Performance fibers for energy harvesting

Science, Physics

Energy harvesting is the technique of capturing and accumulating by-product energy as the energy becomes accessible, keeping the energy for some time and treating it into a form that can be utilized later – for example working a microprocessor with in its points of confinement. Energy harvesting holds incredible versatility for both low-voltage and low-power applications in an extensive variety of portable or compact markets such as medical equipment, consumer devices, transportation, industrial controls and military. It is additionally a strong substitute for applications that require a back-up battery, especially if the battery is in a remote or difficult location to reach.

The energy can be seized from different types of sources considered dissipated or generally unusable for any active or experimental reasons. The process, otherwise called energy scavenging, seizes remaining energy as a by-product of a natural environmental phenomenon or mechanical process and is along these lines considered free energy. More usually than not, this residual energy is discharged into the environment as waste. Like, mechanical energy resulting from vibration, thermal energy, and stress and strain. Other sources are biological, solar energy; electromagnetic energy in inductors, coils and transformers; wind and fluid energy resulting from air and liquid stream; chemical energy from normally repeating or biological processes.

Applications

Fiber Super Capacitors

Fiber Super Capacitors are designed as 1D wires with cross sectional diameters from micrometers to millimeters, and they are for the most part little in size and light in weight. As a result of their remarkable wire-formed structure, they are profoundly adaptable and can be woven or weaved into textures/materials with amazing wear ability. So, because of such unique structural properties these designs have great adaptability when contrasted with conventional SCs, since they can be manufactured into different wanted shapes and found at better places. Further, in comparison with regular SCs, fiber SCs can possibly be effectively coordinated with other fiber based energy harvesting gadgets or sensors to shape coordinated multifunctional frameworks.

There are three simple arrangements, i. e., two parallel fibers, two twisted fibers, and one coaxial fiber but short-circuit is to be avoided in order to achieve high performance. Various flexible fiber electrodes are been fabricated using metal wires or metal-coated plastic wires, carbonaceous fibers, such as CNT fibers, carbon fibers, graphene fibers or their hybrid fibers. Many approaches have also been used to modify these fibers to improve their conductivity and available surface area in order to get higher capacitance and better flexibility and stretchability.

Nanofibers in Li-ion Batteries

Li-ion Batteries have four components: Anode, Cathode, Electrolyte and Separator. Principle of working is based on electrochemical reactions between separated electrodes through electrolyte as conductive medium for ions. Blended nanofiber are used as electrodes and separators. The improved qualities of fibrous materials emerge from the mixture of compound properties and unique morphologies and structures shaped in the strands.

The one-dimensional morphology, high surface area, customizable density, and high porosity of filaments diminishes the length of Li+ dispersion pathways, and subsequently improves the power ability and dynamic properties of the battery. Nanofiber production techniques: (A) Electrospinning (B) Solution blowing and (C) Centrifugal spinning processes. Electrospinning has low production rate being easy and low at cost. And the procedure depends on the rheological properties of solution and solution conductivity and surrounding conditions. Solution and Centrifugal Spinning Processes are preferred. Mainly because of large scale production alternative systems are used instead of electrospinning. Still there is a lag in range of morphologies and narrow fiber diameter, customization and combination of these systems as an alternative in used to minimize the drawbacks.

C. Photovoltaic Fibers: Light Harvesting Essential outline of photovoltaic cells is to develop solar energy based cells on fiber or wire like substrates. Fiber electrodes with thin films of dynamic photovoltaic materials on the curved surface are made layer by layer, which is a three dimensional structure. Coordinating two useful terminals as photoanode and cathode shapes the photovoltaic fibers. In comparison with planar gadgets, fiber gadgets could harvest light from the three dimensional space because of the barrel symmetrical photoanode and the three dimensional light harvesting properties offered open doors for upper level light-concentrating applications.

Additionally, devices are highly adaptable and could be acknowledged by expanding the length/distance across proportion of fiber appearance, which make wearable solar energy gathering and change conceivable.

Current Research

Fibre Super Capacitors

Significant progress has been made in developing flexible bulk SCs using solid electrolytes, but they do not allow sweat and heat to pass freely. So, a new family of SCs, fiber SCs with 1D fibers as electrodes are considered. Fiber super capacitors are shaped as 1D wires, making them flexible, hence they can be easily woven. Currently it is difficult to design high performance super capacitors with sufficient power and energy capacity. Conventional super capacitors are 2D in nature, but currently, extensive research is being done to create high capacity 1D super capacitors.

B. Nanofibres in Li-ion battery

Working of cathode determines the power and capacity of battery. Material used for making Cathode should chemical composition with high reactivity and specific power depending on its structure and morphology. Preferred polymers were PVP, PAN, PVAc , modified with different oxides and phosphates. But synthesizing active materials by carbonization is more preferred. Graphite is most commonly used anode. But Porous Carbon Nanofibers were also later used because of their high porosity and with large surface areas, high Li-ion absorption would take place resulting in rapid charge – discharge rates.

Silicon and metal oxide composites are most preferred ones because of very high capacity and rate capability. Changes in configurations and doping materials with nanofibers can give higher and stable battery capacity, battery life.

With a specific end goal to guarantee the protected and smooth activity of the battery, separators must meet the accompanying necessities:

- at the same time great electronic insulator and particle conductors,
- mechanical and dimensional dependability
- resistance to degradation from electrolytes, pollutions, and anode response finished results.

So, fiber based membranes and fiber coated membranes are used like Polyester (PET) PAN polyimide(PI) and polyvinylidene fluoride (PVDF) as electro spun separator materials. Better wettability and more porosity increases the conductivity and lowers the resistance of separators. C. Photovoltaic Fibers: Light Harvesting Inorganic photovoltaic fibers: Silicon solar cells work on the simple principle of electron – hole pairing separated by the internal electric field induced in the p-njunction. For maximum amount of light harvesting and quantum efficiency the concentration of doping in p- and n- doped layer resulted in fiber poly-Si solar cell with efficiency of up to 10. 5%. Amorphous silicon solar cells on textile glass fiber fabrics give efficiency of 1. 4%. It is difficult to prepare more complex inorganic compounds on fiber substrates. (a) Scanning electron micrograph (SEM) of a deposited and cleaved junction in-fiber structure. (b) Differential interference contrast (DIC) optical micrograph of a representative 15 µm diameter Si p-i-n junction.

Organic photovoltaic fibers: For ease in structural configuration organic photovoltaic fibers are used. ITO coated glass and metal wires were used. Metalwires were replaced by Carbon Nanotubes (CNT) as more flexible, lightweight and bendable, good for wearing purpose.

Dye/quantum dots sensitized photovoltaic fibers: Dye sensitized solar cells like tube were designed for better light harvesting and its storage but the devices were rigid. Normally Dye – sensitized photovoltaic filaments utilize Ru-based N719 as the sensitizer, CDs and CdSe quantum spots co-sensitizer could work with Aquaelectrolyte and added to adaptable, stable and practical fiber gadgets.

Perovskite photovoltaic fibers: Perovskite materials, which could be effortlessly prepared through solution coating, vapor deposition and solid state development process at low temperature, have been coated on solar cells, light transmitting devices, photodetectors, etc. The film crystalline, light collecting and charge transport efficiency really good at the curved surfaces. Despite the fact that the perovskite layer could be set upon long strands, ongoing gadget length is still significantly shorter than different kinds.

Conclusion

After researching various literature on energy harvesting fibres, we realized that it has a lot of potential, even though the research is in its nascent stages. Fibre Supercapacitors have unique merits of being ultra-thin and being able to be weaved to form wearable electronics. All presently created fiber SCs can't contend with smaller scale batteries as low energy storing gadgets regarding energy density. Therefore, real research endeavors are expected to create fiber electrodes, which have high capacitances without giving up their power density and cycling life, and in addition keeping up their mechanical adaptability. We are a long way from creating an industrially viable product owing to the need carefully tailor fabrication methods, which take into the need to mass production.