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RECENT INNOVATIONS IN LITHIUM-ION BATTERY TECHNOLOGY AND ENVIRONMENTAL IMPACT OF ELECTRIC VEHICLES

НЕДАВНИЕ ИННОВАЦИИ В ТЕХНОЛОГИИ ЛИТИЙ-ИОННЫХ АККУМУЛЯТОРОВ И ИХ ЭКОЛОГИЧЕСКОЕ ВОЗДЕЙСТВИЕ НА ЭЛЕКТРОМОБИЛИ

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This article reviews various international studies and dissertations to highlight recent advancements in lithium-ion battery technology and assess the environmental impact of electric vehicles. Additionally, it offers insights into future expectations regarding the development trends of these technologies.

В данной статье проводится обзор различных международных исследований и диссертаций с целью выявления последних достижений в технологии литий-ионных аккумуляторов и оценки экологического воздействия электромобилей. Кроме того, предоставляются прогнозы относительно будущих тенденций развития этих технологий.

***Keywords**: electric vehicles, lithium-ion, battery, thermal management, environment.*

***Ключевые слова**: электромобили, литий-ионные аккумуляторы, аккумуляторы, тепловое управление, окружающая среда.*

INTRODUCTION

In the early part of 1900 s, the EV design could not compete with the plethora of inventions for the internal combustion engine. The speed and range of the internal combustion engines made them an efficient solution for transportation. By the middle of the 1900 s, discussions about the impending oil supplies, the growing demands of fossil fuels began to rekindle the inventions of alternate energy systems and discovery of alternate energy sources. By the mid-1970 s, oil shortages led to aggressive development of EV programs. In the 1990 s, concerns both over the worldwide growth of demand for fossil fuels for transportation, namely petroleum and the reduction of vehicle emissions has once again intensified EV development. This in turn has led to advances in research and development of traction batteries for EVs. Li-ion batteries are the third type most likely to be commercialized for Electric Vehicle applications. Because lithium is the metal with the highest negative potential and lowest atomic weight, batteries using lithium have the greatest potential for attaining the technological breakthrough that will provide Electric Vehicles with the greatest performance characteristics in terms of acceleration and range. Unfortunately, lithium metal, on its own, is highly reactive with air and with most liquid electrolytes. To avoid the problems associated with metal lithium, lithium intercalated graphitic carbons (Li_xC) are used and show good potential for high performance, while maintaining cell safety. There are various types of materials under evaluation for use in Li-ion batteries. Generally, the anode materials being examined are various forms of carbon, particularly graphite and hydrogen-containing carbon materials. Three types of oxides of transition are being evaluated for the cathode: cobalt, nickel, and manganese. Initial battery developments are utilizing cobalt oxide, which is technically preferred to either nickel or manganese oxides [1]. However, cobalt oxide is the costliest of the three, with nickel substantially less expensive and manganese being the least expensive.

MAIN PART

The «lithium-ion battery» encompasses a number of chemistries where lithium-ions move back and forth between the electrodes (cathode ↔ anode) in a process often referred to as a “rocking chair” mechanism.

Performance of the battery is primarily a function of the ability of the cathode and anode to accept and release lithium ions. This means that power and time between cycles is largely dependent on the amount of reversible lithium-ions and the kinds of materials in the electrodes. Typically, the materials are chosen to amplify this interaction as well as ensure that the lithium ions remain reversible [2].

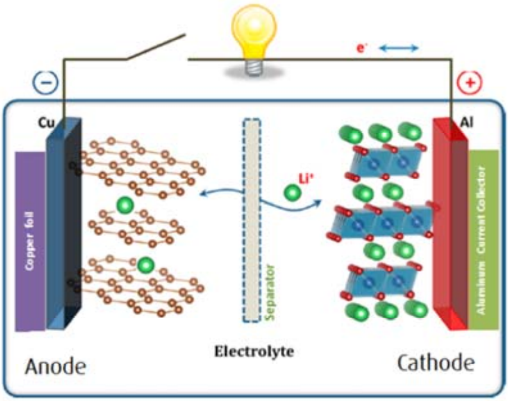


Figure 1 – Lithium-Ion Batteries working system

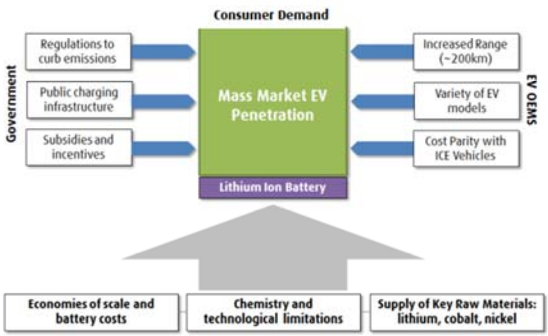
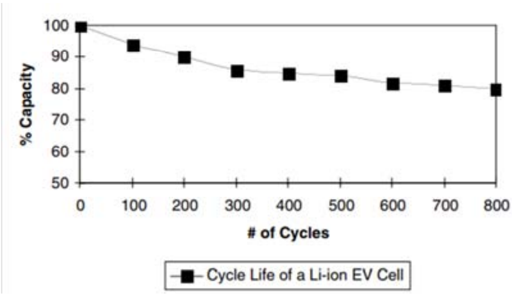


Figure 2 – Mass Market Electric Vehicle Penetration

Growth of the global Electric Vehicles market is led by China. With progressive subsidies, penetration targets, investment, and the number of manufacturers, China has been leading the charge. Tesla might have the highest brand recognition, at least in North America, but Chinese manufacturer BYD (8,25 % owned by Berkshire Hathaway) is the world's largest EV company and battery manufacturer. We believe China's lead can be attributed mainly to the following factors. China has 40 % of the world's EV car stock and 30 % of global sales over all. Over 600 000 units (BEVs, PHEVs and straight hybrids) were sold in 2017, up 71 % from 2016 [3]. The commercialization of the lithium-ion battery (LIBs) has provided the thrust for the electromobility market to take off as it offers more range between charges than its predecessors while providing the power density needed to compete with Internal Combustion Engine Vehicles. Given the higher specific energy and specific power, along with a lighter weight principally due to higher nominal voltage of LIBs, companies such as Tesla were motivated to adapt the technology for use in the automotive industry. Compared to the nickel-metal hydride (NiMh) battery, LIBs provide the same energy at half the size and weight with much higher voltage. For example, Walmer (2015) calculated that a 350 V NiMh battery would require about 292 cells while a lithium-ion battery with the same voltage would require only 98 cells. LIBs also have a much better cycling life (i.e., charge and discharge) compared to other rechargeable chemistries on the market and can reach thousands of cycles before needing to be replaced. Part of this is due to the lack of a memory effect. For example, if a NiCd battery were charged after being only partially discharged, it would lose capacity because it would begin to mirror that partial range.



Picture 3 – Life cycle of Li-ion Electric Vehicles Cell

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