Reduction of the CO_2 emission from battery electric cars

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Abstract. Nowadays, it is known that climate change is a serious environmental problem around the world. The CO_2 emission of transport occupies a part of the total emission amount, which contributes majorly to increase the average temperature of Earth. Through investigation, it is found that the so-called 'zero emission' electric vehicles actually emit CO_2 gas., mostly due to the production process. Thus, it is necessary to reduce the amount of CO_2 emission from electric cars. By researching the amount of CO_2 produced from making each component of battery electric cars, it is found that the emission from producing lithium-ion batteries stands for a very big proportion of the sum of CO2 emission. In order to improve the situation, the author searched and assessed some relevant solutions that had been provided by other researchers to find out feasible and useful ways to reduce the CO_2 emission from operation and disposal electric cars. Through the research, one efficient way is to improve the recycle of $LiCoO_2$ batteries by a green deep eutectic solvent (DES) of $LiCl\text{-}CH_4N_2O$. This way is both low-cost and helpful to reduce CO_2 emission from recycling batteries. Because it saves some valuable metals extracted from the old batteries and consumes low energy. Another approach is to use photovoltaic-energy storage charging station to charge electric cars. One of the most predominant benefits of this type of stations is that it is much safer than other general charging stations, as it reduces the intensity of grid operation by constructing a energy storage system. At the same time, it is helpful to reduce the greenhouse gas from electric cars by encouraging drivers to use solar energy to charge their vehicles. Therefore, these two ways are both efficient to reduce CO_2 emission from electric cars.

Keywords: CO_2; electric car; manufacture; lithium-ion batteries.

1. Introduction

In today's world, battery electric vehicles have been widely used among various nations and has been regarded as an effective transport to relieve the problem of global warming. This is because that battery electric cars use batteries, instead of fossil fuels as the source of energy. Fig.1 illustrates the full life cycle of an electric car, which includes production, use, secondary use, recycle and mining. What's surprising is that through assessing the CO_2 emission of these five steps, it is found that CO_2 gases, which contributes to the climate change, is majorly emitted during the production step. This makes electric vehicles less green than people originally thought.

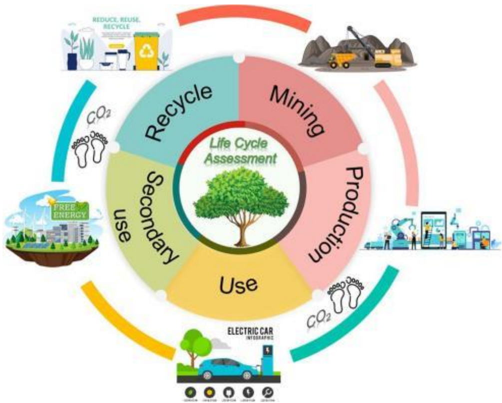

Fig 1. The full life cycle of an electric car [1].

Therefore, in order to make battery electric vehicles greener, the production process should be improved. According to Fang Wang, about 11.3 million people have bought battery electric vehicles worldwide at the end of 2021. [1]. Meanwhile, China made a big contribution of 51% of global

Electric vehicle sales [1]. Nowadays, it seems that the production and sales of electric cars will keep rising. Hongliang Zhang et al. assessed the life cycle and entropy weight of battery-powered electric vehicles to investigate the comprehensive environmental influences brought from 11 types of Li-ion batteries in electric cars, both globally and regionally in 2023 [2]. As a result of this research, Li-S battery was regarded as the battery that emitted the least amount of CO_2 gas in the use stage of electric cars [2].

In this research, some effective ways to reduce the CO_2 emission during the manufacture of these cars will be investigated. In this way, the battery electric vehicles will be greener and the problem of global warming will be alleviated if the solutions mentioned in this essay are applied to the manufacture of them. Therefore, the essay provides useful methods for the protection of the living environment.

2. The Component of Battery Electric Cars and its Emission

2.1. The Component of Battery Electric Cars

The components of a battery electric cars include the chassis, lithium-ion battery, motor and inverter. The functions of them are different. It can be seen in Fig.2, the chassis parts of a car contain lots of components, such as the interior, body and tires.

Fig 2. The chassis of a car [3].

As the chassis affords the whole load and prevent drivers from being harmed seriously in car crashes, it is regarded as the most essential passive safety feature of a car [4, 5]. At the same time, it provides stability for the body in which it is installed and makes the body intact structurally [3]. Lithium-ion battery provides the electric energy required for electric vehicles. One commonly used lithium-ion battery uses $LiCoO_2$ and graphite to make a cathode and an anode respectively. This provides the battery with high energy density, exceptional cycle life and reliability. The appearance of a motor is like the one shown in Fig.3, and the function of it is to supply the energy used in operating an electric car by converting electric energy into mechanical energy. A car power inverter is a device taking the direct current power that an electric car's battery and alternator use and converting it to alternating current for the stator, as shown in Fig.4, which is a stationary part of the electric motor. It is used to generate a strong magnetic field used for driving the rotating motor, which produces the working motion.

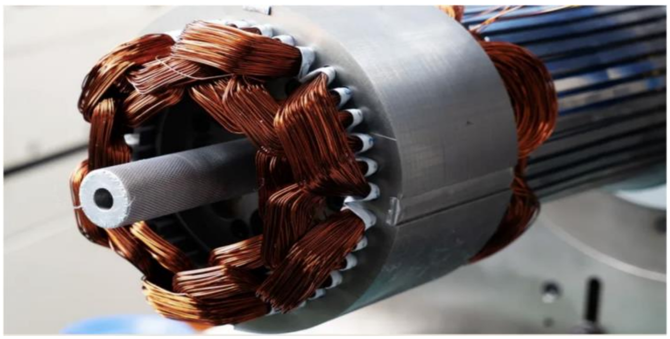

Fig 3. Electric motors are everywhere.

Fig 4. Stator-in-motor.

2.2. The Assessment Method of CO2 Emitting

There are several things to do to find out the methods to optimize the production of a battery electric vehicle. Firstly, searching the components manufactured of it. Secondly, calculating the percentage of each component contributing to the sum of CO_2 emission for the manufacturing process. Thirdly, finding out the component whose CO_2 emission stands for the largest proportion of the total amount of CO_2 emitted. Fourthly, investigating the reasons for this and trying to find some improvements that can be done based on the reasons. Finally, assessing whether each solution is available and feasible, and deciding the effective approaches that can be used to reduce the CO_2 emission from manufacturing a specific component of battery electric vehicles.

A large number of academic articles has illustrated that the production of electricity is the main factor affecting battery electric car's impact on global warming, followed by battery production [6,7]. This study will focus on the CO_2 emission from manufacturing battery. In the past, lead-acid battery was used commonly in electric vehicles, however, it was started to be replaced by the invention of lithium-ion battery in the beginning of 21^{th} century. They are widely utilized in a variety of electronic products, including mobile phones and digital cameras [8]. In recent years, the output of this type of battery enjoyed a significant incline, especially in China. It is reported that the produced Li-ion batteries rose to 324 GWh by 2021 [9]. Additionally, the Nickel manganese cobalt oxide Li-ion battery emits 172±47 kilograms of CO_2 per kilowatt-hour of battery capacity for electric cars worldwide [10]. To understand this, the definition of carbon footprint is in need. In Wiedmann and Minx's view, carbon footprint is used to indicate the CO_2 emissions which result directly or indirectly from a product's activity throughout its life cycle [8]. In this research, the value of carbon footprint is used to describe the CO_2 emission from the manufacture, operation and disposal of battery electric car. Therefore, from these data, it can be deduced that producing battery is indeed one of the main drivers of electric vehicles' contribution to global warming [11]. In this sense, the measures to reduce the carbon footprint during manufacture process is vital for resolving the problem of climate change.

3. Improvement of Manufacturing Process of Battery Electric Cars

3.1. The Way to Improve the Recycle of Li-ion Battery

The first way to reduce the carbon emission of manufacturing Li-ion batteries is to recycle them. As is known, $LiCoO_2$ batteries are traditionally recycled through destructive degradation, which is required for valuable Li and Co to be extracted by high temperature roasting or acid leaching [12]. In order to avoid the serious pollution and the waste of valuable metal of lithium-ion batteries, Junxiong Wang et al. suggested a direct way to repair the totally degraded $LiCoO_2$ batteries [13-15]. In order to replace the lithium and cobalt needed for the simultaneous direct repair of deteriorated $LiCoO_2$, the DES functions as a carrier of Li-ions and Co-ions [12].

The first method mentioned above is feasible and useful. Firstly, it ensures that the defective structure is effectively supplied with Li-ions and Co-ions to achieve a desired electrochemical performance [12]. Secondly, the energy consumption and emissions during the process are low and few, so this way is green [12]. Thirdly, it is low-cost. Since the DES has high thermal stability and sustainability, no redox reactions happen when it is heated to 120 degrees [12]. Therefore, the composition of the DES is constant, which enables it to be recycled [12]. In this sense, the cost of changing the DES regularly is able to be avoided.

3.2. Photovoltaic–energy Storage Charging Station

The mining and refining processes of metals used in making batteries, such as lithium and cobalt, emit a considerable amount of greenhouse gas, which contribute to the large carbon footprint of manufacturing lithium-ion batteries. Thus, it can be deduced that replacing batteries by renewable energy, like wind power and solar energy, to charge electric cars is possible to reduce the CO_2 emission from the production of electric cars effectively. In this way, a new charge station named Photovoltaic–energy storage charging station (PV-ES CS) has been invented and used worldwide [16]. There are various benefits of this charging station. On the one hand, it guarantees the grid system's stability, safety, and the quality of the power [16-18]. Due to these stations' concentrated charging and high charging power, the operation of the power grid would be extremely dangerous if a large number of EVs were charging simultaneously [16]. In comparison, through PV-ES CS, the risks to the power grid instability will be mitigated greatly. As can be seen in Fig.5, there is a solar charging panel at the roof of PV-ES CS. A large proportion of the electric energy supplied is accessed through photovoltaic power generation. In addition, the construction of battery energy storage system provides a certain part of electricity for EVs as well. In this way, PV-ES CS not only controls the uncertainty of generating solar power, since sun light cannot maintain strong, but also reduces its demand for grid power as well as an impact on energy load in the electricity network, when the EV is charged. As a result of this, the efficiency of power generation and the safety of operating grid are ameliorated substantially. On the other hand, PV-ES CS uses renewable energy to charge electric cars, so the demand of batteries and the amount of CO_2 emission seems to increase greatly.

Fig 5. Photovoltaic–energy storage charging station.

4. Conclusion

This academic article focuses on solutions dealing with the large amount of CO_2 gas emission from battery electric vehicles. One approach is to improve the recycle of $LiCoO_2$, which is widely used in making the cathode of batteries. To that end, the new environmentally friendly LiCl-CH_4N_2O DES product is suggested to deal with material waste and pollution caused by an outdated destructive way of recycling batteries. The recycle is improved through using DES to help the selective transport of Li-ions and Co-ions for replenishing Li and Co required for the direct repair of degraded $LiCoO_2$ simultaneously. In this way, fewer valuable materials, such as Li, is likely to be wasted, which resolves the high-cost problem. Recycle plays an important role in diminishing the CO_2 emission from producing batteries, since it decreases the demand of producing many batteries and lowering the energy consumption of production. Hence, recycling Li-ion batteries with the help of LiCl-CH_4N_2O DES is profitable for making the manufacture of electric vehicles greener. This research brings lots of benefits. Apart from that, the goal of reducing CO_2 emission from electric cars is assisted to be achieved by improving the charging way of electric cars. The invention of PV-ES CS plays an important role in it. Meanwhile, it relieves the problem of solar power generation’s uncertainty and reduce the electric intensity of operating grid by constructing energy storage system.

PV-ES CS is able to supply electric energy needed from EVs sustainably and ensures the safety of operation grid. The construction of PV-ES CS is effective to make EVs greener, since it is both economically feasible and highly safe. In the future, the reduction of carbon footprint in whole life-cycle of electric cars is likely to be attached greater importance by researchers.

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