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Can Organic Compounds Help Build Better Capacitors?

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ABSTRACT

Want to know about the latest innovation in capacitor technology? Here's how researchers are building better capacitors with organic compounds.

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Introduction

Capacitors are one of the most fundamental passive components in electrical circuits.[1] Like batteries, they store a charge, but unlike batteries, they do not discharge at a fairly constant rate. Instead, it depends on the change in voltage between their terminals and the inherent capacitive properties they possess.[2-3] Since the voltage between the terminals of a capacitor cannot change instantaneously, they can be used in applications where it needs to be stabilized, governed, and tuned.

Capacitors haven't seen much innovation over the years; however, newer high-voltage electrical applications in smart grids, electric vehicles, and signal processing have called for scientists and researchers to design better capacitors that can prevent bottlenecks in future technologies.[4-5] Organic compounds may soon change that. But how?

Why Problems Plague Capacitors?

Before we elaborate on how organic compounds can help us, we need to discuss the problems facing capacitors. Capacitors have two plates of conducting materials separated by an insulating layer. Charged gets stored on the plates by virtue of an electric field when a difference in voltage is applied between the two plates.

The insulating layer (dielectric) in the middle facilitates the electric field by preventing an electrical connection between the two plates, determining the capacitance of the component and the energy it stores. Common dielectric materials used in capacitors include paper, metal oxides, and plastics.

The problem lies in material selection for the dielectric. These materials tend to break down, degrade, and leak out depending on the voltage, frequency, temperature, and environment of the capacitor. This impacts their longevity and makes them a common point of failure in many electrical and electronic applications. In some cases, their failure may lead to short circuits that impact other components of the electrical circuit.

Figure 1.

An image of a printed circuit board with different electronic components

How Can Organic Compounds Address These Problems?

Organic compounds are a class of materials that deal with carbon and its bond with other atoms. Carbon forms strong covalent bonds with other atoms to form compounds that require a strong electric field to strip away electrons; however, at the

molecular level, weaker interactive bonds allow the electric current to pass, making organic compounds, as a whole, a weak dielectric material for capacitors.

The answer lies in hydrogels and their interaction via supramolecular assembly chemistry. In a paper published in the American Chemical Society in 2018, researchers claimed to have fabricated a solid-state capacitor with plates and dielectric made out of organic compounds PEDOT (poly(3,4-ethylenedioxythiophene)) and PVA poly-vinyl alcohol.

The resultant hydrogel electrode and electrolyte enables the flexible capacitor to withstand higher voltages, store more energy, and make it more durable. Although, in its infancy, more researchers are now following the same principle and trying different organic compound configurations that result in better hydrogel combinations.

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