Proceedings of the 5th International Conference on Materials Chemistry and Environmental Engineering
DOI: 10.54254/2755-2721/2025.23745

Application of Lithium-ion Battery in New Energy Vehicle

Qiuxin Liu

Chemistry and Chemical Engineering College, Central South University, Changsha, China
8202220511@csu.edu.cn

Abstract: With the shortage of fossil energy and global warming, traditional cars are gradually being replaced by new energy vehicles. The new energy automobile industry has made great progress, in which lithium-ion battery is widely used. The paper aims to discuss the current status and challenges of the application of lithium-ion batteries in the field of new energy vehicles. By combing and analyzing relevant literature, it summarizes the basic working principle, performance characteristics and applications of lithium-ion batteries, and discusses in detail the technical bottlenecks encountered during their use in new energy vehicles, including energy density, charging speed, safety and battery recycling. This paper proposes solutions to these challenges and looks forward to the future development trend of lithium-ion batteries. The results indicate that although lithium-ion battery technology has a broad application prospect in the field of new energy vehicles, it is still necessary to further improve its performance and solve the recycling problem in order to promote the sustainable development of new energy vehicles.

Keywords: Lithium-ion Battery, New Energy Vehicles, Battery Recycling, Challenges and Development

1. Introduction

With the rapid economic development of all countries in the world, the demand for energy has also shown a rapid growth trend [1]. Traditional fossil energy sources like coal, oil, and natural gas are convenient but have many negative consequences on the environment, including the release of greenhouse gas CO2, which contributes to global climate change. Lithium-ion batteries (LIBs) have been regarded as one of the most promising electrochemical energy storage systems, and LIBs has unique advantages in energy density, volumetric energy density and power density compared to other metal ion batteries. These characteristics enable LIBs to provide more energy storage, while also having a higher output power capacity [2-4]. In recent years, LIBs has been widely used in the field of energy storage and has promoted revolutionary changes in technology development. The paper aims to discuss the current status of the application of lithium-ion batteries in new energy vehicles, analyze the technical challenges it faces, and propose targeted solutions. Existing research results are analyzed through a literature review to identify technical bottlenecks and research gaps, assess the effectiveness of lithium-ion battery application in new energy vehicles, and explore feasible technical solutions. By solving the current technological bottlenecks, it is expected to contribute to the enhancement of battery performance, extension of service life, cost reduction and safety improvement. In addition, this study will promote the sustainable development of the new energy

© 2025 The Authors. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

DOI: 10.54254/2755-2721/2025.23745

vehicle industry, reduce environmental pollution, and help form a more complete battery recycling system, making a positive contribution to the global energy transition.

2. Overview of lithium-ion battery technology

2.1. Basic principle and features

Lithium-ion batteries are mainly composed of a positive electrode, a negative electrode, an electrolyte and a diaphragm [5]. Different types of lithium-ion batteries work on the same principle: when charging, Li+, driven by an external electric field, diffuses from the positive electrode material into the electrolyte, passes through the diaphragm and enters the negative electrode, and at the same time releases electrons, which flow to the negative electrode through an external circuit, and the battery stores energy. When discharged, the process is reversed, losing electrons Li+ from the negative electrode, through the electrolyte, and then through the diaphragm to move to the positive electrode material, and ultimately re-embedded in the positive electrode. Lithium-ion batteries are also known as “rocking chair batteries” because during the charging and discharging process, lithium ions cycle back and forth between the positive and negative electrodes like a rocking chair. Lithium-ion batteries have many advantages, such as high energy density, which allows them to store more energy in a smaller size and weight; long cycle life, typically hundreds to thousands of charge/discharge cycles; and low self-discharge rate, which means that the battery loses less power even when not in use for a long period of time. However, they are not without their disadvantages, such as a gradual decrease in cycle life and efficacy over time, potential safety hazards such as thermal runaway and short circuits at high temperatures or overcharging and discharging, and higher costs.

2.2. Commonly used lithium-ion batteries

Batteries utilized in electric vehicles encompass lead-acid batteries, fuel cells, nickel-metal hydride batteries, and lithium-ion batteries. Lithium-ion batteries can be further classified into lithium iron phosphate ($LiFePO_4$), lithium manganate ($LiMn_2O_4$), lithium cobaltate ($LiCoO_2$), and lithium ternary batteries ($LiNiCoMnO_2$) based on the varying cathode materials. In terms of thermal stability, $LiFePO_4$ battery is the best, followed by $LiMn_2O_4$ battery and $LiCoO_2$ battery is the worst. Li-$FePO_4$ battery has long cycle life, low toxicity, low cost, large charge/discharge multiplier and good high temperature stability, but with lower energy density and poor consistency, it is mainly used in larger electric vehicles such as electric buses. Lithium manganate battery has low cost and low toxicity, but poor thermal stability and shorter cycle life, so it is less used. Lithium ternary batteries have high energy density, but easy to heat up in high-power charging and discharging, poor thermal stability, and shorter service life, usually used in space-constrained electric passenger cars. Although lithium cobalt-acid batteries have great energy density, its cathode decomposes at high temperatures, accelerating thermal runaway. However, their range is strong [6]. A performance comparison of mainstream Li-ion batteries is shown in Table 1.

Table 1: Performance comparison of commonly used lithium-ion batteries

Commonly Used Lithium-ion Batteries	Cost	Energy density	Thermal stability	Theoretical cycle life
$LiFePO_4$	low	low	high	middle
$LiMn_2O_4$	low	low	middle	short
$LiCoO_2$	high	high	low	short
$LiNiCoMnO_2$	middle	middle	low	long

DOI: 10.54254/2755-2721/2025.23745

For example, in China's electric vehicle market, lithium iron phosphate batteries can reach an energy density of 170 W-h/kg with high safety and are mainly used in medium and large vehicles [7]. The cathode material for lithium iron phosphate batteries is an olivine structure with an orthorhombic crystal system, where the crystals consist of twisted hexagonal stacks, as shown in Figure 1 [8, 9]. Its space group is Pnma, with Fe and Li located in the octahedron and P in the tetrahedron.The FeO_6 octahedral layers are arranged in the bc plane in a co-angled manner, whereas the linear chains of the LiO_6 octahedra share edges in a direction parallel to the b-axis. The linear chains are connected by phosphate tetrahedra that share edges, forming a stable three-dimensional structure with lattice parameters of a = 10.33 Å, b = 6.01 Å, c = 4.69 Å, and V = 292.33 $Å^3$ [10]. Since the discovery of lithium iron phosphate cathode materials, they have become one of the common lithium-ion battery materials due to their low cost, good thermal stability, structural stability, and high theoretical specific capacity [11-13].

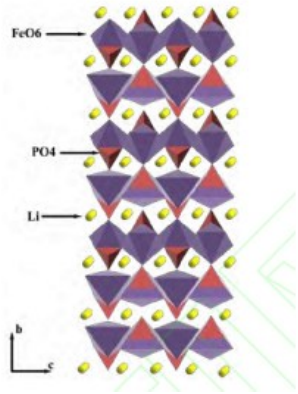

Figure 1: The crystalline structure of $LiFePO_4$

The charging and discharging principle of $LiFePO_4$ batteries is as follows: during charging, the positive electrode ($LiFePO_4$) loses electrons, lithium ions are released and move through the electrolyte to the negative electrode. The negative electrode (graphite) gains electrons, and the lithium ions are embedded, converting to $FePO_4$. During discharging, the positive electrode ($FePO_4$) gains electrons, the negative electrode (graphite) loses electrons, and the lithium ions are released and return to the positive electrode, converting back to $LiFePO_4$ [14].

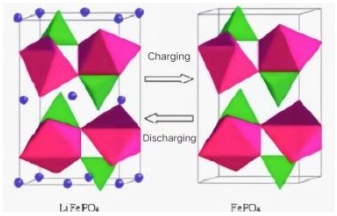

Figure 2: Schematic diagram of $LiFePO_4$ charging and discharging process

Although $LiFePO_4$ has excellent thermal stability, its electronic conductivity (about 10^{-14} $S \cdot cm^{-1}$) and lithium ion diffusion coefficient (about 10^{-14} $cm^2 \cdot S^{-1}$) are relatively poor, which limits its application in high-speed charging and discharging. This is primarily due to two factors: first, the lack of a continuous FeO_6 coplanar octahedral structure in $LiFePO_4$, which results in an incoherent electron conduction path; second, the spatial hindrance of the PO_4 tetrahedra along the c-axis, which forces lithium ions to diffuse in a nonlinear, zigzag manner along the b-axis.

DOI: 10.54254/2755-2721/2025.23745

3. Application of lithium-ion battery in new energy vehicle

3.1. The power-train of electric vehicles: the role of the battery management system (BMS)

In recent years, power battery technology has developed rapidly and matured. BMS optimizes battery management to boost service efficiency, service life, cost, and reliability as the battery pack's link to the user [15]. Thus a BMS must be used to monitor the battery status and perform energy management during the energy storage and supply process of lithium-ion batteries.

The basic structure of BMS mainly includes distributed structure and modular structure [16]. A simple monitoring module is attached to each battery cell in the distributed structure to monitor its status in real time and ensure safety, but it has many modules, which can cause data loss and other issues and lower system efficiency and stability. Modular battery packs have many modules, and the main control unit maintains each module separately. The structure is suitable for electric cars with many batteries because to its high collecting accuracy, reliability, and expansibility.

The main task of the BMS is to ensure that the battery pack operates efficiently under suitable operating conditions and to safeguard the safety, durability and performance of the battery system. Its core functions include real-time monitoring of battery current, voltage, and temperature, and collecting and uploading data, which are the basic functions to ensure the normal operation of the system [17]. Also, the BMS is also responsible for battery equalization management, which eliminates the differences between different cells within the battery pack to avoid reducing battery life and discharge efficiency, making it one of the key technologies for battery management [18]. Besides, The BMS estimates the remaining charge (SOC) and drivable range of the EV's battery in real time [19]. The BMS guards against over-voltage, over-current, over-charging, over-discharging, and over-heating thereby preserving system safety [20]. And the temperature control management function prevents overheating from damaging the battery by regulating the temperature of the battery and keeping it within the normal operating range.

3.2. Battery charging technology: fast charging technology and wireless charging technology

Fast charging techniques include pulse charging method, reflection charging method and intermittent variable current constant voltage charging method. Pulse charging uses adjustable amplitude and duty cycle pulse current, as shown in Figure 3. The charging process starts with high current constant current charging for a period of time, then stops charging for a short time to eliminate the polarization phenomenon of the battery, and then repeats the process periodically until the battery is fully charged. The pulse charging method has the advantages of low gas generation, low heat generation and short charging time, but the energy conversion efficiency is low and it is easy to lead to the shedding of the active material of the battery pole plate, which in turn affects the battery life. Additionally, the approach can enhance charging current to a limited level, but a considerable increase requires an extended charging stop period, which may increase charging time.

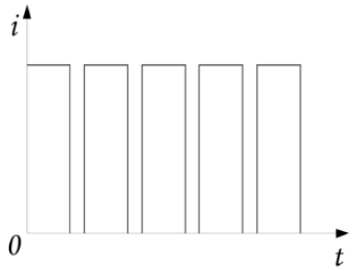

Figure 3: Charging curve of pulse charging method

DOI: 10.54254/2755-2721/2025.23745

As shown in Figure 4, the reflex charging method first charges with a high constant current for a period of time, then stops charging briefly, then discharges for a short time with a negative pulse current, and operates cyclically. Compared to the pulse charging method, the reflex charging method offers improvements in cell polarization, gas precipitation, and charging rate.

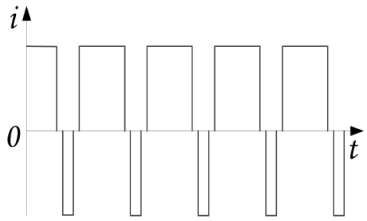

Figure 4: Charging curve of reflective charging method

As shown in Figure 5, the intermittent variable-current constant-voltage charging method uses variable-current intermittent charging in the early stages of charging, stopping charging whenever the battery voltage reaches the cutoff charging voltage, thereby increasing the amount of charge in the battery. In the later stages of charging, the current is reduced and constant voltage charging is used. This method has the advantages of low gas generation, high energy utilization and faster charging rate.

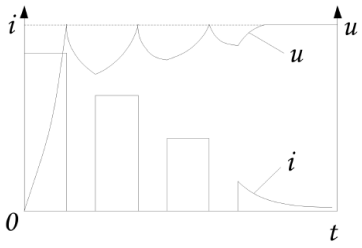

Figure 5: Charging curve of intermittent variable current-constant voltage charging method

In addition, power supplies transmit electromagnetic energy to electrical charges through air gaps without the need for interconnecting wires, a technology known as wireless charging. This technology has been widely recognized for its safety, convenience, and improved user experience [21-23]. Static charging and dynamic (mobile) charging are the two primary categories of wireless charging [24]. Static charging is appropriate for charging stations located at home and in public areas, while dynamic charging enables vehicles to be charged while in motion. Compared to wired charging, wireless charging suffers from lower efficiency, lower power density, higher cost, larger size, and manufacturing complexity [25]. Therefore, in order to enhance power transmission, wireless charging technology for electric vehicles needs to address key issues such as cost reduction and charging efficiency improvement in order to promote its wide application.

3.3. Battery recycling and management: recycling technologies and processes, environmental impacts and controls

The increasing global demand for sustainable development is driving the rapid growth of the electric vehicle market. As one of the core components of electric vehicles, power batteries generate a large number of used batteries at the end of their service life, which contain both valuable resources and hazardous substances. As such, the recycling of power batteries realizes the recycling of resources and reduces the waste of resources, and saves energy and reduces the negative impact on the environment.

DOI: 10.54254/2755-2721/2025.23745

Currently, the recovery methods of lithium batteries are mainly categorized into pyrometallurgy, hydrometallurgy and direct regeneration [26]. The metal elements in decommissioned lithium batteries are separated and purified using high-temperature roasting, acid and alkali leaching, and other techniques in pyrometallurgy and hydrometallurgy to enable resource reuse [27]. Although these two technologies can meet certain elemental recovery needs, pyrometallurgy has high energy consumption, large carbon emissions, high pollution control costs, and it is difficult to recover metals such as lithium and manganese remaining in the slag [28]. Wet metallurgy, on the other hand, has high investment, high cost of wastewater treatment in the later stage, and complicated process [28]. Direct regeneration technology represents a novel recycling method characterized by high efficiency. This approach preserves the original crystal structure, enhances the cathode material through elemental supplementation and structural reconstruction, restores the electrochemical and physicochemical properties of the anode material, and circumvents the intricate processes associated with the extraction and separation of similar elements [29].

The proliferation of new energy vehicles has led to the disposal of power batteries and the substantial accumulation of battery waste, presenting a significant challenge. Resource conservation, environmental preservation, economic growth, and the sustainable development of the new energy vehicle industry are all dependent on the recycling and reusing of waste from power batteries in new energy vehicles [30]. Recycling waste batteries allows for the effective recovery of rare metals and valuable materials, including lithium, cobalt, and nickel, thereby reducing dependence on finite resources and promoting resource recycling. Also, recycling mitigates the release of harmful substances and diminishes environmental pollution. Establishing an effective recycling system and technology can extend the service life of electric vehicles, reduce the overall cost of new energy vehicles, and promote the sustainable development of the electric vehicle market.

4. Challenges and future developments in lithium-ion batteries

4.1. Challenges encountered

The new energy vehicle sector still has various difficulties, particularly in core technology, even if it has made great development. At present, key technologies such as power battery, motor electronic control and vehicle operating system are still mainly dependent on imports, and independent research and development capabilities need to be improved. For example, in the case of power batteries, China still lags behind the international advanced level in terms of energy density, safety, and service life, with a shortage of high-end products. Therefore, breakthroughs in high specific energy, long life, high security battery technology, improve battery energy density, cycle life, and reduce costs, the industry has become the core problem to be solved. Meanwhile, technology research and development should be accelerated to solve the key technical bottlenecks such as short battery life, long charging time, poor thermal stability. In recent years, the domestic lithium-ion battery industry is faced with unstable supply chain, fluctuations in the price of some materials, poor upstream and downstream convergence and other issues, and the blind expansion of production capacity also occurs from time to time. The demand for lithium batteries is closely related to changes in the end market, resulting in fluctuations in demand for raw materials, further exacerbating cost pressures. The main materials for lithium batteries such as Co, Ni, Mn and other rare metals have high processing costs, especially Li_2CO_3 import dependence, which increases production costs. In addition, the rapid development of the new energy vehicle industry, mass production scale surge, followed by a large number of waste batteries, bringing environmental pressure. Hazardous waste is inevitably generated during the battery production process, while the recycling of end-of-life batteries is also an urgent problem to be solved. In battery recycling, power batteries' chemical properties render them prone to combustion or explosion during breakdown,

DOI: 10.54254/2755-2721/2025.23745

hence specialized support is needed. Chemical deterioration and battery reuse are difficult, therefore broad marketing is doubtful. Complex and hard to degrade used batteries may contaminate the environment more, thus technology research and development must improve.

4.2. Future development

The foundation of the development of new energy vehicle industry is breakthroughs in fundamental core technologies and improvement of independent innovation capacity. Mastering core technology is the prerequisite for realizing independent control and sustainable development. In the field of power battery, we should focus on attacking the high specific energy, long life and high security battery technology, improve the energy density and cycle life of the battery, and reduce costs. At the same time, it is necessary to increase the research and development of solid-state batteries, lithium-sulfur batteries and other new types of batteries to seize the high ground of future technology. Encourage businesses to increase R&D investment, support universities and research institutes in basic and applied research, and promote the transformation of scientific and technological achievements, creating an enterprise-driven, market-oriented innovation system that integrates industry, academia, and research. The rapid growth of the new energy vehicle market has drawn attention to lithium-ion batteries. The design, development and application of lithium-ion batteries have a high degree of convenience, China also attaches great importance to the development of new energy vehicle industry, especially in the field of lithium-ion batteries, and gradually introduced more industrial policy support. Moreover, the recycling of lithium-ion batteries has gradually become an important part of the new energy automobile industry. Therefore, in order to safeguard the ecological environment and the sustainable development of the industry, it is necessary to accelerate the research of lithium-ion battery recycling technology and the construction of the recycling system.

5. Conclusion

New energy vehicles have become the general trend. This paper briefly introduces the application of lithium-ion batteries in the field of new energy, such as battery management system (BMS) of electric vehicle, rapid charging technology, wireless charging technology and battery recovery technology. At the same time, lithium-ion batteries also face many challenges, such as technical challenges, economic cost challenges and environmental challenges. At present, the paper is not enough to throw the solution. Looking for solutions is very helpful to the future development of lithium-ion batteries.

References

[1] *Lin, S., et al. (2022) Recent Progress and Future Perspective on Practical Silicon Anode-Based Lithium Ion Batteries. Energy Storage Materials.*
[2] *Kapustin, N.O. and Grushevenko, D.A. (2020) Long-term electric vehicles outlook and their potential impact on electric grid. Energy Policy. 137: 111103.*
[3] *Das, H.S., et al. (2020) Electric vehicles standards, charging infrastructure, and impact on grid integration: A technological review. Renewable and Sustainable Energy Reviews, 120: 109618.*
[4] *Quilty, C.D., et al. (2023) Electron and Ion Transport in Lithium and Lithium-Ion Battery Negative and Positive Composite Electrodes. Chemical reviews.*
[5] *Nishi, Y. (2014) 2 - Past, Present and Future of Lithium-Ion Batteries: Can New Technologies Open up New Horizons? Lithium-Ion Batteries. 21-39.*
[6] *Wang, X., Bao, J. and Wang, X. (2020) Combustion risk and control of lithium-ion batteries in electric vehicles. Automotive Digest, 5-17.*
[7] *Tang, Z., et al. (2024) Advances in Synthesis and Modification of Olivine-Type Lithium Iron Phosphate Anode Materials. Inorganic salt industry, 1-14.*

DOI: 10.54254/2755-2721/2025.23745

[8] Jiang, W. (2018) Preparation and Properties of Anode Materials for Olivine-Type Lithium-Ion Batteries.
[9] Du, Y., et al. (2016) Preparation of three-dimensional free-standing nano-LiFePO4/graphene composite for high performance lithium ion battery. Rsc Advances. 6(57): 52279-83.
[10] Wang, Y., et al. (2024) Advances in high performance of lithium iron phosphate. Modern Technical Ceramics, 45(Z1): 74-99.
[11] Duan, J., et al. (2019) Building Safe Lithium-Ion Batteries for Electric Vehicles: A Review. Electrochemical Energy Reviews, 1-42.
[12] Eftekhari, A. (2017) LiFePO4/C nanocomposites for lithium-ion batteries. Journal of Power Sources, 395-411.
[13] Guan, L., et al. (2021) A LiFePO4 regeneration method based on PVAc alcoholysis reaction[J]. Renewable Energy, 559-67.
[14] Zhang, Q. (2023) Preparation of Rare Earth Ion-Doped Lithium Iron Phosphate Anode Materials and Study of Their Electrochemical Properties.
[15] Liu, D. (2020) Exploring the Current Status of Lithium Battery for Electric Vehicles and Its Development Trend. Internal Combustion Engines and Accessories. 176-177.
[16] Lv, J., Song, W. and Feng, Z. (2019) Design and Implementation of Battery Management System. Battery, 49(06): 499-501.
[17] Chen, G, Quan, L. and Liu, T. (2015) Design of a Multiplexed Battery Status Monitoring System Based on ADuC485. Industrial Control Computer, 28(12): 128-9+32.
[18] Song, W., et al. (2017) Research Progress on Inconsistency Control of Lithium-Ion Battery Packs. Battery , 47(05): 303-306.
[19] Li, J., et al. (2018) Research on Equivalent Model Construction and SOC Estimation Method of Lithium Battery Pack. Chemical Automation and Instrumentation, 45(02): 150-153.
[20] Xue, C. (2017) A Study on the Thermal Management of Pure Electric Vehicle Lithium Battery Based on Liquid Cooling.
[21] Costanzo, A., et al. (2014) Electromagnetic Energy Harvesting and Wireless Power Transmission: A Unified Approach. Proceedings of the IEEE, 1692-1711.
[22] Garnica, J., Chinga, R. and Lin, J. (2013) Wireless Power Transmission: From Far Field to Near Field. Proceedings of the IEEE, 1321-1331.
[23] Lu, X., et al. (2016) Wireless Charging Technologies: Fundamentals, Standards, and Network Applications. Ieee Communications Surveys and Tutorials. 18(2): 1413-1452.
[24] Hong, H., et al. (2024) Automotive Wireless Charging Research and Future Trends. Times Automotive, 12: 10-12.
[25] Ahmad, A., Alam, M.S. and Chabaan. R. (2018) Comprehensive Review of Wireless Charging Technologies for Electric Vehicles. IEEE Transactions on Transportation Electrification, 4(1): 38-63.
[26] Qu, X., et al. (2022) Mechanisms of the Ammonium Sulfate Roasting of Spent Lithium-Ion Batteries. Global Challenges, 6(12).
[27] Roy, J.J., et al. (2022) Green Recycling Methods to Treat Lithium-Ion Batteries E-Waste: A Circular Approach to Sustainability. Advanced Materials. 34(25).
[28] Yu, X., et al. (2022) Current Challenges in Efficient Lithium-Ion Batteries' Recycling: A Perspective. Global Challenges. 6(12).
[29] Zhao, Y., et al. (2020) Regeneration and reutilization of cathode materials from spent lithiumion batteries. Chemical Engineering Journal, 383: 123089.
[30] Chen, Z. (2024) Current Situation and Countermeasures of Power Battery Recycling in New Energy Vehicles. Automobile and New Power, 7(03): 85-88.