Optimization of Hybrid Capacitors: Role of Electrode Composition and Surface Area

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Supercapacitors store ten to a hundred times more energy than a simple capacitor; however, supercapacitors possess only one tenth of the energy of a standard battery. Therefore, through the course of this experimentation it was tested to see if a combination of graphene, activated carbon fiber, and manganese oxide active material produces an optimum hybrid capacitor, facilitating the creation of a high power and energy density device. The preliminary hypothesis stated the synthesis of electric-double layer and pseudocapacitance principles with the use of activated carbon fiber (ACF) and manganese oxide (MnO2) will produce an optimum hybrid capacitor, due to ACF possessing the greatest surface area and the high electrochemical potential of manganese oxide. In order to conduct the experimentation, graphene and MnO2 were synthesized. The capacitors were assembled with coated stainless steel mesh electrodes submerged in a 1.5 M sodium sulfate (Na2SO4) electrolyte. The initial results of the ACF-MnO2 capacitor depicted a capacitance of 15.8 F/g. Therefore, the cell's results indicated the purchased MnO2 lacked essential surface area. Hence, a high surface area sample of MnO2 was synthesized and used in conjunction with ACF to produce a hybrid capacitor. This high surface area cell produced an energy capacity of over 98 F/g (54.59 Wh/kg), producing the optimum hybrid capacitor and therefore supporting the hypothesis. Current capacitors on the market have an energy density of only 14-15 Wh/kg. Therefore, these truly revolutionary capacitors have a variety of consumer, industrial, and even military applications.