Organic batteries operated at −70 ℃

With the great support by the National Natural Science Foundation of China, the research team directed by Prof. Xia YongYao (夏永姚) and Prof. Wang YongGang (王永刚) at the Department of Chemistry, Institute of New Energy, iChEM (Collaborative Innovation Center of Chemistry for Energy Materials), Fudan University, recently designed a rechargeable battery that can be operated at the ultra-low temperature of −70 ℃, which was published in *Joule* (2018, 2: 902—913).

Commercialized Li-ion batteries (LIBs) based on intercalation compound electrodes are being widely applied in various portable devices and electric vehicles. However, there is a common phenomenon that the LIBs lose most of their capacity and power with the sharp decrease of the electrolyte's conductivity when the temperature falls below 0 ℃. It has been widely reported that at −40 ℃ conventional LIBs only retained ~12% of the normal capacity at room temperature. Although many efforts have been focused, the ultra-low temperature (below −40 ℃) operation of Li-ion full cells has rarely been broken through up to present.

Their group have achieved the successful operation of rechargeable battery at ultra-low temperature of −70 ℃ for the first time. An ethyl acetate (EA)-based electrolyte with a sufficient ionic conductivity of 0.2 mS cm^{-1} at the ultralow temperature of −70 ℃ was firstly developed. Then, low temperature behavior of the intercalation compounds-based LIBs and an organic-based rechargeable battery with EA-based electrolyte has been further investigated. It is demonstrated that the sluggish de-solvation of Li^+ should be another obstacle for the ultra-low temperature operation of conventional LIBs, besides freezing point and ionic conductivity of electrolyte. The results revealed that the polymer-electrodes based LIBs using the above electrolyte can work well at the ultra-low temperature of −70 ℃ and retain ~70% of the capacity at room temperature, because of its charge storage on the surface groups or in the large interstitial space of organic solids.

The realization of rechargeable batteries at ultra-low temperature of −70 ℃ is of great importance for their application under a greater span of temperature and climate such as aerospace, cold temperatures, some extreme climates and high altitude areas. These results might shed light on the design of rechargeable batteries that can be operated at ultra-low temperatures.

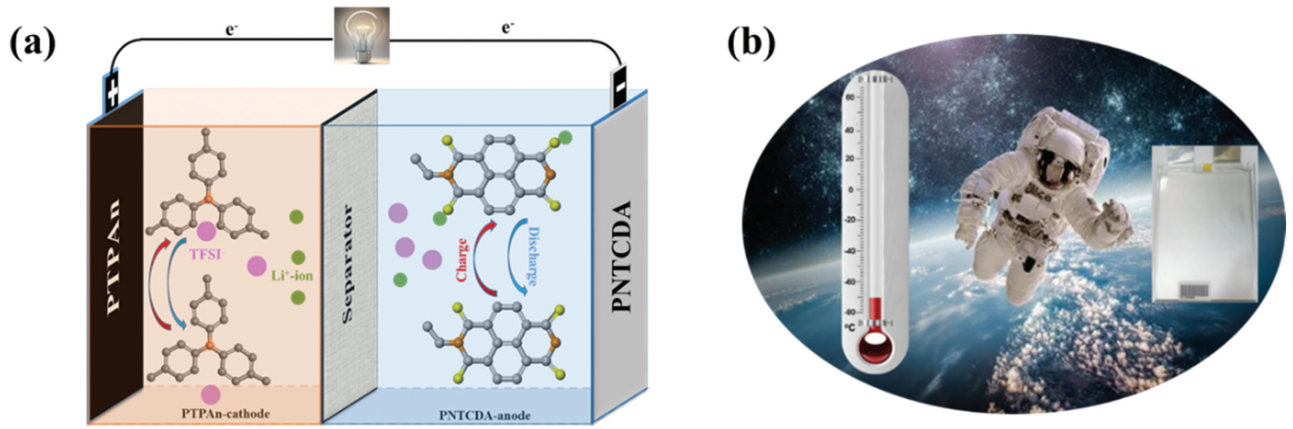

Figure Schematic illustration of the battery working mechanism (a) and perspective for the potential application at the ultra-low temperature of −70 ℃.