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BATTERIES & SUPERCAPS
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Fiber Electronics: An Emerging Field

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What is our Research Focus and why is it Important?

It is predicted that wearable technology will result in a revolution in the world. The main attentions have been paid to making their key parts such as power systems and sensors thin. However, there remains intrinsic challenges that seem very difficult to be overcome due to their planar structure. Once these key components are made thin, their performances will be largely decreased, e.g., the energy storage capability of a thin battery will be low due to the reduced loading of active materials, and they also easily break during use and under deforming conditions. In addition, they cannot be fully contacted with soft and curved surfaces such as our bodies and they are not breathable either. The above disadvantages limit the advance of wearable electronics as well as various related fields.

In the past decade, we have made a variety of energy and electronic devices including solar cells, electrochemical capacitors, lithium-ion batteries, lithium sulfur batteries, metal–air batteries, and sensors into a fiber shape (see Figure 1). Some fiber-shaped energy harvesting and storage devices such as carbon/water generators based on totally new mechanisms have also been discovered. Based on the one-dimensional architecture, they share many promising advantages including lightweight, miniature size, breathability, high flexibility, and even stretchability, compared with their traditional planar counterparts. The fiber-shaped devices are further integrated into wearable electronic facilities with high performances, or implanted to monitor the health condition by detecting biomarkers and even make treatments with high efficiencies. We name this new direction as fiber electronics, a multidisciplinary field that covers chemistry, physics, biomedicine, engineering, and electronics.

From a viewpoint of applications, these fiber-shaped energy and electronic devices can be further woven into textiles or other flexible structures through the low-cost textile technology. Therefore, they may be effectively used for the wearable electronics as well as many other fields such as smart textiles and biomedical applications.

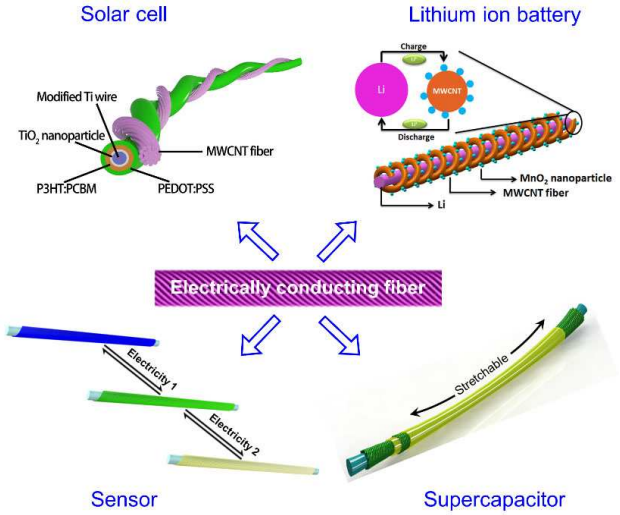

Figure 1. Use of conducting fibers in electrochemical energy storage devices.

What are the Critical Issues and what are the Future Perspectives that need to be Addressed for the Field to Progress?

Despite of the great progress made in fiber electronics; we have to realize that most of the research results are far from practical applications due to several existing obstacles. The performances of fiber-shaped electronic devices are not good enough to attract investors. For instance, although fiber-shaped solar cells have achieved a record power conversion efficiency (PCE) of 10%, this value falls far below the certified efficiency of 24.2% for planar solar cells. Besides, fiber-shaped electronic devices often decay in performance further as their lengths

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increase. Apart from low performances, scalable fabrication is another hard nut to crack if fiber-shaped electronic devices are to be commercialized. On one hand, researchers usually can only realize fiber-shaped electronic devices with the lengths from several to hundreds of millimeters at present owing to the absence of appropriate scale-up processes. On the other hand, it seems heavy and complicated to electrically connect these numerous fiber-shaped electronic devices as required. When it comes to the wearable application, safety and stability should be the two key issues to be dealt with as many fiber-shaped electronic devices involved poisoning and/or flammable components such as lead and acetonitrile. Under the circumstances, researchers should abandon these poisoning and/or flammable components as much as possible or develop reliable encapsulation technologies if these cannot be avoided. After breakthrough in application, it will inspire more scientists to further advance the basic research in synthesizing new materials, creating novel structures, enhancing electronic properties, and designing effective integrating methods in fiber electronics.

What is, in your Personal Opinion, most Critical to Teach Students in University Chemistry Courses?

The most important thing, I think, is to inspire undergraduate students to love chemistry. Chemistry plays a critical role both in the history and the future development of humankind. Chemistry is also interesting as it creates new materials for fun and for use. Besides theoretical studies, it is particularly important to make many experiments to deepen the understanding of chemical courses. In other words, experiments are the heart of chemistry, especially organic chemistry. We should further expand the scope of basic chemical experiments to attract the attention of undergraduate students. It is also necessary to teach the students how important chemistry can be for the other fields such as biomedical science and physics. The importance of chemistry on multidisciplinary studies may be very attractive for many students in the other majors.