purpose Multiple battery technologies are available for use in traction applications. The industry has moved from matured technologies viz. lead acid, NiMH (Nickel Metal Hydride), NiCd (Nickel Cadmium) to commercialized technologies such as lithium-ion, flow batteries, etc. A comparison of battery chemistries reveals that lead acid batteries are lower in prices, tolerant to overcharging and can withstand extreme temperatures. However, lead acid batteries have certain shortcomings since they lead to increased weight, environmental concerns due to improper handling after end-of-life, etc. Lithium-ion batteries, on the contrary, provide advantages such as availability in compact sizes, longer service life, faster charging rates, no memory effects, lower self-discharging rate, etc. These are the factors which make lithium-ion as the chemistry of choice for EV applications.

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