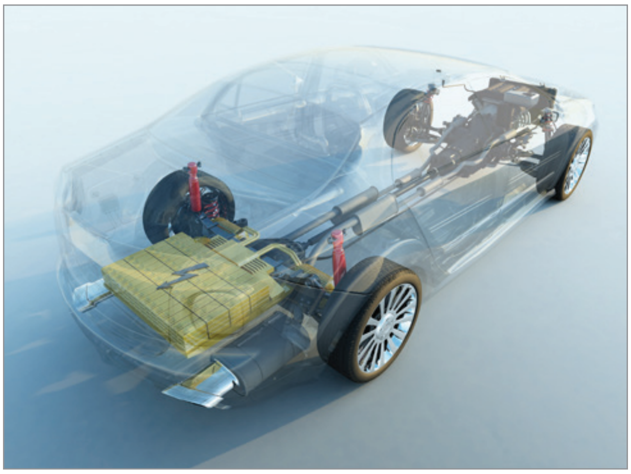
An electric flight to a post-oil era

"Ignorance more frequently begets confidence than does knowledge: it is those who know little, not those who know much, who so positively assert that this or that problem will never be solved by science" - Charles Darwin in 'The descent of man'

Exploring the untapped potential of li-ion batteries

The extent of human technical prowess can never be underestimated; particularly in situations endangering our existence to its core. There is no bigger fear of mankind than extinction. And the risk threatening human civilisation the most is catastrophic climate change, as per the report by Global Challenges Foundation. In such a world, the potential power of batteries brings in the hope of recovery and someday, a carbon neutral world. Since its first commercialisation by Sony in 1991, lithium-ion batteries have steadily grown as our battery of choice given their staggering advantages over other batteries. Today, li-ion batteries are in our hands, in our laps and below our car seats; à la Tesla. However, the potential doesn't end there, and that is where it gets interesting.



A li-ion battery, like any other battery, consists of a collection of cells. Each cell contains two electrodes with an electrolyte in between. Transfer of ions and electrons between the two electrodes then powers electronic devices. However, what made li-ion batteries pique our interest is its fundamental chemistry. Lithium is one of the lightest elements and has one of the smallest ionic radii. Also, it has the lowest reduction potential [1]. What this means is that it can pack more power in a lighter more compact battery. Moreover, li-ion batteries tend to have a low memory effect and very low self-discharge. With the unbeatable energy paired with high power density, it is not surprising in the rechargeable battery market share [2], li-ion batteries are forecasted to overtake lead-acid batteries in 2020.

Farewell to fuel in cars?

Awareness about the pressing need for zero-emission vehicles in the near future, along with the eccentric buzz created by companies like Tesla, have renewed public interest in electric vehicles. In fact, the global electric vehicles battery market is predicted to reach around $94 billion by 2026 [3]. li-ion batteries, however, still have a long way to go before they can fully exploit their commercial potential and replace fossil fuels completely.

Tesla, with its research, focused on developing a more efficient li-ion battery for their electric powered cars, describes the biggest challenge in regard to the li-ion, as increasing its energy density while maximising the battery life [4]. Batteries inherently decay with time, regardless of whether or not they are being used. Temperature, humidity and other environmental factors could affect battery performance. Demonstrable reliability and safety while in operation are still critical issues, not to mention the economy of scale. Rightfully then, extensive research is being carried out across the world in attempts to maximise performance outputs and mitigate risks. For example, nanomaterials are being investigated for electrodes to provide a larger surface area for lithium ions, improving the density of ions circulating in the cell. This could significantly improve energy density of these batteries [5].

Battery powering future flights

What could then be a future avenue for li-ion batteries? A zero emission all-electric powered aircraft? Perhaps. In 2017, the aviation industry was responsible for around 2% of the global greenhouse gas emissions. By 2025, this number is projected to increase by 70% [6]. li-ion battery powered aircrafts could not only curb air pollution but also noise pollution.

So, what would it take to power an electric plane? Whereas the limiting factors in electric cars are the costs and size of the battery, in aircrafts weight takes precedence [7]. Batteries currently do not offer the power to weight ratio (the energy density of li-ion battery will need to be at least ten times its current value to be comparable to that of jet fuel) required for the commercial aeroplane. Engineering new materials and innovative chemistries for the batteries is one way to tackle the problem. The less obvious route is exemplified by NASA's X-57 Maxwell, an aircraft designed to operate more energy efficiently. They have employed 12 electric motors to provide 'distributed electric propulsion' which is expected to decrease the energy requirements by around five times [8]. This takes a significant burden off of battery energy requirement for an aircraft. The final solution would probably be somewhere in the middle between high-energy density batteries and energy efficient aircrafts. Nevertheless, incessant research efforts can potentially give us our first electric aircraft worth taking on the next challenge of its commercialisation.

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Magic powder and beyond

Efforts continue to improve li-ion battery performance. Sila Nanotechnologies is a company looking to innovate li-ion batteries by developing a silicon 'powder' that would replace the more commonly used graphite in the anode. Silicon exhibits a higher capacity for lithium ions as compared to graphite. With further engineering, a product like this could realise the possibility of electrification of aviation. With the potential for 40% increase in energy performance of lithium-ion batteries [9], the material is then rightfully referred to as 'magic powder' [10].

As we unearth key improvement areas to bring out the superior performance of li-ion batteries, the possibilities and future of our technological prowess could be endless!

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