Review

Application of Life Cycle Assessment to Lithium Ion Batteries in the Automotive Sector

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Abstract: This study is a critical review of the application of life cycle assessment (LCA) to lithium ion batteries in the automotive sector. The aim of this study is to identify the crucial points of the analysis and the results achieved until now in this field. In the first part of the study, a selection of papers is reviewed. In the second part of the study, a methodological approach to LCA is adopted to make clear the strengths and weaknesses of this analysis method. The lack of primary data is a crucial concern. Even if the cradle-to-grave approach is the most chosen system boundary, further scientific contribution to the life cycle inventory phase is necessary. It is likely that the more the electric vehicle becomes widespread, the more data will be accessible. Many authors have not specified the chemistry of the used batteries (5% of the studies), the software tool used (30%) or the functional unit used (17%) and, consequently, their obtained results can be questionable. However, even with the aforementioned limitations, the performed review allows us to point out the potential of electric vehicles and lithium ion batteries to reduce the overall contribution of the transportation sector to GHG emissions.

Keywords: automotive industry; electric vehicles; LCA; lithium ion batteries; second life

1. Introduction

Advanced power storage devices are increasingly desirable for stationary and mobile applications. High energy and power density are required for the more recent mobile applications, to keep safety standards high. In contrast, older batteries characterized by long life and reliability are suitable for stationary applications [1]. Lithium ion cells are among the most suitable candidates for both these kinds of applications, thanks to their power and energy density as well as their low self-discharge rate [2]. They are essentially made of two electrodes, an electrolyte that closes the electrical circuit, assuring the ionic transport, a separator preventing the short-circuiting of the cell due to electrodes' contact, and two current collectors. The cathode, which is the positive electrode, is the only element that changes across the different lithium batteries' chemistry [3].

During the past decade, lithium ion cells have been widely used in the automotive sector as energy sources for electric vehicles (EV), hybrid electric vehicles (HEV) and plug-in hybrid electric vehicles (PHEV) [4]. Figure 1 shows the geography of lithium battery producers. The Asiatic area is predominant: China is the biggest producer of lithium ion cells and batteries; together with Japan and South Korea, it makes more than three-quarters of the entire world's production. Among all other countries, only the USA has significant production [5].

Figure 1. Distribution of lithium ion cell production in the world [5].

Total production of lithium ion batteries (LIBs) was 103 GWh or 11,400 metric tons in the year 2017, and in the future a quick increase is expected. The forecast annual demand for LIBs is 1300 GWh (145,000 metric tons) in 2030 [6]. The annual demand for LIBs, and for raw materials as a consequence, is related to the market penetration of EVs, batteries' lifespan and recycling capacity.

The lifespan of LIBs is influenced by secondary reactions that lead to the degradation of their components and results in an increase of internal impedance and in a decrease of residual capacity [7,8]. The mechanisms causing the decrease of the overall performance of LIBs are known as "aging mechanisms". It is important to consider these mechanisms in order to improve the performance of the batteries and precisely check the health status of the cells (SOH) [9].

The lifespan of LIBs in automotive applications is estimated to be up to ten years [10]. At the end of life (EOL) of automotive applications, batteries are not suitable for mobility because they do not guarantee a sufficient autonomy and traction capacity. Nevertheless, they have sufficient residual capacity to stabilize an electricity grid in their so-called "second life" [11] or in energy storage systems (ESS) for residential, commercial or industrial applications [12]. The criteria to change from mobile to stationary use for lithium ion batteries at EOL are commonly agreed as:

- Residual capacity of the battery in the range of 60–80% with respect to the initial capacity [13];
- Doubling of internal impedance with respect to the initial capacity [14].

Extracting a second use from repurposed EV batteries may also assist EV owners in recovering some of the initial costs of the vehicle purchase [11]. After the end of the second life, it has been shown that the recycling of lithium ion batteries can be beneficial to the environment because it reduces first of all material discharge, and reduces greenhouse gas emissions (GHGs) as well as avoids the extraction of new raw materials. However, similarly to any other industrial process, it is impossible to recycle LIBs without causing environmental impacts with the recycling processes [15]. Therefore, the impact of recycling LIBs has to be evaluated.

The life cycle assessment (LCA) methodology can be used to evaluate the potential environmental impacts. The LCA method provides an overall view of the life cycle of products, processes or services during the entire life cycle (cradle-to-grave approach) or only some parts of it (cradle to gate, gate to grave, etc.). The use of a "cradle-to-gate" approach considers all energy transformation, material and components production and assembly, from resource extraction to the factory gate. A "cradle-to-grave" approach considers cradle-to-gate phases, adding use and disposal phases. The "well-to-wheel" approach is usually used for fuels. Inputs and outputs of an LCA study have to be referred to as a functional unit (F.U.), which is a measure of the function of the studied system. The International

Standards Organization (ISO) provides all the necessary guidelines to perform an LCA in the ISO 14000 series [16,17]. A framework of the LCA phases is shown in Figure 2.

Figure 2. Life cycle assessment phases as described in ISO 14040.

LCA studies on LIBs are growing in interest, but they are still under development. In April 2020, a total of 383,000 papers is available on LIBs, but only one out of a hundred is related to LCA or energetic and environmental analysis. In this review, fifty-nine papers and studies on the topic have been selected in literature. As a rule, papers without original and proven results have not been considered. As shown in Figure 3, among the reviewed studies, the number of publications has grown over the years.

Figure 3. Distribution over year for the reviewed literature.

The research of papers has been conducted on the main available scientific databases (Scholar, Scopus, Science Direct, Web of Knowledge, etc.) using different key words such as LCA, life cycle assessment, electric vehicle, battery, lithium ion battery, hydrometallurgy, pyrometallurgy, recycling, second life, end of life, etc. as well as combining them with the 'and' boolean operator.

Specialized journals are the main sources for the reviewed literature. As shown in Figure 4, many contributions are from the *Journal of Cleaner Production* and *Environmental Science & Technology*.

Figure 4. Number of publications per journal among the reviewed literature (IF = impact factor).

Among the selected studies, thirty-two are LCA papers on EV, twenty-three are LCA studies on LIBs and four are not related to LCA studies but to cost and energy analysis.

Identifying the main aim of the papers reviewed is important. In 51% of the studies, a cradle-to-grave approach was used; for example, Marques et al. [18] implemented a cradle-to-grave study in order to compare the environmental behavior of electric vehicles with different cathode's chemistries. In 25% of the studies, a well-to-wheel approach was used; Faria et al. [9], for example, analyzed the advantages of batteries repurposed for energy storage at home in cases of peak shaving and load shifting. Despite being similar, the cradle-to-grave approach focuses on the product, process or service considered, whereas the well-to-wheel approach mainly focuses on the fuel.

Table 1 shows the main characteristics of the studies considered in this review.

Table 1. Main characteristics of the studies considered in this review.

LCA ^a Approach	Functional Unit (F.U.)	Main Topic	Location	References
Battery				
Cradle-to-cradle	1 kWh	LCA analysis on recycling and reuse of lead acid, LIBs ^b and vanadium redox flow batteries	Germany	2016 [19]
	1 kg of cathode	Different impact assessment methods comparison	-	2019 [20]
	1 kg of raw material	Real energy demand and GHGs ^c emission comparison to GREET ^d	China	2019 [21]
Cradle-to-gate	1 kWh	LCA on NMC ^e battery	United States	2019 [15]
	100 kg of batteries	Production environmental impact of different batteries (LIBs and non-LIBs)	United Kingdom	2012 [22]
	1000 kWh	LCA comparison among LIBs, NMHs and solar cells	China	2016 [23]
	Local energy demand [MWh]	Optimized consequential LCA for ESS ^f application	France	2019 [24]
Cradle-to-gate + end-of-life	17 kWh	LCA on innovative LIB chemistry	-	2018 [3]
Cradle-to-gate, cradle-to-grave	1 battery pack (250 kg)	LCA approach and EIO ^g -LCA	United Kingdom	2019 [25]

Table 1. Cont.

LCA ^a Approach	Functional Unit (F.U.)	Main Topic	Location	References
Cradle-to-grave	1 battery	Complete LCI for NCM battery	-	2014 [26]
	1 battery pack (346 kg)	LCA on LithoRec project for LIBs recycling	Germany	2018 [27]
	1 battery pack (43.2 kWh)	LCA on battery with silicon nanowire anode	-	2014 [28]
	1 battery pack (43.75 mAh)	LCA on SSBs manufacturing	Germany	2016 [29]
	1 kWh	LCA on different battery types	-	2015 [30]
		LCA on battery reused for ESS application	Canada	2015 [11]
		LCA on new advanced material for LIBs	European Union	2011 [31]
		Environmental burdens of used batteries	Japan	2002 [32]
	1 MWh	LCA comparison between LIBs and LMPs	Canada (Quebec)	2017 [33]
	50 kW power / 450 kWh capacity	Energy analysis on eight battery technologies	-	2005 [34]
End-of-life (recycling phase)	Average yearly energy balance	LCA of repurposed EV ^h batteries in ESS applications	Netherlands	2018 [12]
	1 metric ton of batteries	LIBs recycling processes investigation and LCA	Australia	2016 [14]
Well-to-wheel	-	Different battery chemistries assessment	European Union	2012 [35]
	1 km	LCA study	Sweden	2016 [36]
Vehicle				
Cradle-to-gate	-	Energy consumption and GHGs emissions evaluation of ICEVs ⁱ and BEVs ^j production	China	2017 [37]
	100,000, 150,000 and 200,000 km	Impact of driving patterns, geographic locations and heating/cooling use on energy consumption of EV. LCA approach.	Germany, Brazil and Spain	2015 [38]
	150,000 km	LCA study on BEV and ICEV	European Union	2018 [39]
Cradle-to-grave	-	LCA on BEV, HEV and PHEV with LMO ^k batteries	United States	2012 [40]
		LCA study for different LIB chemistry in PHEV ^l	United States	2011 [41]
		Energy use and GHGs emission of vehicle	United States	2010 [42]
	1 km	LCA on five different powertrain scenarios	Brazil	2018 [43]
		LCA comparison between ICEVs and BEVs	European Union	2016 [44]
		LCA on different EV types and LIB chemistries	United States	2016 [45]
	1 kWh	Different impact methods sensitivity on electric powertrains LCA	European Union	2017 [46]

Table 1. Cont.

LCA ^a Approach	Functional Unit (F.U.)	Main Topic	Location	References
	1 mile	LCA analysis on different advanced powertrains	United States	2018 [5]
	100 km	Carbon and water footprint analysis	Czech	2019 [47]
	120,000 km	Batteries production impact on EV life cycle	United States	2015 [48]
	150,000 km	LCA with present and future energy mixes	Czech and Poland	2018 [49]
	160,000 km	LCA on electric vehicle and LIBs second life scenarios	Canada	2014 [10]
	200,000 km	Comparative LCA on two batteries type: LFP and LMO	China, Germany, France, Portugal	2019 [18]
	200,000 km	CO ₂ emissions comparison between BEVs and ICEVs	United States, European Union, Japan, China, Australia	2019 [50]
	4000 days	Second life scenarios LCA	Spain	2019 [2]
Gate-to-gate	1 km	Impact of different vehicle technologies on online shopping using LCA	Thailand	2018 [51]
Well-to-wheel	-	LCA study on different size segments EVs	European Union	2016 [52]
	-	Environmental profile for EV	Germany	2011 [53]
	1 kg of battery	Exergetic efficiency analysis on thermal management system for EV an ICEV	European Union	2014 [54]
		LCA on ICEV and BEV	-	2011 [55]
		ICEVs and BEVs environmental comparison using LCA	Switzerland	2010 [56]
	1 km	LCA comparison between EVs and ICEVs	European Union	2013 [57]
		Evaluation of GHGs emission for PHEV	United States	2008 [58]
	10 kWh	LCA on LFP batteries in PHEV application	European Union	2010 [59]
	180,000 km	LCA on electric, hybrid and fuel cell vehicles	European Union	2006 [60]
	180,000 miles	Energy inputs and GHGs emission for ICEVs, HEVs and BEVs	United States (California)	2012 [61]
	200,000 km	LCA on automotive and second life for LIBs and sensitivity on energy mixes.	Portugal, France and Poland	2014 [9]
	230,500 km	Environmental impact of conventional and electric vehicles.	-	2011 [62]
	50 MJ (equivalent to 100 km)	Environmental comparison between LIBs and NMHs in EV applications.	European Union	2011 [63]

Table 1. Cont.

LCA ^a Approach	Functional Unit (F.U.)	Main Topic	Location	References
Others				
Cradle-to-grave	kg of batteries	Material and energy flows for different LIB chemistries.	United States	2014 [64]
	20 kWh	Material and energy flow for NMC production	-	2013 [65]
	-	Energy and mass flow	European Union	2007 [66]
	-	Cost analysis for LIBs	United States	2000 [67]

^a life cycle assessment; ^b lithium ion batteries; ^c greenhouse gases; ^d greenhouse gases, regulated emissions, and energy use in transportation; ^e nickel manganese cobalt lithium ion battery; ^f energy storage system; ^g economic input-output; ^h electric vehicle; ⁱ internal combustion engine vehicles; ^j battery electric vehicles; ^k lithium manganese oxide lithium ion battery; ^l plug-in hybrid electric vehicle.

Seventeen percent of the studies considered a cradle-to-gate approach. For example, Liang et al. [23] focused on the evaluation of emissions related to the production of batteries. Seven percent followed different approaches such as gate-to-gate, cradle-to-cradle and end-of-life.

Figure 5 shows the percentage distribution of the impact categories of all the studies considered in this review.

Figure 5. Impact category distribution among the reviewed studies.

Climate change and energy use are the most common impact categories. They are useful to evaluate technical and environmental performances of products and processes. The climate change category is related to greenhouse gas emissions (GHGs), while energy use gives an indication of the harvested energy across the life cycle of the considered process. There is a strong relevance between climate change and energy use; thus, it is possible to speculate that energy intensive processes are more impacting from a climate change perspective [21] and the magnitude of this correlation is related to the energy mix selected to perform the study. The more the energy mix relates to non-renewable sources and the higher is supposed to be the magnitude of the climate change category.

2. LCA Application to Lithium Ion Batteries for Automotive: A Practical Point of View

The widespread use of lithium-ion battery's systems in electronics and vehicles has pushed towards the assessment of their environmental impacts [20]. LCA studies on LIBs appeared in the early 2000s and their number increased over time. Among the considered studies, 38% are related to

LCA studies on lithium ion battery, while 55% are related to life cycle assessments on electric vehicle powered by a lithium ion battery pack.

The geographic location in which the LCA studies were performed is one of the aspects taken into consideration. Figure 6 shows that more than half (57%) of the studies have been conducted in Europe considering an average European energy mix, 21% of the studies have been conducted in the USA considering an average USA energy mix, while about 6% have used a Chinese energy mix. Other contributions come from Canada, Brazil, Japan and Australia.

Figure 6. Geographic location considered in the LCA studies.

A second important aspect taken into consideration concerns the cathode's chemistry of the lithium ion batteries. In 6% of the papers, the chemistry of the battery is not specified. The range of chemistry considered in the papers is shown in Figure 7.

Figure 7. The considered LIBs' chemistries and their respective shares; LFP (lithium iron phosphate); NCM (lithium nickel cobalt manganese); LMO (lithium manganese oxide); LCO (lithium cobalt oxide); NCA (lithium nickel cobalt aluminum); LCP (lithium cobalt phosphate); LFMP (lithium iron manganese phosphate); LMP (lithium metal polymer); LCN (lithium cobalt nickel).

Lithium iron phosphate (LFP) and nickel cobalt manganese (NCM) are the most analyzed chemistries. LFP batteries are made of cheap, nontoxic and easily accessible materials like iron and phosphorus [20]. The cobalt-based batteries show high environmental impacts to human and ecosystems because of the metal extraction process [68]. Furthermore, LFP batteries are safer than cobalt-based batteries [69]. For these reasons, LFPs are the best candidates to be used for next generation

of green LIBs. NCM is the most diffuse cathode's chemistry in the EVs sold in Europe, Japan and the United States [15].

In the analyzed works, it is possible to evaluate the average ratio between the weight of a LIB and its capacity. From Figure 8, it is possible to assess an average value of the ratio capacity/weight [kWh/kg] equal to 0.1103. The inverse value is equal to 9.066 kg/kWh and gives an indication of the average energy density. The batteries with NCM and LMO cathodes' chemistries have values of the weight/capacity ratio lower than the average. Other chemistries, such as LFP, have values higher than the average, due to the different energy densities among the different chemistries. From a size point of view, batteries with a lower value of weight/capacity are preferable for automotive applications. Obviously, lighter batteries are less impacting on the consumption of electricity.

Figure 8. The trend of the ratio between lithium ion battery pack weight and lithium ion battery pack capacity.

3. LCA Application to Lithium Ion Batteries for Automotive: A Methodological Point of View

In this section, the reviewed studies are presented from a methodological point of view. The approaches adopted in the LCA main phases (goal and scope definition, inventory analysis, life cycle impact assessment, interpretation) are going to be underlined.

3.1. Goal and Scope Definition

In the goal and scope definition's section, F.U. and system boundaries are defined. Furthermore, all the assumptions are stated and discussed.

The most common F.U. (33.90% of the studies) is the distance traveled by the vehicles. It is a common choice when comparing the environmental behavior of different vehicles (i.e., internal combustion engine vehicle and electric vehicle) [44]. The second most common F.U. (30.51%) is the energy provided by the batteries. It is a correct choice when it is necessary to consider the influence of parameters such as lifetime, efficiency and depth of discharge (DOD) on the output delivered by the batteries [33]. The third most common F.U. (16.95%) is the battery pack mass. This type of F.U. is commonly used when it is necessary to compare different cathode materials [20] or when the work mainly relies on LIBs' production phases focusing on raw materials' acquisition, transportation, production [21] and EOL recycling phases.

There are other possibilities for choosing a F.U. to perform an LCA study. Ioakimidis et al. [2], for example, have chosen an amount of time (4000 days) as F.U. In their work, they considered a second life repurposing for batteries as energy storage units in building. They were able to compare two scenarios (base case and repurposing scenario) on a time basis [2]. All the F.U. definitions are valid because the choice depends on what is the focus of the analysis.

3.2. Inventory Analysis

The inventory analysis' phase (LCI) is one of the most crucial in performing an LCA study. The study performed must afford the problems of data quality and their availability. The primary data, collected from stakeholder of lithium ion batteries' supply chain, can be subject to non-disclosure agreements and cannot be easily accessed. The recycling of lithium ion batteries is a novel problem and it is likely to experience lack of data. Another way to obtain primary data is to perform experimental procedures. Databases on which LCA software tools are built can be considered as a sort of benchmark for data. These are the so-called secondary data. It would be preferable to perform LCA studies using inventories totally made up of primary data, because they are more reliable since their operational origin. Secondary data represent a valid substitute if they are based on robust models and assumptions.

Among the reviewed papers, 83% used a mix of primary and secondary data, 12% used only primary data and, finally, 5% only secondary data.

The most cited articles are Majeau-Bettez et al. [63] (in 19% of the papers), Hirschier et al. [66] (in 13% of the papers) and Zackrisson et al. [59] (in 10% of the papers).

Around 41% of the reviewed papers (i.e., 24) do not precisely state which database is used to perform the LCI phase. Among the remaining studies, Ecoinvent is chosen in 66% of the studies, while BatPac is preferred in 17% of the studies. Ecoinvent is developed by the Swiss Centre for Life Cycle Inventories. It contains around 17,000 LCI datasets in many areas such as energy supply, agriculture, transport, biofuels and biomaterials, bulk and specialty chemicals, construction materials, wood, and waste treatment [70].

Finally, another important aspect that can be pointed out is related to the software tool used to perform the LCA. In 49% of the reviewed studies, it is not specified. In these cases, it would be useful to know if the authors have chosen not to use any software, and in this case why and what calculations were made. Among the remaining 51% studies, SimaPro is used in 38% of the cases, GREET in 31% GaBi in 25% and OpenLCA in 6%.

3.3. Life Cycle Impact Assessment

In the life cycle impact assessment's phase (LCIA), the potential environmental impacts are calculated in relation to the LCI phase results.

In 23% of the reviewed papers, it is not clearly expressed which LCIA method is used. Besides these studies, the most used LCIA method is ReCiPe (19%) developed by PRè Sustainability in collaboration with Dutch National Institute for Public Health and the Environment (RIVM), Radboud University Nijmegen and Norwegian University of Science and Technology [71]. The ReCiPe method is able to determine environmental impacts category on two levels: midpoint and endpoint. Midpoint indicators focus on an environmental problem while endpoint indicators show the impact from a higher aggregation level. The passage from midpoint to endpoint simplifies the LCIA phase, although the uncertainty could increase due to the aggregation process. Other LCIA methods used are IPCC (9%) and CML-IA (9%).

Among the reviewed studies, 22.8% consider only one impact category (i.e., global warming, potential or cumulative energy demand, CED, etc.). The remaining 77.2% consider more than one impact category.

Where possible, data were derived from the studies considered for the critical review. Some results in terms of impact categories per kg of LIBs are shown in Figure 9. The process of data obtained from the reviewed papers was not straightforward and the values gained show a lot of variability.

This variability can be related to the different system boundaries among the different studies and to the lack of precise numerical data.

Figure 9. (a) Climate change value, derived from papers, per kg of batteries; (b) Energy use, derived from papers, per kg of batteries; (c) resource depletion, derived from papers, per kg of batteries; (d) Eutrophication, derived from papers, per kg of batteries.

3.4. Interpretation

Interpretation is the last phase of an LCA study. Usually it includes a sensitivity analysis and a discussion on the reliability of results. Many reviewed papers have not provided numerical values of the environmental impacts and this complicates the comparison of results. When hypotheses are made, it is important to check the influence of the input parameters on the obtained results. In order to quantify this influence, a sensitivity analysis has to be conducted. As a matter of fact, in 51% of the reviewed studies a sensitivity analysis has been performed.

4. Conclusions

This review aims to give critical insights into the upcoming changes in the application of LCA method to lithium ion batteries in the automotive sector.

More than half of the studies are conducted in Europe and considered an average European energy mix. The problem of assessing the environmental impacts of batteries is less acute in countries where batteries are manufactured. Other studies are necessary to quantify the LIB's environmental impacts in countries in which battery production takes place. An increase of LCA studies on LIBs' environmental impacts is necessary considering the trends of production and use of these devices in the next ten years. The environmental impacts need to be precisely quantified in order to increase the sustainability of the electric mobility.

Lithium iron phosphate (LFP) and nickel cobalt manganese (NCM) are the most analyzed chemistries for electric batteries, but different chemistries will be analyzed in the future as long as they become more widespread. In fact, as emerged from the analysis, batteries with a lower value of weight/capacity are preferable for automotive applications, whereas lighter batteries are less impacting on vehicle's electricity consumption. New chemistries are necessary to meet these requirements. The cradle-to-grave approach is adopted in around 50% of the case studies, while climate change and energy use are the most used impact categories. The results obtained by the studies considered

in the review emphasized the potential of EVs and LIBs to reduce the overall contribution of the transportation sector to GHG emissions.

From a methodological point of view, the followings are the main outcomes of the review. In the goal and scope definition, the distance traveled by the vehicles is the most used F.U. because the studies focus mainly on comparing the different vehicles. In the inventory analysis, Ecoinvent is the preferred database, while SimaPro is the preferred software tool. The lack of primary data is a crucial concern. It is likely that the more the EVs become widespread, the more data will be accessible. In the life cycle impact assessment, ReCiPe is the most used method. In the interpretation, many articles do not provide all the numerical values, thus not allowing an easy comparison of the environmental results.

It is suggested that any further LCA study on LIBs from automotive application should adopt a cradle-to-grave approach at least. These LCA studies should rely more on recent primary data to be the more accurate as possible.

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Abbreviations:

BEV	Battery Electric Vehicle
CED	Cumulative Energy Demand
DOD	Depth Of Discharge
EIO	Economic Input-Output
EOL	End Of Life
ESS	Energy Storage System
EV	Electric Vehicle
F.U.	Functional Unit
GHG	Greenhouse Gas
HEV	Hybrid Electric Vehicle
ICEV	Internal Combustion Engine Vehicle
IF	Impact Factor
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standards Organization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LCN	Lithium Cobalt Nickel Battery
LCO	Lithium Cobalt Oxide Lithium Ion Battery
LCP	Lithium Cobalt Phosphate Battery
LFMP	Lithium Iron Manganese Phosphate
LFP	Lithium Iron Phosphate Lithium Ion Battery
LIB	Lithium Ion Battery
LMO	Lithium Manganese Oxide Lithium Ion Battery
LMP	Lithium Metal Polymer Battery
NCA	Lithium Nickel Cobalt Aluminum Battery
NMC	Nickel Manganese Cobalt Lithium Ion Battery
NMH	Nickel-Metal Hydride
PHEV	Plug-in Hybrid Electric Vehicle
SOH	State Of Health
SSB	Solid State Battery

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