섬유/직물 기반 전자 저장 장치 II
(Textile for Electricity Storage II)

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목차

개요

- 일반적으로 사용하는 리튬 이온 배터리(lithium-ion batteries, LIBs)와 슈퍼커패시터(super-capacitors, SCs)는 다층 구조로 쌓인 금속박 전극으로 제조된다.
- 최근 다양한 물질로 합성된 섬유/직물 기판 배터리들이 연구되고 있으며, 그 이유는 유연한 LIBs와 SCs를 섬유 전극으로 실현할 수 있기 때문이다. 특히 섬유/직물 기판으로 된 전극은 표면적이 크고 가벼우며 유연성이 뛰어나고 탄성이 균일한 복합 전극을 생산할 수 있는 장점을 가지고 있다.
- 또한 이러한 섬유/직물 전극은 에너지 저장 장치에 추가적인 통기성과 3차원적 적합성의 장점을 제공할 수 있어 웨어러블 디바이스 분야로 적용하기에 매력적이다.
- 이러한 섬유 전극은 유연성과 고용량의 성능을 지닌 섬유/직물 기반 에너지 저장 장치를 만들 것이라고 기대되고 있다.

"Textile Composite Electrodes for Flexible Batteries and Supercapacitors: Opportunities and Challenges", Y.Gao et al.

슈퍼커패시터(Super-Capacitor)

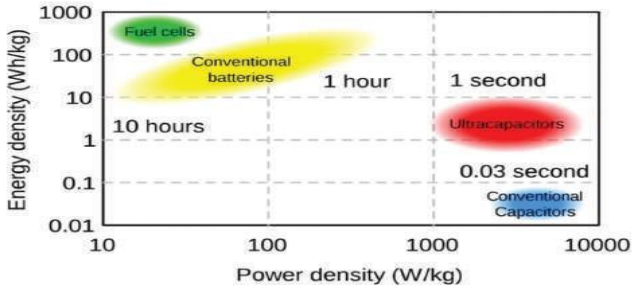

Fig 1. The power density for different types of energy storage devices.

Feature	Li-ion Battery	Supercapacitor
Gravimetric energy (Wh/kg)	100 – 265	4 - 10
Volumetric energy (Wh/L)	220 – 400	4 - 14
Power density (W/kg)	1 500	3 000 – 40 000
Voltage of a cell (V)	3.6	2.7 - 3
ESR (mΩ)	500	40 - 300
Efficiency (%)	75 – 90	98
Cyclability (nb recharges)	500 – 1 000	500 000 – 20 000 000
Life	5 - 10 years	10 - 15 years
Self-discharge (% per month)	2	40 - 50
Charge temperature	0 to 45°C	-40 to 65°C
Discharge temperature	-20 to 60°C	-40 to 65°C
Deep discharge pb	yes	no
Overload pb	yes	no
Risk of thermal runaway	yes	no
Risk of explosion	yes	no
Charging 1 cell	complex	easy
Charging cells in series	complex	complex
Voltage on discharge	stable	decreasing
Cost per kWh	200 – 1 000 €	10 000 €

Fig 2. The key parameters of Lithium ion battery and supercapacitor

"Will supercapacitors supersede batteries?", Electronics Weekly. Com
"Smart electronic textiles" W Wenget al.

- In contrast to batteries with high energy densities, supercapacitors have been widely investigated in regard to high power densities.
- Similar to lithium ion batteries, super-capacitors have a structure with the electrolyte sandwiched between two electrodes. They can be categorized as electrostatic double-layer capacitors and pseudocapacitors according to the energy-storage mechanism.
- An electrostatic double-layer-capacitor is typically made from carbon electrodes and realizes charge separation at the interface between the electrode and electrolyte. `
- A pseudocapacitor is generally fabricated from metal oxide or conducting polymer electrodes and uses redox reactions to store energy.
- Both types of capacitor have been made into fibers and textiles used.

슈퍼커패시터(Super-Capacitor)

- **Electrostatic double-layer capacitor(EDLC)**

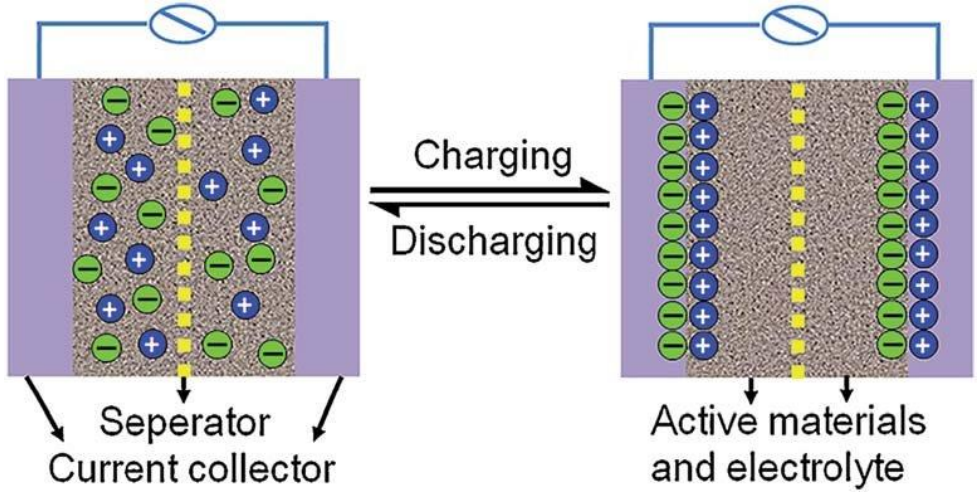

Fig 3. The charge storage mechanism of Electrostatic double-layer capacitor(EDLC)

"Recent Advances in Porous Graphene Materials for Supercapacitior Application", X. Zhang et al.
"Smart electronic textiles" W Wenget al.

- The Electrical Double-Layer Capacitor (EDLC) contains no conventional dielectric. Instead, an electrolyte (solid or liquid) is filled between two electrodes.
- In EDLC, an electrical condition called "electrical double layer," which is formed between the electrodes and electrolyte, works as the dielectric.
- Capacitance is proportional to the surface area of the electrical double layer. Therefore, using activated carbon, which has large surface area for electrodes, enables EDLC to have high capacitance.
- The mechanism of ion absorption and desorption to the electrical double layer contributes to the charge and discharge of EDLC.
- By applying voltage to the facing electrodes, ions are drawn to the surface of the electrical double layer and electricity is charged. Conversely, they move away when discharging electricity. This is how EDLC charge and discharge.

슈퍼커패시터(Super-Capacitor)

- **Pseudocapacitor**

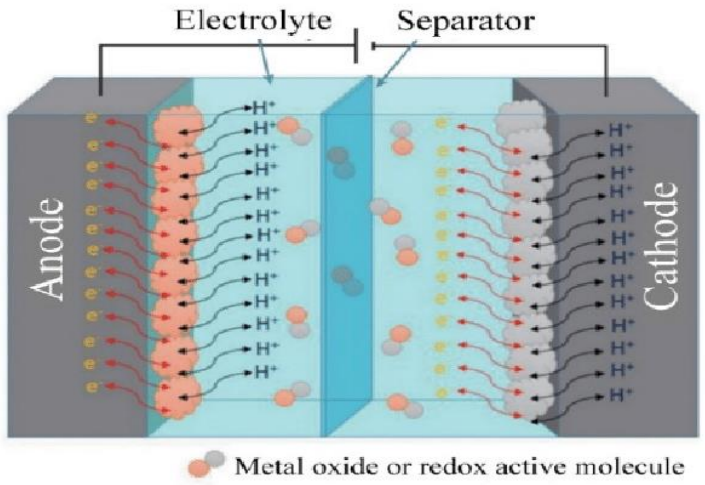

Fig 4. Diagram of a pseudocapacitor

- A pseudocapacitor is a hybrid between a battery and an electric double layer capacitor.
- It also consists of two electrodes separated by an electrolyte. Charge storage occurs by chemical and electrostatic means.
- Chemical process involves charge transfer by means of reduction-oxidation(redox) reactions.
- While the charge transfer is similar to that in a battery, transfer rates are higher because of use of thinner redox material on the electrode or lower penetration of the ions from the electrolyte into the structure.
- Because of multiple processes acting to store charge, the capacitance values are higher in pseudocapacitors.

"A Comprehensive Review on Energy Storage System: Types, Comparison, Current Scenario, Applications, Barriers, and Potential Solutions, Policies, and Future Prospects", E. Hossain et al
"Smart electronic textiles" W Weng et al.

섬유형 슈퍼커패시터(Fiber-Shaped Super-Capacitor)

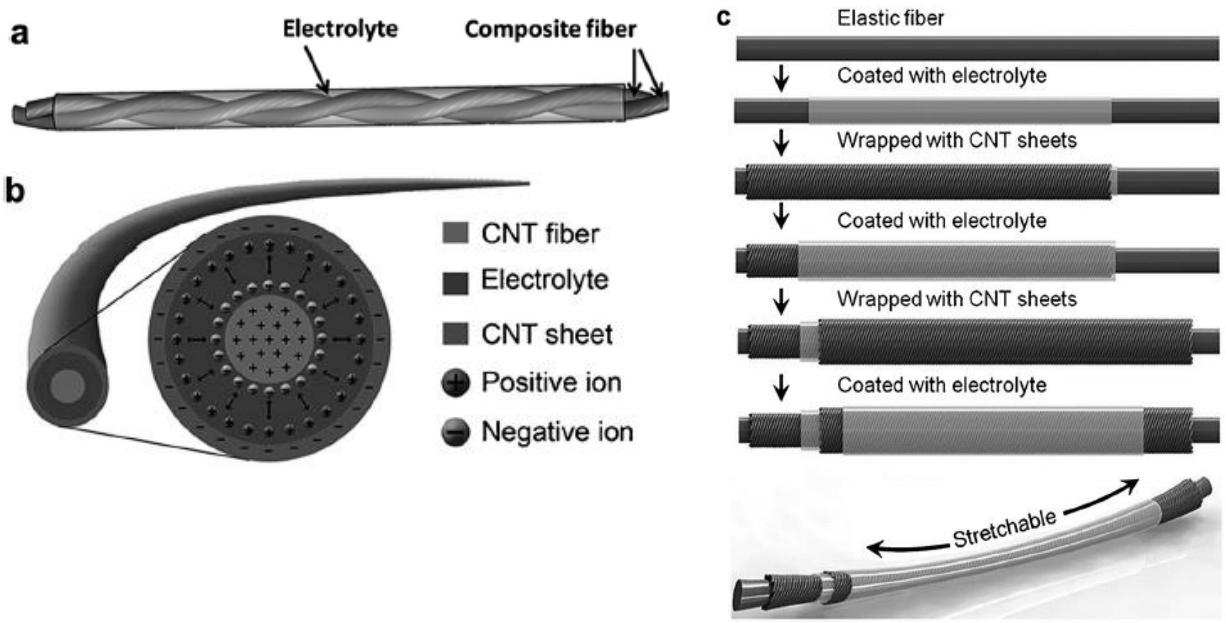

Fig 5. Fiber-shaped supercapacitors. a) Two aligned CNT/polyaniline composite fibers twisted into a supercapacitor. b) Coaxial fiber-shaped supercapacitor based on aligned CNT fibers and sheets. c) Illustration of the fabrication of a stretchable, coaxial fiber-shaped supercapacitor on an elastic polymer fiber

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- There are many more reports on fiber-shaped super-capacitor than lithium ion batteries, possibly because the fabrication of the former is much easier.
- Three fiber electrodes, namely, polymer fibers, metal fibers, and carbonaceous fibers have been mainly explored to produce fiber-shaped super-capacitors.
- Similar to the other fiber-shaped electronic devices, the fiber-shaped super-capacitor can have coaxial and twisted structures.
- The fiber-shaped super-capacitor maintained a specific capacitance of 18 Fg^{-1}after stretching 100 times by 75%

직물형 슈퍼커패시터(Textile-Shaped Super-Capacitor)

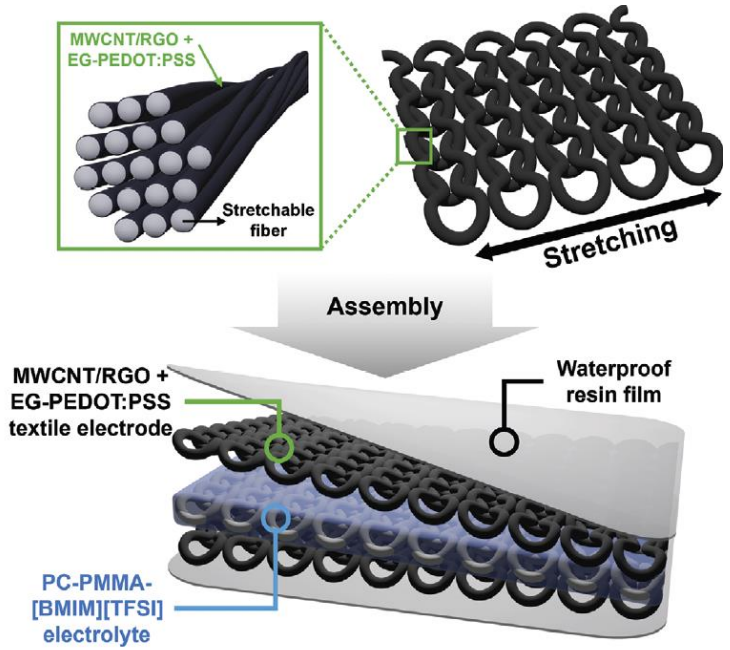

Fig 6. A schematic illustration of the fabricated super-capacitor that shows the cross-section of the stretchable fiber, the knitted stretchable textile, and the assembled supercapaciror composed of the stretchable textile electrode, gel-type electrolyte, and waterproof resin film.

"Smart electronic textiles" W Weng et al.
"A Textile-Based Temperature-Tolerant Stretchable Supercapacitor for wearable Electronics", H.C Lee et al.

- Recently, some attempts were also made to produce textile-shaped super-capacitor directly from textile electrodes.
- Some other researches, textile-based stretchable super-capacitor with high electrochemical performance, mechanical stability, and temperature tolerance over a wide temperature range is reported. It exhibits high areal capacitances of 28.0, 30.4, and 30.6 mF cm−2 at −30, 25, and 80℃, respectively.
- However, the packaging materials are typically constructed to be waterproof and airtight, which is opposite to the definition of a textile. The applicability of conventional textile processing for the fiber-shaped devices should be carefully investigated.

참고문헌

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