The energy density of contemporary batteries in popular use today, such as Lithium-ion batteries, is abysmally low when compared to the energy density of fossil fuels. Obviously a battery with a higher energy density is required in order to meet the world’s growing energy demands. Lithium-Air batteries provide a promising alternative over contemporary battery technologies due to their theoretical energy density which rivals fossil fuels. The research being conducted on behalf of Dr. Jun concerns the search towards finding a better electro-catalyst for these batteries, which will help the kinetics of the battery and lead to a more efficient, rechargeable, and reliable battery with an extraordinary high energy density. This research group also works on improving the overall quality of current Lithium-Air battery designs by developing catalyst coating that will increase the efficacy and cyclability of the Lithium-Air cell. In order to provide conclusive evidence that a stride in Lithium-Air batteries has been reached, many battery cells must be assembled and analyzed.

Abstract

The energy density of contemporary batteries in popular use today, such as Lithium-ion batteries, is abysmally low when compared to the energy density of fossil fuels. Obviously a battery with a higher energy density is required in order to meet the world’s growing energy demands. Lithium-Air batteries provide a promising alternative over contemporary battery technologies due to their theoretical energy density which rivals fossil fuels. The research being conducted on behalf of Dr. Jun concerns the search towards finding a better electro-catalyst for these batteries, which will help the kinetics of the battery and lead to a more efficient, rechargeable, and reliable battery with an extraordinary high energy density. This research group also works on improving the overall quality of current Lithium-Air battery designs by developing catalyst coating that will increase the efficacy and cyclability of the Lithium-Air cell. In order to provide conclusive evidence that a stride in Lithium-Air batteries has been reached, many battery cells must be assembled and analyzed.

Introduction

Contemporary Lithium – Air batteries suffer from a variety of defects which render them incapable of becoming viable towards use in the real world. A few of these problems are listed below:

1. As far as anyone is concerned these cells have yet to reach their proposed theoretical energy density of 11 kWh/kg
2. These cells fail to recharge efficiently; the battery discharges at a voltage of around 2.6V, however a voltage of at least 4.0V is needed to recharge the battery
3. The lifetime and cyclability within the battery is jeopardized as a result of the accumulation of Lithium Peroxide (LiO2), the end product material as a result of the redox reaction occurring inside the battery, and Lithium Carbonate (Li2CO3), Carboxylate (LiCOOH), and Hydroxide (LiOH), the by-products resulted from the side reactions with CO2 and H2O.

How it works: Most batteries operate on the same basic principle which is, having a simple redox reaction between two different ends of the battery (known as the electrodes) as a result there is a potential which will drive electrons towards different sides of the cell, depending on whether or not the cell is discharging or recharging. A Lithium-Air battery is no different.

Methods

Goal 1: Find a suitable electro catalyst to help facilitate the battery reaction better

Cheap, sustainable ORR and OER catalysts are needed to improve Li-air practicality

Molecular cooperative assembly (MCA) assisted synthesis of carbon nitride and metal carbodinitride: 1) Controlled organization of carbon nitride nanoparticles, nanodots, and nanoshells, 2) MCA as reactive template to synthesize mesoporous transition metal carbodinitride/carbodinitride/amorphous carbon

Fig 1: Crude Galvanic Cell Diagram

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Gaseous cathodes lead to unique cell configurations and considerations

R2032 coin cells with one holey current collector are placed in a beaker-type oxygen chamber at ~ 1.1 atm of O2. This cell affords a gas sampling port for GC-TOF analysis. The cell utilizes 0.2 mL CF3SO3Li (LiTFA) in tetraethylene glycol dimethyl ether (TEGDME) which has a upper potential limit of 4.7 V vs. Li
c

Summary and Conclusion

Most of the testing with cells shows promising results. More specifically, catalysts synthesized with compounds in the nitride family are particularly effective, such as titanium nitride and graphite carbon nitride

Goal 2: Analyze how these battery cells are behaving in terms of interpretable data

Graph 1: I (mA) vs. V (vs Li/Li+) for mesoporous MCA-g-C3N4 and TiN@C vs. GDL catalyst

LSV analysis reveals the stability of TiN@C and MCA-g-C3N4 up to 4.75 V in LiTFA/TEGDME electrolyte. TiN@C and MCA-g-C3A show a discharge capacity of 7.501 and 5.432 mAh/g Super P, respectively, while that of Super P is 3.255 mAh/g Super P. Especially, it is notable that TiN@C improves the cyclability in the GGPL test (1.000 mAh/g Super P and 200 mAh/g).

Graph 2: V (vs Li/Li+) vs. capacity (mAh g^-1)

If you were to put every battery on Earth together, that "super battery" could only power the world’s current energy demands for 10 minutes! The researchers involved in this project already know which problems to tackle. What it will come down to really is the electro-catalyst consider this the Holy Grail of Li-Air batteries.

Fig 2: I (mA)

Fig 3: V (vs Li/Li+)

Fig 4: capacity (mAh g^-1)

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Fig 3: I (mA)