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锂电池获奖，是对整个行业的肯定与激励

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2019 年 10 月 9 日，瑞典皇家科学院宣布，美国德州大学奥斯汀分校约翰·班宁斯特·古德纳夫(John B. Goodenough)、美国纽约州立大学宾汉姆分校斯坦利·威廷汉(M. Stanley Whittingham)和日本旭化成株式会社吉野彰(Akira Yoshino)三人获得 2019 年度诺贝尔化学奖，以表彰他们对锂离子电池研发的贡献(for the development of lithium- ion batteries). 三位科学家领衔发展的便携式二次电池，开启了电子设备便携化进程，促进了清洁能源的发展，极大地改变了人们的生活方式. 此外，97 岁的约翰·班宁斯特·古德纳夫教授成为诺贝尔奖历史上最高龄获奖者. 诺贝尔化学奖颁给锂电池领域的三位科学家，是对每一位为锂电池从无到有、从实验室走向商业化做出贡献的锂电池从业者的认可，是对仍在从事锂电池研究和志在继续推动清洁、便携社会发展的人的激励. 毫无疑问，锂电池已经逐渐深入到社会的方方面面，与你我的生活朝夕相处.

此次诺贝尔化学奖授予锂电领域的科学家，彰显了锂离子电池作为能源存储器件，有效地满足了人们对美好生活的向往. 20 世纪 70 年代，由石油危机直接促成了锂电池研发的开端. 美国石油巨头埃克森公司(Exxon)判断石油资源作为典型不可再生资源，将不久之后面临枯竭，于是组建团队开发下一代替代石化燃料的能源技术. 斯坦利·威廷汉提出二硫化钛作为一种全新的正极材料，可以在分子层间储存锂离子. 当其与金属锂负极匹配的时候，电池电压高达 2 V. 然而，金属锂活性高，导致电池安全风险大. 当时在英国牛津大学的无机化学实验室担任主任的古德纳夫推断，采用金属氧化物替代硫化物作为正极，可以实现更高电压，改善锂离子电池的性能. 1980 年，古德纳夫用钴酸锂作为电池正极，将电池的电压提高到 4 V. 钴酸锂的横空出世是锂离子电池领域的极大突破，至今仍是便携式电池的主力正极材料. 受制于金属锂负极的不稳定特性，当时锂离子电池的安全性仍是严重的问题. 1985 年，吉野彰采用石油焦替换金属锂作为负极，发明了首个可用于商业的锂离子电池. 1991 年日本索尼公司发布了首个商用锂离子电池. 经过 30 多年的工业化发展，锂离子电池的能量密度、成本和安全性取得了长足进步，并深入到我们生活的方方面面. 正如诺贝尔奖委员会表示，“锂离子电池已经彻底改变了我们的生活，广泛用于从手机到笔记本及当代的电动汽车. 他们三位的研究为推动一个无线(可移动)、无化石燃料的社会奠定了基础”(Lithium-ion batteries have revolutionised our lives and are used in everything from mobile phones to laptops and electric vehicles. Through their work, this years’ Chemistry Laureates have laid the foundation of a wireless, fossil fuel-free society).

张强 清华大学长聘教授，从事能源材料研究，尤其是金属锂、锂硫电池和电催化的研究. 曾获得国家自然科学基金杰出青年科学基金资助、中组部“万人计划”青年拔尖人才、英国皇家学会 Newton Advanced Fellowship、2017~2019 年科睿唯安全球高被引科学家.

锂离子电池从基础到广泛应用的成功离不开多学科、多领域、多国家的交叉合作. 锂离子电池从原理提出到如今的商业化，历经 50 多年的路程，其间充满了曲折. 锂离子电池是一个涉及物理、化学、材料、能源、控制、信息、电力等领域的交叉体系，通过内部的化学反应实现能源的存储. 支撑当代锂电池走入每个人的生活，不仅是科学家原创思想的产生，还有工程人员的研发试制，产业行业的建立和标准确立，终端用户的应用开发和产品推广等多个环节. 在以诺贝尔化学奖得主约翰·班宁斯特·古德纳夫，斯坦利·威廷汉和吉野彰为代表的广大锂离子电池研究人员的不断交流合作和互相启发下，锂离子电池才能在波折中不断前进.

时至今日，锂离子电池的发展也逐渐走向成熟，循环寿命、成本、安全性方向都有了极大低提升. 基于此，便携式设备、电动汽车和储能电站也蓬勃发展，清洁能源的利用更加高效，人们的生活和出行方式极大改变. 中国的锂离子电池技术和市场正在蓬勃发展，涌现出一大批具有国际竞争力的新能源企业，如宁德时代新能源科技有限公司(CATL)、比亚迪等，在便携式电池和动力电池领域具有更高的话语权，推动美丽中国的建设.

2019 年度的诺贝尔化学奖授予锂电池领域是对这个行业巨大的一种肯定，也是对这个行业的一种激励. 随着锂电池应用推广，锂电池领域发展还将面临更艰巨的挑战.

受制于锂离子电池原理的限制，现有体系的锂离子电池能量密度从每年 7%的增长速率已经下降到 2%，并逐渐逼近其理论极限. 与之相反，随着社会的进步，人们对便携、清洁生活的需求更加强烈. 如何提出新原理、新体系、新方法实现能量密度更高、更安全、充电更快的储能过程？如何在电子、原子、分子、材料尺度理解储能过程中电极的演变规律？如果锂电池成为未来社会储能的主体，如何结合地球上有限的资源，实现电池的全链条回收和再制造还是悬而未决的挑战. 在这样的形势下，涌现出锂硫电池、锂空电池、钠离子电池、钾离子电池、镁离子电池、铝离子电池、锌离子电池、固态电池等许多新体系电池. 新材料的产生，也给这些新体系的发展带来了新机遇. 例如，将纳米碳材料引入到金属锂负极中，能够产生亲锂特性调控金属锂的形核和沉积，提升金属锂负极的利用效率和安全性；复合固态电解质引入二次电池中，带来了锂离子的新输运机制，降低可燃物质的比例，提升了电池的安全性；采用钠、钾、铝、锌等离子并研发其能源化学新原理，有望提出具有独特性质的新型储能器件，有效满足未来社会对于储能设备的新需求. 中国、美国、日本、韩国、德国、英国等国都制定了各自的电池发展战略，有望推动电池原理的创新以及核心技术的开发，支撑当代社会的可持续发展. 下一代解决能源存储与转化技术的突破，正在来临的路上.

Summary for "锂电获奖，是对整个行业的肯定与激励"

2019 Nobel Prize in Chemistry to Li-ion batteries: A milestone but fresh start

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On October 9, 2019, the Royal Swedish Academy of Sciences announced that the 2019 Nobel Prize in Chemistry was awarded jointly to John B. Goodenough of University of Texas at Austin, M. Stanley Whittingham of the State University of New York at Bingham, and Akira Yoshino of Asahi Corporation of Japan for the development of lithium (Li)-ion batteries. It is a recognition for each practitioner who has contributed to the development of Li-ion batteries: proposing the fundamental working mechanism, creating the prototype in laboratory, and achieving the successful commercialization that the Nobel chemistry prize was awarded to three scientists in the field of Li-ion batteries. Moreover, it is also an encouragement for those who are still engaged in the research and development of Li-ion or next-generation batteries and devote to promoting the processes of a clean and wireless society. There is no doubt that Li-ion batteries have gradually touched every aspect of the society and accompany with us in our daily life.

50 years has passed from the firstly proposed concept to the present commercialization, which is a journey full of twists and turns. The success of Li-ion batteries from concept to commercial products with wide application is highly depended on the cooperation from multi-disciplines, multi-fields and multi-countries. The research and development of Li-ion batteries involves physics, chemistry, materials, energy, mechanics, automation, informatics, electronics, and other fields, in which the basic principle of energy storage in Li-ion batteries relies on the internal electrochemical reactions. The popularization of Li-ion batteries in our daily life requires not only the creation of original innovations from scientists, but also scale-up manufacture from engineers to form a products, the establishment of standards in industry, the design of product according to the demand of end-users, the product marketing, and other aspects, which is a system engineering. Through the continuous communications and inspirations of the researchers in Li-ion batteries, in which Nobel Prize winner, John B. Goodenough, Stanley Whittingham, and Akira Yoshino are representative, Li-ion batteries keep on advancing in the ups and downs.

Li-ion batteries have revolutionized our daily life significantly towards wireless and clean style, leading to rapidly increasing demands for batteries with higher energy density and safety. However, limited by the working principle, the energy density of Li-ion batteries is approaching to the theoretical value recently and the growth rate of energy density has decreased from 7% to 2% per year. In order to further promote the development of high-energy-density and rechargeable batteries, the new working principles, systems, and methods to achieve the new energy storage devices with higher energy density, safer and faster charge are highly required. The fundamental understanding on the evolution of battery materials at the electronic, atomic, molecular and material level while working is necessary. Moreover, the integral recycling and remanufacturing of Li-ion batteries should also be taken into consideration owing to the limited resources and environmental capacity in the earth, especially when Li-ion batteries become the mainstream of energy storage systems in the future. Under such background, many new battery systems have been proposed, such as Li-sulfur batteries, Li-air batteries, sodium-ion batteries, potassium-ion batteries, magnesium-ion batteries, aluminum-ion batteries, zinc-ion batteries, and solid-state batteries. The emerging but increasing new materials provide new opportunities for the development of battery systems. It is highly expected to propose new-type energy storage devices with unique properties to satisfy the needs of energy storage equipment in the future by introducing sodium, potassium, aluminum, zinc, and other alkaline or alkaline earth metals in battery system. The breakthroughs of next-generation batteries are on the way for a wireless and non-fossil society.

Next-generation batteries are in strong pursuit around the world for the breakthrough in key technologies. The emerging battery chemistries with different features can be developed for the various scenarios in practical applications. Batteries render a better life.

2019 Nobel Prize in Chemistry, Li-ion batteries, rechargeable batteries, next-generation batteries

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