Ultra-Safe Lithium Ion and Lithium Polymer Batteries

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India is the world's 2nd largest smartphone market (according to *The Hindu*), however, lagging behind in manufacturing. With the existing huge market of smartphone, demand is also growing for electric 2-wheelers, e-rickshaws, 4-wheelers, etc. All of these devices require lithium ion batteries to operate. As per the projection by NITI Aayog, 300 billion U.S. dollar market (2,11,80,84 crores INR) exists only for electric vehicles, within the time period of 2017 to 2030. The report ('India's Energy Storage Mission' 2017) also says, 80% of market coverage is possible if India goes for battery manufacturing rather than importing them.Undoubtedly, it is a great time for India to move into lithium ion battery manufacturing.

Now, the most shocking fact is that conventional lithium ion batteries are prone to catch fire. Case in point is the notorious Samsung Galaxy Note 7 cell phone saga in which there were a lot of incidents of phones unexpectedly catching fire or blow-ups, causing concerns among users, especially during airtravel. In addition, incidents of electric vehicle battery explosion have been in the news. The story of Tesla Model S explosion in Florida is well-known. Recently, the Government of India has been pushing hard for the adoption of electric vehicles and renewable energy. Unfortunately, for a country like India, it is very difficult to run an electric vehicle as the average temperature is quite high in most cities in the country. Running an electric vehicle at a higher temperature will obviously increase the chance of battery explosion, risking life.

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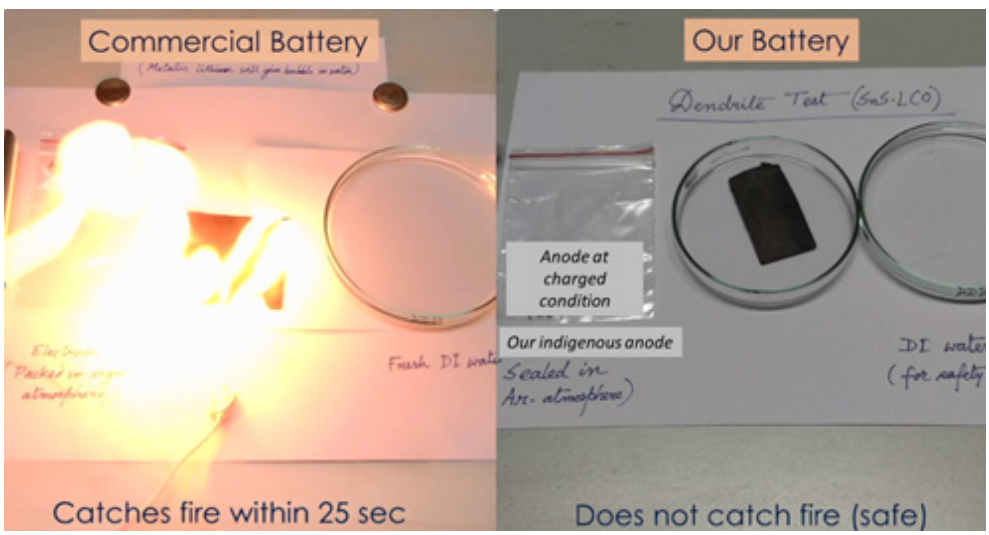
* Mr. Prasit Kumar Dutta, Ph.D. Scholar from Indian Institute of Technology, Mumbai, is pursuing his research on "Sulphide based Anode and Interface Studies for Sodium-Ion and Lithium-Ion Batteries." His popular science story entitled "Ultra-Safe Lithium Ion and Lithium Polymer Batteries" has been selected for AWSAR Award.

Prof. Sagar Mitra's research group at the Indian Institute of Technology Bombay (IITB) is involved in lithium ion battery fabrication from 2009. His team is focused on developing safe lithium ion batteries by replacing the commercial materials. Obviously, those materials should be made available in India at a low -price, compared to the commercial one. The author is one of the key members of Prof. Mitra's battery fabrication team. He has come out with a new material which can be made available at a 1/4th cost of a commercial material. At the same time, that material can provide ultra-safety featuring higher energy density and impressive battery life. The synthesis of the material fortuitously happened at the IITB laboratory and was further scaled up for commercial level production with a very high conversion efficiency of more than 97%.

Now, the question is the meaning of ultra-safety and its importance for India. It is well-known that a lithium ion battery explodes due to dendrite formation. This can happen due to overcharging, avoid of protection circuit to make a cheaper battery, fabrication issues and many more. Scientifically, dendrite is actually a grass-like form of lithium metal which can grow like a spike onto the anode material, graphite. Thus, short-circuit the battery internally by connecting both the electrodes and can explode randomly. Fortunately, smartphone batteries are small compared to an electric vehicle's. Hence, the concern is not so much for small devices. But a vehicle battery is much bigger. Hence, the safety issue must be considered. It is expected that an electric vehicle battery will not explode at any cost and at the same time should be capable to endure high-temperature operation. So, the technical meaning of ultra-safety for Indian is a dendrite-free battery which will never swell even at high temperature in any region of India. The current lithium ion battery technology cannot offer all of these criteria. So, the overall battery development has to be India specific. The new material, developed by IITB actually solve all these issues as it has been solely developed for India. With the advent of that material and India specific electrolyte, the battery does not allow dendrite formation as well as tolerate high-temperature operation which is suitable all over India. This is the reason we are calling it 'ultra-safe battery'.



To prove the claim, 'ultra-safe', dendrite tests were performed with commercial and IITB batteries. Both batteries were opened at a fully charged environment in IIT Bombay, inside the inert atmosphere and the graphite and IITB electrodes were safely collected. Further, they were placed in sealed packs, separately. In the next step, both sealed packs were opened and the electrodes were exposed to air. As the battery was in charged condition, lithium metal was supposed to be present onto the graphite surface for the commercial one. For the IITB battery, it had to be different as the newly developed material was used instead of graphite. The assumption of this eye-opening experiment was very simple. Lithium dendrite catches fire immediately coming in contact with air. Exactly, the same thing happened at the time of the experiment. Commercial anode caught fire within 25 seconds of exposing to air. On the other side, IIT Bombay anode did not catch fire as the used material stored lithium in a different form which was actually non-explosive in nature. Hence, there was no chance of catching fire. For the IIT Bombay anode, the experiment was continued for 6 minutes; however, no signature of fire or getting warm was observed. This test can be considered as a benchmark test to examine ultra-safety of a battery.

In addition to ultra-safety, this indigenously developed battery offers many more features. Firstly, it can store 4 times the energy per unit mass as compared to graphite, which translates into a potential weight and volume reduction of ~15-20%and ~10-15%, respectively. Secondly, the material is cheaper to produce as compared to graphite because of the simplicity of the manufacturing process and cheaply available raw materials, especially in India. Lastly, this material is synthesized at a much lower temperature (~500 °C) as compared to graphite (~3000 °C), which makes it less energy-intensive or greener as compared to graphite. With this new material, lithium ion and lithium polymer batteries can be made available at 10-15% cheaper price compared to a commercial one. These batteries are widely applicable to mobile phones, tablets, laptops, electric vehicles, grid storage, telecom towers, drones (defense applications) and many more. Additionally, it can support the advanced fast charging feature which is a recent trend in smart gadgets.

IITB battery is powering a mobile phone

Prof. Sagar Mitra is demonstrating the 'Ultra-Safe Li ion/Li polymer batteries' project in front of hon'ble prime minister at IIT Bombay

The ultra-safe battery program at IITB under the direction of Prof. Sagar Mitra has been demonstrated several times in technological exhibitions. This year, the ingenuity and material innovation were awarded the first prize among 300+ participants in the Academia Industry Training (AIT) program, jointly organized by the Govt. of India and the Govt. of Switzerland. Recently, IITB had organizedan R&D exhibition on the last convocation where our hon'ble Prime Minister was invited as the chief guest. This project was also demonstrated as a selected entry from IITB, in front of Prime Minister Narendra Modi.

The ultra-safe battery team (called InSTech) includes Prasit Kumar Dutta (the author), Sunil Mehta, Vishwas Goel, Aakash Ahuja, Abhinanda Sengupta, A. T. Shashidhar and Prof. Sagar Mitra. The ultra-safe technology involving material preparation has been filed as an Indian patent.