Renewable-biomolecule-based full lithium-ion batteries

Rechargeable batteries, as promising energy-storage systems, are deriving wide attention. However, with the booming development of modern electronic society, the production quantity of energy-storage devices rises sharply, which will inevitably cause the emerging of two issues, *i.e.*, high cost and abundant electronic waste. In nature, its energy conversion and storage systems have been evolved for billions of years and spawned highly efficient and well suited cellular respiration machineries in living organisms for external energy assimilation, metabolism and distribution. Inspired by cellular respiration metabolism which generates electrochemical energy through a redox elements chain, naturally originated biomolecules with redox centers are being applied to fabricate advanced energy storage devices. Such bio-inspired electro-active materials possess advantages as follows: (1) Low cost ascribed to abundant resources; (2) Good biocompatibility and easy degradation; (3) Structural diversity as well as tunable capability.

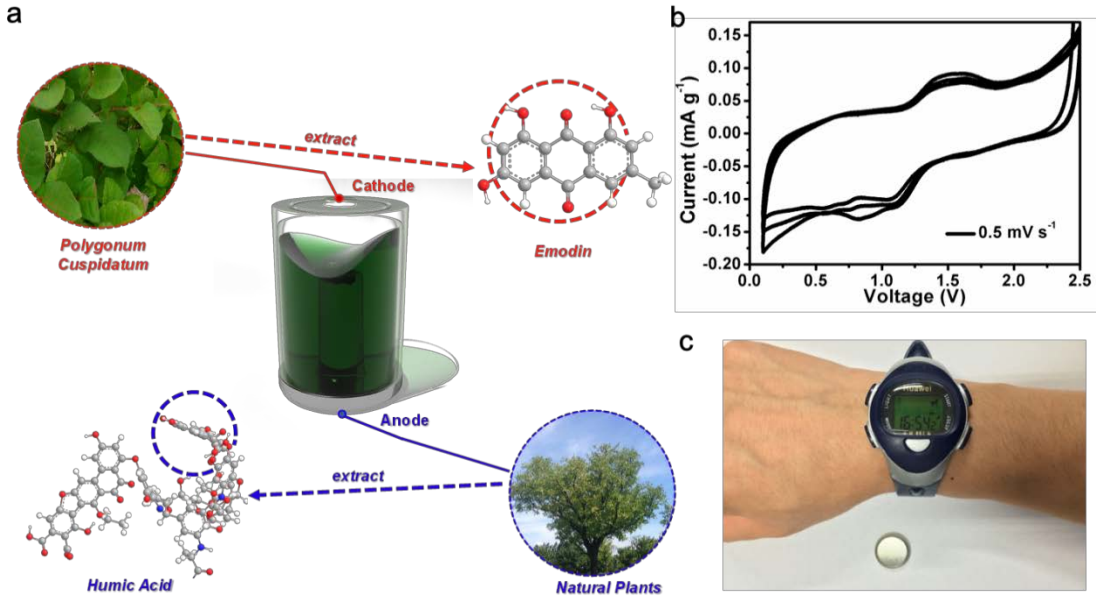

Fig1. a, Configuration of renewable-biomolecule-based full lithium-ion batteries with Emodin-based cathodes and Humic Acid-based anodes. b, CV curves of renewable-biomolecule-based full lithium-ion batteries. c, A coin-type full battery used to power an electronic watch.

Recently, Dr. Hua Wang and Prof. Lin Guo's team fabricated a

renewable-biomolecule-based full lithium-ion battery for the first time, based on their previous work about Juglone-biomolecule-based sodium-ion half battery. (*Adv. Mater.*, 2015, **27**, 2348-2354., reported by our REPORTER in 2015).

Emodin, a small biomolecule which could be extracted from rhubarb and polygonum cuspidatum, served as the cathode material owing to its redox-active quinone groups. However, as organic materials inherently, biomolecule-based electrodes also possess beneficial properties of lightweight and easy processing, but are subjected to capacity fading due to their dissolution into organic electrolyte and poor rate capacity due to low conductivity, restricting their practical application in energy storage. Immobilization on carbon scaffold such as single wall carbon nanotube (SCNT) through π-π interaction, providing stable anchoring and fast electrical path, could improve the electrochemical performance dramatically. Thus, Emodin/SCNT hybridized electrodes were prepared through a simple ultrasonic-assisted vacuum filtration method without additional binder or conductive agent. Furthermore, optical and photoelectron spectroscopes were utilized to prove that it is the reversible redox reactions of carbonyl groups that account for the charge storage capabilities of renewable electrodes.

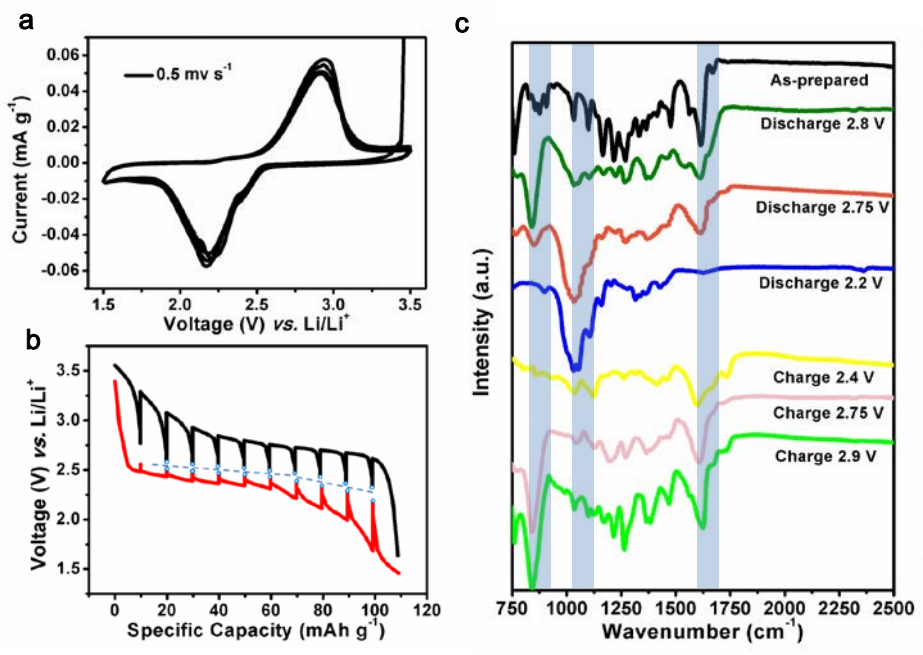

Fig 2. a, CV curves; b, galvanostatic intermittent titration technique (GITT) curves;

c, FTIR spectra at different charge and discharge voltage of Emodin/SCNT electrodes.

Humic acid, a principal component of humic substances and major organic constituents of soil, peat or coal arising from dead plants, is abundant across the whole nature. It also exists in the gastrointestinal tract as well as blood of humans to be metabolized in the liver. As a complex mixture of different acids containing massive carboxyl, carbonyl and phenolate groups as redox centers, humic acid possesses potential application in energy storage systems. Lithium Humate was prepared through asimple lithiation process with lithium hydrate and exhibited enhanced electrochemical performance, of which the specific capacity reaches as high as 537.2 mAh/g.

The as-fabricated full lithium-ion battery based on Emodin and Humic acid biomolecules exhibited superb specific capacity with operating potential at 1.5 V and succeeded in powering an electronic watch. The significant progress in realization of biomass-based battery provides insights for design and fabrication of various wearable and implantable electronics.

This innovative prototype of green battery with biomolecule-based anode and cathode provides new solutions for resource crisis and environmental puzzles and opens new opportunities for the construction of next generation energy storage systems, which is of great scientific and practical significance. Related work has been published in Advanced Materials（*Adv. Mater.* 2016, **28**, 3486–3492）.

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Reference

Pengfei Hu, Hua Wang*, Yun Yang, Jie Yang, Jie Lin and Lin Guo*, Renewable-Biomolecule-Based Full Lithium-Ion Batteries, ***Adv. Mater.***, ***2016***, 28, 3486–3492.

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