Flexible electrodes and energy storage devices

Can paper-based electrodes be used for flexible energy storage devices?
This review summarizes recent advances in the synthesis of paper-based electrodes, including paper-supported electrodes and paper-like electrodes. Their structural features, electrochemical performances and implementation as electrodes for flexible energy storage devices including supercapacitors and batteries are highlighted and compared.

What is a flexible electrode?
As a flexible electrode for batteries or other devices, it possesses favorable mechanical strength and large specific capacity and preserves efficient ionic and electronic conductivity with a certain shape, structure, and function.

What is a flexible energy storage device?
One of the key components for flexible energy storage devices is a flexible and conductive substrate that can be used as a current collector. Papers and textiles have been considered ideal substrates due to their low cost,flexibility,and highly porous structures,which can absorb active electrode materials 1,13.

What are the different types of flexible electrode materials/substrates?
Here,this review aims to provide a comprehensive survey on the recently developed free-standing and flexible electrode materials/substrates for flexible electrochemical energy storage devices,which are categorized into four different types including metal-based,carbon-based,polymer-based,and micro-patterned flexible electrodes.

What materials are used to make electrodes for energy storage devices?
Most of the electrodes for energy storage devices are generally made by mixing particulate active materials with polymeric binders e.g., polyvinylidene fluoride (PVDF) and polytetrafluoroethylene (PTFE) and conducting agents (e.g. carbon black) with the help of appropriate solvent.

What is the mechanical reliability of flexible energy storage devices?
As usual,the mechanical reliability of flexible energy storage devices includes electrical performance retention and deformation endurance. As a flexible electrode,it should possess favorable mechanical strength and large specific capacity. And the electrodes need to preserve efficient ionic and electronic conductivity during cycling.

applications of the flexible energy storage devices. Finally, the limitations of materials and preparation methods, the functions, and the working conditions of devices in the future were discussed and presented. KEYWORDS electrode, electronics, energy storage device, flexible, wearable device 1 | INTRODUCTION

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Integrating ultraflexible energy harvesters and energy storage devices to form an autonomous, efficient, and mechanically compliant power system remains a significant challenge.

Here, this review aims to provide a comprehensive survey on the recently developed free-standing and flexible electrode materials/substrates for flexible electrochemical energy storage devices, which are categorized into ...

Flexible energy storage devices based on an aqueous electrolyte, alternative battery chemistry, is thought to be a promising power source for such flexible electronics. ... Up to date, various types of porous substrates have been studied as an electrode matrix for flexible energy devices which includes carbon-based substrates (e.g., carbon ...

Electrically conducting hydrogels have great application prospects in portable energy storage devices. CNTs (CNTs) fiber is considered as ideal fiber electrodes or substrates for energy storage device because of their high electrical conductivity, mechanical strength, large surface area, and excellent flexibility.

Efficient energy storage depends on the electrode material"s surface area, ion conductivity, and chemical structure. EDLCs have a higher power density but a lower energy density. Flexible energy storage devices must perform under a variety of bending or folding conditions due to their operating conditions.

Flexible fiber energy storage devices including electrochemical capacitors and LIBs, as well as integrated wire-shaped energy systems that have arisen in the past several years have been summarized systematically, with special emphasis on the design of fiber electrodes, structure construction, electrochemical properties and mechanical stability ...

The rise of portable and wearable electronics has largely stimulated the development of flexible energy storage and conversion devices. As one of the essential parts, the electrode plays critical ...

Flexible energy storage devices are a key enabling factor for the propagation of wearable or paper electronics in biomedical, consumer electronics, and military applications 1,2,3,4,5.Lithium-ion ...

With the growing market of wearable devices for smart sensing and personalized healthcare applications, energy storage devices that ensure stable power supply and can be constructed in flexible platforms have attracted tremendous research interests. A variety of active materials and fabrication strategies of flexible energy storage devices have been ...

As an important component of flexible batteries, novel electrodes with good flexibility, mechanical stability and high energy density are required to adapt to mechanical ...

Based on the issues of current flexible EES devices, this review presents various strategies from the design of

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CNFs-based electrodes to the fabrication of devices and overviews their applications in various flexible metal ion/air batteries (Li/Na/K-ion batteries, Li-S batteries, metal-air batteries, and other novel secondary batteries) and ...

When utilized as electrode materials for energy storage devices, electrodes can alter the color in response to the storage state of energy and reflect this change ... The film retained 66 % of its initial state after compression. Furthermore, flexible zinc-ion energy storage devices were fabricated using a combination of hydrogel and PB film. ...

Our approach to designing flexible MF@NF composite electrodes and using of PLP anode for flexible LMBs will have a major influence on the advancement of flexible energy storage devices with high energy density. 4 Experimental Section Materials. PET nonwoven was purchased from Amotech Co., Ltd. (Korea).

extensive efforts have been devoted to make flexible and high performance energy storage devices.[12-19] Among all flexible energy storage devices, supercapacitors and Li-based batteries (e.g., Li-ion, Li-S and Li-O 2 batteries) stand out because of their ease of fabrication, compatibility with other electronic devices and excellent ...

Flexibility is a key parameter of device mechanical robustness. The most profound challenge for the realization of flexible electronics is associated with the relatively low flexibility of power sources. In this article, two kinds of energy applications, which have gained increasing attention in the field of flexibility in recent years, are introduced: the lithium-ion ...

The booming wearable/portable electronic devices industry has stimulated the progress of supporting flexible energy storage devices. Excellent performance of flexible devices not only requires the component units of each device to maintain the original performance under external forces, but also demands the overall device to be flexible in response to external ...

During the past decade, flexible/stretchable energy storage devices have garnered increasing attention, with the successful development of wearable electronics. However, due to the repeated deformation accompanied with the electrochemical depletion process, these devices suffer from unavoidable damage, including cracks, crazing, puncture and ...

CNTs can be easily assembled into different flexible/stretchable configurations and architectures including 1D CNTs fibers, 2D CNTs films [18] and 3D CNTs sponges [19], regarding as ideal flexible substrates to fabricate flexible electrodes for various flexible energy storage devices. Active materials can be easily incorporated with CNTs into ...

5 · Flexible supercapacitors (SCs), as promising energy storage devices, have shown great potential for both next-generation wearable electronics and addressing the global energy ...

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Free-standing flexible electrodes have also been produced by electrospinning combined with other techniques, such as electrospray, for flexible batteries. ... Up to now, a coplanar or non-coplanar design has been developed for the serpentine structure and applied for energy storage devices with a significantly enhanced stretchability (>100% ...

[1-12] To fabricate flexible electrodes, one of the most promising strategies is to grow the active materials in situ onto various self-standing and flexible carbon- or metal-based substrates, such as carbon cloth, graphene, nickel foam, and etc. [13-19] However, the current flexible electrode configurations are still facing some limitations ...

The emergence of multifunctional wearable electronics over the past decades has triggered the exploration of flexible energy storage devices. As an important component of flexible batteries, novel electrodes with good flexibility, mechanical stability and high energy density are required to adapt to mechanic Horizons Community Board collection: new trends in energy ...

Research into flexible energy-storage devices with high energy density and superior mechanical performance has aroused considerable interest for the development of flexible electronics. Numerous new materials and strategies have been developed to obtain soft, safe, and high-performance flexible electrodes, which are essential components of flexible ...

To prevent and mitigate environmental degradation, high-performance and cost-effective electrochemical flexible energy storage systems need to be urgently developed. This demand has led to an increase in research on electrode materials for high-capacity flexible supercapacitors and secondary batteries, which have greatly aided the development of ...

Up to now, several reviews on flexible nanofibers applied in EES devices have been reported. [] For example, Chen et al. [] summarized the latest development of fiber supercapacitors in terms of electrode materials, device structure, and performance. In addition, there are a couple of reviews on the fabrication and future challenges of flexible metal-ion ...

As flexible, ultrathin, safe energy storage and conversion electrodes are required for use in various technological devices, studies into flexible electrodes have been of particular interest . Flexible electrodes are also required for portable lightweight devices, smart cards, flexible displays, sensors, electronic textiles and implantable ...

This review is intended to provide strategies for the design of components in flexible energy storage devices (electrode materials, gel electrolytes, and separators) with the ...

Conducting polymers, which were discovered in 1976, are one important type of electrode materials for

energy storage due to their large capacitance, good electrical conductivity, ease of synthesis and low cost. 25, 32, 67, 68, 69 Over the decades, conducting polymers have received significant attention in flexible energy storage devices.

Interdigital electrochemical energy storage (EES) device features small size, high integration, and efficient ion transport, which is an ideal candidate for powering integrated microelectronic systems. However, traditional manufacturing techniques have limited capability in fabricating the microdevices with complex microstructure. Three-dimensional (3D) printing, as ...

To fulfill flexible energy-storage devices, much effort has been devoted to the design of structures and materials with mechanical characteristics. This review attempts to critically review the state of the art with respect to materials of electrodes and electrolyte, the device structure, and the corresponding fabrication techniques as well as ...

In addition to flexibility, stretchability is another important factor in wearable devices. The proposed 3D structure could be potentially used for stretchable applications. There are several reports of stretchable conductive electrodes, sensors, and energy storage devices based on stretchable polymers of polyurethane (PU), PDMS etc. [37 ...

Paper-based materials are emerging as a new category of advanced electrodes for flexible energy storage devices, including supercapacitors, Li-ion batteries, Li-S batteries, Li-oxygen batteries. ...