DOI: https://doi.org/10.36094/sc.v86.2020.Nobel_Prize_Chemistry.Chakrabarty.62



# NOBEL PRIZES IN SCIENCE : 2019

## *CHEMISTRY*

The Nobel Prize in Chemistry for 2019 has been awarded jointly to John B. Goodenough (born in 1922 in Jena, Germany) of the University of Texas at Austin, USA, M. Stanley Whittingham (b. 1941 in Nottingham, U.K.) of the Binghamton University, State University of New York, USA and Akira Yoshino (b. 1948 in Suita, Japan) of Meijo University, Nagoya, Japan 'for the development of lithium-ion batteries'. The prize money of 9 million Swedish krona was shared equally between the three Laureates. The powerful. lightweight and rechargeable (hundreds of times) lithium-ion battery (LIB) is at the heart of portable electronics like smart phones, laptops, i-Pads, electric vehicles and storage of renewable energy like solar energy and wind power energy. The LIBs entered the market in 1991 and have changed our lives ever since. The Nobel Press release aptly commented that the discoverers of the LIBs "*have laid the foundation of a wireless, fossil fuel-free society, and are of the greatest benefit to humankind.*"

**M. S. Whittingham**

In the mid-20th century, the alarming increase in atmospheric pollution by the ever increasing number of petrol-driven vehicles and the fast depletion of liquid fossil fuel (i.e. petrol) highlighted the need to develop electric vehicles and find out alternative sources of energy. Powerful batteries were needed to fulfill both these objectives. But the then extant heavy lead battery and nickel-cadmium battery were not suitable for the purpose.

At this stage, the oil giant Exxon recruited Whittingham from the Stanford University to develop light but more energy-rich batteries. Whittingham found out that 'intercalation' (i.e. the attachment of charged ions within the atom-sized spaces of solid materials) of potassium ions within tantalum disulphide solid resulted in a surprisingly energy-rich (2 Volts) material, considerably more powerful than the then existing batteries. He subsequently replaced heavy tantalum by titanium, a much lighter element. Since the objective of Exxon was to develop a galvanic (i.e. voltaic) cell where electrons freely flow from the negative electrode (anode) to the positive electrode (cathode), titanium was finally replaced by lithium, the lightest solid element on earth, which is known for its remarkable potential to release its lone outer electron. Whittingham was thus able to develop a light and energy-efficient lithium battery that worked at room temperature.

**J. B. Goodenough**

Unfortunately, when the lithium battery was repeatedly charged at room temperature, thin whiskers of lithium grew from the lithium electrode, which ultimately led to explosion of the bettery. Aluminium was then added to the lithium bettery in 1976. Exxon started small scale production of these batteries, but in the wake of falling of oil price across the globe, Exxon backed out from its production in 1980.

**Akira Yoshino**

Goodenough, then a Professor of Inorganic Chemistry at Oxford University, U. K., took up the challenge and found out that replacing pure lithium by lithium-cobalt oxide in the cathode led to a two-fold improvement. The resulting battery was almost twice as powerful, viz. 4 Volts and the battery did not have to be manufactured in the charged state (in contrast to the case of Whittingham's battery) and could be charged afterwards.

Yoshino, then at Asahi Kasei Corporation, Japan took up the final challenge. He used (Whittingham's) lithium-cobalt oxide as the cathode but cheap and commercially available petroleum coke as the anode. When the coke was charged with electrons, lithium ions ($LI^+$) were drawn into the coke, and when the battery was turned on, electrons and $Li^+$ ions flew towards cobalt oxide in the cathode. It resulted in a lightweight battery of high voltage (4 Volts). In 1986, Yoshino put the newly developed battery to safety test, and it was found to be absolutely safe. Thus the commercially viable LIBs were born. The first series of electronic equipment using LIBs were released in the market in 1991 by a Japanese company.

Pertinently, two post-Nobel advances have been made for the LIBs. Firstly, researchers from the Johns Hopkins Advanced Physics Laboratory, USA have developed a new class of gel polymer electrolytes, which has rendered the LIBs incombustible – a breakthrough in safety. Secondly, researchers from Penn State University, USA have modified commercial LIBs in such a way that if such a LIB is heated to 60ºC, it can be charged up to 80% in just 10 minutes to enable electric cars to undertake long road without recharging. A 5-minute charge-up is in the offing. ❐

***Professor Manas Chakrabarty***
*e-mail: chakmanas09@gmail.com*