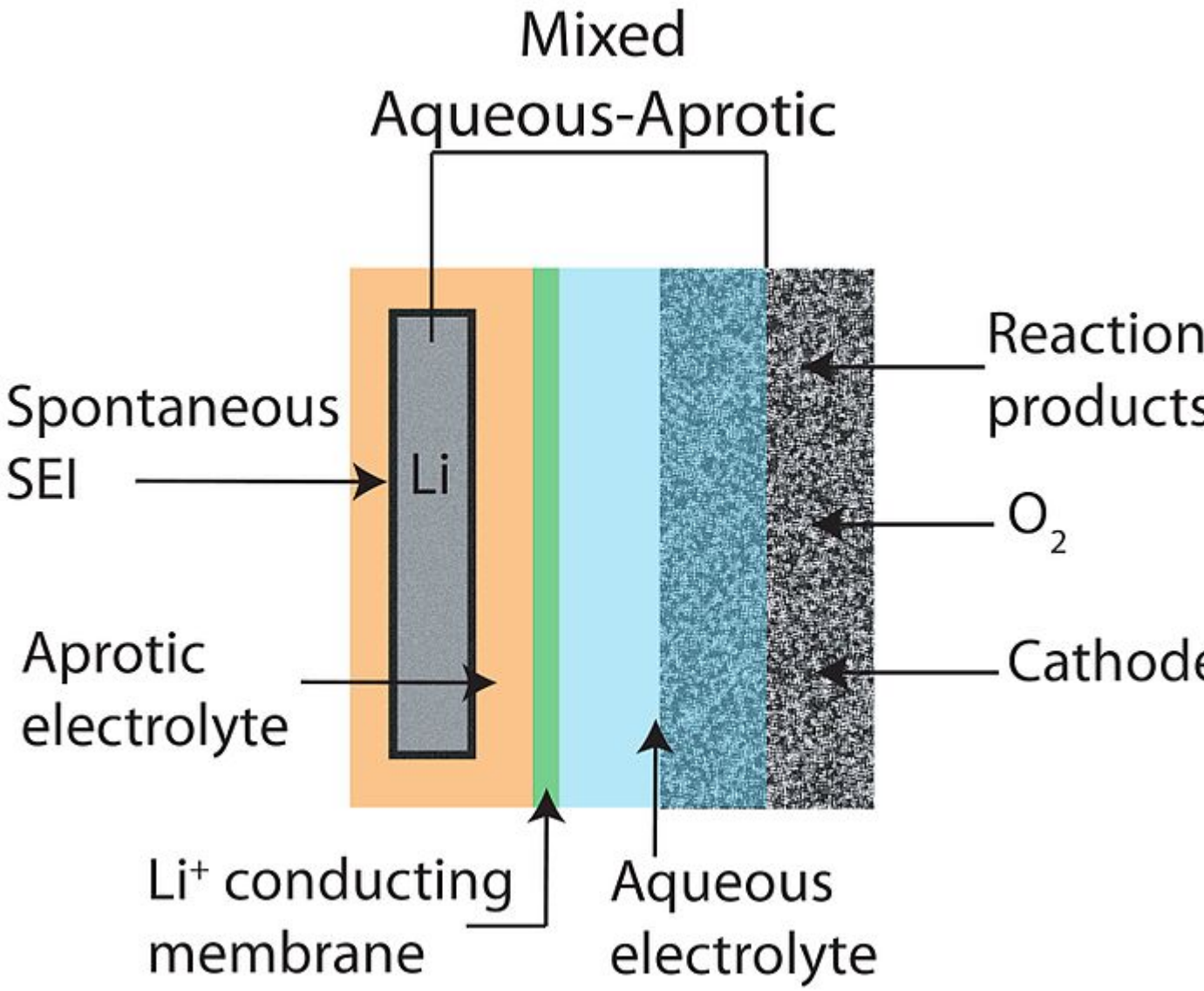
Titanium dioxide nanotubes in lithium-air batteries [1]

Lithium-air batteries [2] are superior to gasoline and lithium-ion [3] batteries with regards to energy density. Energy density is the amount of energy that can be stored in a given system per unit of mass or volume. Lithium-air batteries [2] achieve a higher specific energy density using oxygen from the environment rather than from an internal oxidizer. Lithium-air batteries [2] utilize a chemical reaction between the surface of the lithium and the air at the anode to create lithium ions and electrons, which flow across an electrolyte to reduce oxygen at the cathode and create an electrical current[1]. In this process, lithium peroxide (Li2O2) usually deposits on the cathode as a result of the reaction and causes profound degradation of the battery [4], negatively affecting the ability of the battery [4] to recharge. In lithium-air batteries [2], titanium dioxide [5] (TiO2 [6]) nanotube arrays, with their large surface area and transport channels, accommodate Li2O2 precipitates and aid in the reversal of Li2O2 formation and decomposition that occurs during the discharge and recharge phases of the battery [4][2]. Adding TiO2 [6] nanotubes to pre-existing graphene [7] cathodes also helps to limit side reactions within the cathode and prevent the decomposition of carbon [8], which increases the longevity of the cell. With battery [4] technology heralded as the rate-limiting factor for moving the automobile fleet away from internal combustion engines that emit carbon [8], smog forming compounds, and other air pollutants regulated by the US Environmental Protection Agency[3], Lithium-air batteries? improvement to battery [4] viability make electric and hybrid vehicles better able to facilitate this automobile fleet transition.



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Author:

Abigail Howel [12]

Development Stage:

- Engineering [13]

Key Words:

- TiO2 nanotube arrays [14]
- Lithium-air batteries [2]

Mechanism:

- Passive Nanostructure [15]

Summary:

Using a lithium anode and carbon [8] based cathode with TiO2 [6] nanotubes enhance the production of electrical current in lithium-air batteries [2]. The metal-air exchange generates higher amounts of energy (theoretical 43.2 MJ/kg v. liquid gasoline 36.4-49.6 MJ/kg) by eliminating the

need for internal oxidizers[1]. TiO2 [6] nanotubes improve the integrity of the cell by collecting Li2O2 deposits and decreasing side reactions in the cathode and electrolyte solution.

References

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Function:

- Enhanced Efficiency [16]
- Transportation [17]

Material:

- Titanium [18]
- Lithium [19]
- Oxygen [20]

Benefit Summary:

The addition of TiO2 [6] nanotubes to the cathode of lithium-air batteries [2] preserves the cell by collecting Li2O2 precipitate that could otherwise degrade the porous cathode, and also aids in the reversal of Li2O2 formation and decomposition to prevent deposits. TiO2 [6] nanotubes are more stable, environmentally friendly, easily manufactured, and cost efficient as compared to nanoporous gold particles. The bio-compatibility of these nanotubes due to their transport channels also allows for the introduction of additional catalysts into the cathode, which aid in the oxygen evolution reaction and disrupt the crystalline structure of Li2O2 precipitates[1].

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Benefit:

- Greenhouse gas emission reductions [21]

Risk Summary:

The predominant design of lithium-air batteries [2] is the aprotic-aqueous model, in which ions and electrons pass through an electrolyte to the cathode. Aprotic (liquid organic [22] electrolyte) and aqueous (lithium salts dissolved in water [23]) solutions are flammable and can rupture and ignite, making the design more conductive than solid-state models, but at increased safety risk[1].

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Risk Characterization:

- Simple [24]

Risk Assessment:

- Explosive Risks [25]

Facility:

- Energy Systems [26]

Activity:

- Battery Technology [27]

Challenge Area:

- Energy Efficiency [28]
- Greenhouse Gas Emissions [29]

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