

Polymer Gel Electrolytes for Solid-State Supercapacitors

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Abstract. The ability to achieve high surface areas with nanotechnology brought advancements in energy storage devices and their applications. Supercapacitors have the ability to charge and discharge quickly, and hold as much energy as batteries and other chemical storage devices. This study focuses on the polymer gel electrolytes for the solid-state supercapacitors, and eliminating the use of liquid electrolytes, which could be harmful to the environment when disposed or leaked. In this research, various supercapacitors were constructed using reduced graphene oxide electrodes with different polymer gel electrolytes, and the best candidates were determined for commercial use. The comparison varied from different polymers to different weight ratios of doping materials, while testing specific resistivity and specific conductivity of the supercapacitors constructed.

1. Introduction

Low-cost, environmentally friendly, and high-performance energy storage systems are increasing in demand alongside the needs of modern society and increased environmental conscious [1]. Batteries hold a lot of energy, but long charging times. Capacitors charge quickly, but don't hold as much energy. The gap between batteries and capacitors is filled by supercapacitors with their unique combination of high power capability, along with good specific energy. Supercapacitors are generally constructed with two electrodes, an electrolyte, and a separator that electrically isolates the two electrodes. The electrodes are fabricated from nanoscale materials since high surface area and high porosity are important in achieving high capacitance values [2]. Electrolytes should have high ionic conductivity. Because of that, aqueous and organic solutions are popular electrolyte choices in supercapacitors. However, liquid electrolyte are difficult to produce, and can have leakages. Solid-state supercapacitors provide easy construction, wide temperature range of operation, long shelf life, and eliminate the risk of leakage [3]. Hence, the goal of the study will be to create and compare solid-state supercapacitors with different polymer gel electrodes.

2. Experiment, Results, Discussion, and Significance

The electrodes used in the experiment are made with Laser Reduced Graphene. Graphene Oxide flakes are dispersed in deionized water (3.7:1 weight ratio) using a sonicator for two hours to allow uniform dispersion. The solution is then drop-casted onto a PET film that is precut into a CD shape. After drying overnight, the film is then adhered on a Lightscribe CD. The disc is inserted into a Lightscribe CD Drive. By using the laser, the graphene oxide is exfoliated into Laser Reduced Graphene [4].

Polyvinyl alcohol (PVA) and Phosphoric Acid (H_3PO_4) were chosen to use as electrolyte materials because of their high ionic conductivities. PVA was heated under constant stirring until a clear liquid is attained. Then the liquid was mixed with phosphoric acid, using a 1:1 PVA to H_3PO_4 weight ratio. This electrolyte was improved upon by the addition of different amounts of carbon nanotubes (CNT); 0.1%, 0.5%, 1%, and 2% weight ratio specifically. Supercapacitors are constructed by applying the electrolyte materials on the electrode surfaces and sticking the electrodes together; therefore, the electrolytes also eliminate the need for a separator and a way to adhere the system together.

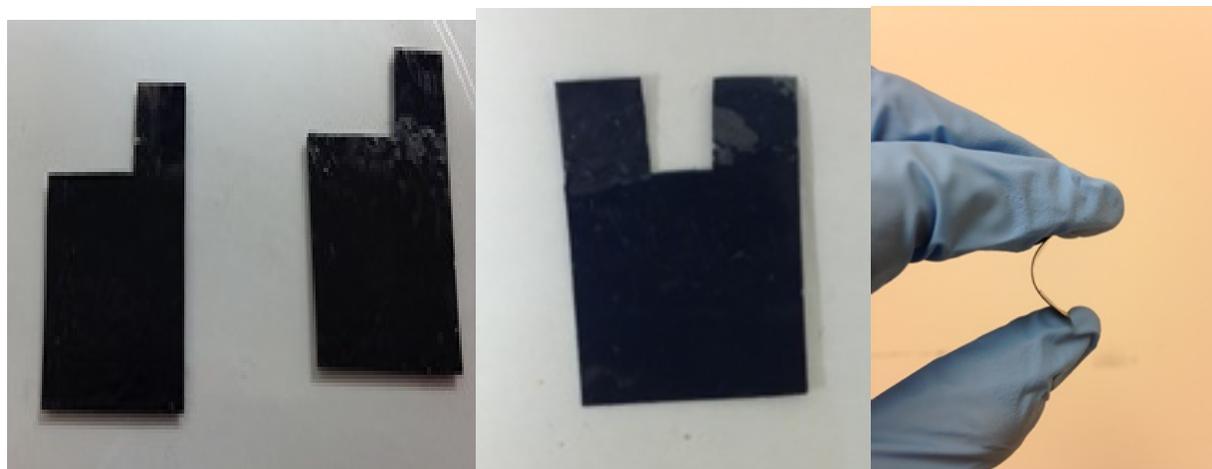


Fig. 1. Left to right: 1. Application of the electrolyte material. 2. Completed supercapacitor. 3. Flexibility of the supercapacitor.

The specific resistivity of each electrolyte, as well as the specific capacitance of each supercapacitor was measured. The PVA/H₃PO₄ supercapacitor exhibited a specific capacitance of 97.27 Fg⁻¹, which is a similar result for a supercapacitor of this type [5]. Addition of CNT between 0.1 wt% and 1 wt% improved specific capacitance a great deal. The supercapacitor with the 1 wt% of CNT exhibited a specific capacitance 123.52 Fg⁻¹, which is a staggering 27% increase in capacitance. Although the 2% CNT exhibited a capacitance value of 97.27 Fg⁻¹, it is too small of an increase to show as a significant improvement. This could be attributed to the agglomerations occurring in the electrolyte, causing imperfections on the surface and gaps between the electrodes. The lowest resistivity was exhibited by 0.5% CNT at 294 Ωcm. 1% CNT with the highest capacitance had the second best value at 306 Ωcm.

3. Conclusions

Solid-state supercapacitors provide a more environmentally friendly alternative to electrical energy storage devices. Supercapacitors made with graphene electrodes and PVA/H₃PO₄ electrolytes that were improved by the addition of CNT show promising results for future commercial usage because of their environmental friendliness, simple production, relatively low cost, high safety, and high capacitance. Supercapacitor with the 1 wt% of CNT electrolyte exhibited the most promising results with a specific capacitance 123.52 Fg⁻¹, and an electrolyte resistivity of 306 Ωcm, showing a great increase in properties from the baseline electrolyte with no CNT present.

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5. References

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