Improved Electrochemical Double-Layer Capacitor Using Organosilicon Electrolytes

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WARF: P08415US

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The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing improved supercapacitors that use organosilicon electrolytes in place of conventional liquid electrolytes.

Overview

Although a battery can store significant amounts of energy, it cannot deliver it quickly. But a battery can be used to charge a capacitor, which then can provide much power all at once.

Supercapacitors consist of electrodes, collectors, a separator that keeps the electrodes out of electrical contact, and an electrolyte, which allows ions to move freely through the separator. Typically, supercapacitors use aqueous electrolytes, which can be unstable at high voltages, or organic liquid electrolytes like acetonitrile, which are highly toxic and flammable.

UW-Madison researchers previously developed novel electrolytes that could be used in supercapacitors (see WARF reference number P07356US). These electrolytes are quaternary ammonium salts that contain organosilicon groups. Unlike electrolytes currently in use, they are stable at high voltages and not highly flammable or toxic.

The Invention

UW-Madison researchers now have developed improved supercapacitors that use the novel organosilicon electrolytes in place of conventional liquid electrolytes, along with improved electrodes. These supercapacitors are safer than supercapacitors that use conventional electrolytes and are capable of stable operation at high voltages. They are useful in applications including electric and hybrid-electric vehicles, satellites, wind generators, photovoltaics, copy machines, household appliances, electric tools and electric power generation and distribution systems.

The organosilicon electrolytes can be produced as liquids or solids with high room temperature ionic conductivity. As liquids, they are stable and capable of withstanding voltages higher than any other known organic or aqueous electrolyte. As solids, they have excellent mechanical stability and great packaging versatility. In solid form they have somewhat lower ionic conductivity than liquid electrolytes, but their stability is higher, and they can be used for all-solid-state supercapacitor production. Both forms exhibit low volatility, flammability and toxicity.

The electrodes consist of a porous solid material having high surface area, such as carbon nanofibers or nanotubes, which allows ions to easily flow at high density from the electrode to the collector and vice versa. These electrodes exhibit increased accessibility of ions and better electrical contact with collectors as compared to conventional electrodes, increasing the response time of the supercapacitor to rapid changes in current. This is particularly important in automobiles, which require high instantaneous electrical current for functions such as acceleration.

Applications

- Electric and hybrid electric vehicles
- Medical devices
- Portable generators
- Other applications that require a high amount of power quickly

Key Benefits

- Capable of stable and efficient operation at a wide range of voltages, including voltages higher than 2.7 V
- Can be fabricated as an all-solid-state device, enabling cost-effective, high speed and high volume industrial production
- Electrolytes and electrodes are easy to make, can be synthesized in high yields from available and inexpensive starting materials and are stable during storage and processing.
- Electrodes can be fabricated using a patterned array of carbon nanofibers to eliminate the need for a separator, potentially simplifying construction of the supercapacitors.
- Alternatively, an ion-conducting organosilicon material could be used as a separator.
- Electrolytes have
    - High room temperature ionic conductivity, providing lower resistance
    - High thermal and electrochemical stability, enabling higher operating voltages and temperatures
    - Low volatility, toxicity and flammability, providing enhanced safety and performance
    - Less hydrophilicity as compared to conventional electrolytes, providing increased compatibility with electrodes and separators

Additional Information

For More Information About the Inventors

- Robert Hamers

Tech Fields

- Clean Technology : Energy storage, delivery & resource efficiencies

For current licensing status, please contact Jennifer Gottwald at jennifer@warf.org or 608-960-9854