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The Potential of Lithium Alternatives in Rechargeable Batteries

1. **Introduction**

With the growing use of rechargeable batteries in many forms, many are searching for methods to improve the power and practicality of these batteries. Specifically, altering the chemical composition is the most drastic way to improve battery life and power. Because of this, many questions have been raised about what chemicals to change. Studies have shown that changing the composition of commonly-used lithium-ion batteries can make them more efficient while not dramatically driving the cost up.

Manganese oxides, when used in rechargeable batteries, can offer efficiency while still maintaining a low cost1. Silicon can improve the specific energy that a lithium battery can contain2. Also, when lithium and sulfur are used together, they have the potential to lower costs if sulfur could be better utilized2. Tellurium is gaining popularity because of its electrical conductivity and high volumetric capacity3. Also, the tellurium-carbon electrode has high-capacity retention which shows improved efficiency in batteries3.

When comparing different batteries, the potential voltage and electric power over time are indicators of a powerful battery. When the possible voltage is higher, the battery is capable of more power. The same assumption can be made with electric power over time. The changes in chemical composition were adding other chemicals to increase productivity but keeping the lithium that is standard in batteries. With this, I intend to explain the possibilities of changing the chemistry of rechargeable batteries and to compare which chemical compositions have the greatest potential.

1. **Methods**

With the voltages and the electric power over time, I have compared the efficiencies of various batteries when the chemical composition is altered. These chemicals include lithium, tellurium, manganese, carbon, and sodium. By comparing the potential voltages and electric power over time of these chemicals, I can determine how including each one will improve lithium battery performance and which one could help the most. The most powerful batteries will have a high potential voltage. Similarly, the most efficient batteries have high electric power over time.

This data comes from studies on how different chemical compositions of batteries have improved battery technology. The sources come from chemical engineers and experts who have the means to create and test batteries, and they touch on the specific properties of these chemicals, why they are better than past chemical compositions, and what possible limitations there are. They also address how safety concerns may overrule efficiency in some cases because of highly reactive chemicals.

1. **Results**

The inclusion of manganese oxides in many different forms of batteries has potential to improve mostly any rechargeable battery. The study of manganese oxides in batteries1 focuses on their potential in batteries, beyond only lithium-ion batteries. It highlights the potential of manganese oxides despite what kind of battery they are chemically combined with. Specifically, MnO nanoparticles produce the greatest specific capacity with 536 mAh g-1. This is much higher than any other manganese oxide. It also continues to run strongly after over 250 cycles, indicating that it will be long-lasting.

The carbon-pore structure in tellurium-carbon electrodes has the potential to significantly alter the chemical reactions in batteries3. Because of carbon’s pores, it can keep the tellurium in batteries from undergoing drastic volume change. Also, the pores help electrons be transported, therefore increasing the efficiency of batteries with tellurium-carbon electrodes. However, the specific capacity of these batteries is not as high as those with manganese oxides. Rechargeable batteries with tellurium-carbon electrodes only have a specific capacity of 418 mAh g-1. They also run at 90% capacity retention after 100 cycles which is not as resilient as manganese oxide batteries.

Lithium-sulfur batteries have a drastically higher theoretical specific capacity3 with 1675 mAh g-1. However, they are not as efficient as that might make them seem. This is due to its poor conductivity. This causes storage loss and significantly decreases the power that a lithium-sulfur battery can contain.

Compared to lithium-sulfur batteries, lithium-selenium batteries have a lower specific capacity of 675 mAh g-1. This can be combatted, however, with the fact that they are significantly more conductive than lithium-sulfur batteries3. Because of this, they can hold much more power and are more practical than lithium-sulfur batteries.

Sodium-ion batteries, instead of lithium-ion batteries, can be taken advantage of for their good conductivity as well4. When sodium-ions are used with antimony, it results in a specific capacity of about 300 mAh g-1. However, this combination is highly flammable, resulting in a safety hazard. Because of this, safety precautions cannot be overlooked when determining how practical different chemical makeups of rechargeable batteries are.

For another test, an aluminum-ionic liquid’s capacity was tested4. It started with a capacity of 305 mAh g-1. However, after only 20 cycles, the capacity had decreased to 273 mAh g-1. This inconsistency makes aluminum an impractical chemistry for rechargeable batteries. Although it started with a relatively high capacity, if it regresses very quickly, it cannot be used for lengthy periods of time and should be replaced with a longer-lasting chemical alternative.

While the use of tellurium in batteries does not produce as high of a volumetric capacity compared to sulfur and selenium, it is promising for small, rechargeable devices because of its high volumetric capacity of 2621 mAh cm-3 and its conductivity5. Also, the energy density of tellurium-based batteries is comparable to lithium-based batteries, therefore solidifying its ability to be an energy storage material.

1. **Conclusion and Limitations**

For many cases, lithium-selenium batteries are a frequently overlooked chemical composition for rechargeable batteries. They have an extremely high specific capacity, and it does not decrease quickly. Although lithium-sulfur batteries have a high theoretical specific capacity, the poor conductivity keeps them from being a practical option because they quickly lose power. Also, as previously stated, in some circumstances, tellurium-based batteries would be a practical chemical composition for batteries because they can hold a significant amount of energy in small volumes.

Because of the inability to test these different chemical makeups in the same environment, these results could be varied because of uncontrollable discrepancies in the batteries’ surroundings or even in how they were created. To get the most accurate results, batteries would have to be tested in the same location and environment under closely monitored conditions to ensure that the data is as precise as possible.

References

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