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Green synthesis of palladium nanoparticles–graphene hybrids as efficient electrode materials for electrochemical double layer capacitors

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A composite of palladium (Pd) nanoparticles decorated Graphene Nanosheets (GNS) was synthesized in a single step by the simultaneous reduction of Graphene Oxide (GO) and palladium chloride from the aqueous phase using ascorbic acid as reducing agent. The palladium nanoparticles–graphene hybrids (Pd–GNS) are characterized by high resolution scanning electron microscopy, transmission electron microscopy, Raman, Fourier transform infrared, X-ray diffraction, and energy dispersive X-ray spectroscopy, which demonstrate that the metal nanoparticles have been uniformly deposited on the surfaces of graphene nanosheets. The synthesized material has been analyzed by cyclic voltammetry, electrochemical impedance spectrometry and chrono-potentiometry using 1 M KCl as the supporting electrolyte for its application as electrochemical double layer supercapacitors. Results showed that the Pd/GNS nanocomposite displayed superior capacitive performance with large capacitance (637 Fg-1), excellent cyclic performance, and maximum energy and power densities of 56 W.h.kg-1 and 1166 W.kg-1, respectively at a current density of 1.25 Ag-1. This highlights the importance of anchoring small Pd nanoparticles on graphene sheets for maximum utilization of electrochemically active Pd nanoparticles and graphene for energy storage applications in supercapacitors.

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Hi-k dielectric ceramic material for supercapacitors

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Supercapacitors are electrical devices with capacitances value upto 10,000 Farad, a value greater than any other conventional or ordinary capacitors. Supercapacitors charges by an electrostatic mechanism with positive as well as negative electric charges on the conducting surface of a capacitor for electrical energy storage non-faradic reaction or the movement of charges. Supercapacitor cell performance depends mainly on the electrode material. The energy density of the supercapacitor has a lower value than the available batteries in the market. The value of energy-storage density of supercapacitor is as low as 10 Watt-hour/kg while lithium ion batteries is more than 90 Watt-hr/kg. Mainly, specific energy and specific capacitance are the two terms used for to determine the performance of the material for supercapacitors. There are many high-k dielectric materials that are used to fabricate supercapacitors. Hi-k dielectric uses ferroelectric ceramics like Barium titanate with large permitivity ranging from 1000-20,000 and dissipation factor or loss factor of around 0.01 to 0.03. Barium titanate ($BaTiO_3$) and barium zirconium oxide $BaZrO_3$ (BTZ) are considered as two main high-k dielectric material suitable in the making of supercapacitor. Zirconium metal (Zr) can be added to the $BaTiO_3$ ceramic to increase its permittivity range and also lowers the cost of the ceramic material. After the restriction of using toxic lead (Pb)-based ceramics, efforts were made to make ferroelectric material without the presence of lead-metal with suitable properties over a wide range of temperature. Ceramic material like BCT-BMT offers stable properties at temperature above 200^{0}C-300 ^{0}C. The dielectric material has high relative permittivity and low loss factor useful for many applications like hybrid vehicles and electronic system.

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