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Graphene has potential for use in flexible batteries

Researchers have shown that graphene paper can be used to construct flexible and rechargeable batteries, which may even perform better than non-flexible batteries. These might be used in a range of portable, bendable and rollable devices and could also help develop new energy generation technology, such as flexible solar cells.

Graphene is a thin layer of carbon, a single atom thick. It had no clear uses when first created by Russian and UK scientists in 2004, but it has since been found to have many useful mechanical, electrical, optical and thermal properties. The latest research has found that graphene paper (graphene layered into sheets 2µm thick) is a suitable material for both the anode and cathode in flexible, rechargeable lithium batteries. Flexible devices need battery units with high energy and power density, but bendable power sources are difficult to manufacture as they require materials which are highly conductive, flexible and electrochemically stable.

Carbon-based materials are electrochemically stable so are often used in batteries, capacitors and fuel cells. Graphene sheets are a new type of carbon structure – effectively two-dimensional, with a high surface area to volume ratio, low weight, high mechanical strength and good electrical transmission properties. They can be easily and cheaply made in large quantities, and graphene paper can act as both current collector and conductor. It is also better than other carbon papers (such as graphite foil or carbon nanotube papers) for stiffness and strength and is an improvement on the polymers typically used in flexible devices but which are not suitable for several elements of the manufacturing process of cathodes.

The research constructed a cathode by growing vanadium oxide onto a graphene sheet structure. Vanadium oxide is an unstructured material with a low voltage requirement that has recently shown to be a promising cathode host material in lithium batteries and potentially suitable for thin film devices. The resulting flexible cathode was found to have higher power and energy density, and better life cycle performance than even conventional (non-flexible) electrodes.

Graphene paper was also used as an anode, without any additional binder substance (the conventional polymer binder actually reduces the conductivity and performance). Both cathode and anode maintained their structure and conductivity after initial tests, so could be integrated into a flexible lithium battery which operates even when rolled up or twisted.

Integration of graphene results in improved electrode architecture even compared with non-flexible technology and suggests significant potential for fully stretchable and bendable devices. The electrochemical properties of the graphene structure can be designed for various applications, in some cases also integrating other functional materials. This suggests many potential development and research pathways which could lead to other new devices, such as catalysts, photo-voltaic cells and organic LEDs. In combination with flexible solar cells, graphene may also play a role in development of new energy generation technology.

Source: Gwon, H.; Kim, H-S; Lee, KE; Seo, D-H; Park, YC; Lee, Y-S; Ahn, BT; Kang, K (2011) Flexible energy storage devices based on graphene paper. *Energy and Environmental Science*. DOI: 10.1039/c0ee00640h.

Contact: matlgen1@gmail.com

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