Diamond nanoparticles/reduced graphene oxide nanocomposites as supercapacitors

Wang Qi[1], Nareerat Plylahan[2], Musen Li[3], Emmanuelle Pichonat[4], Henri Happy[4], Palaniappan Subramanian[1], Thierry Djenizian[2,5], Rabah Boukherroub[1], and Sabine Szunerits[1]

[1]Institut de Recherche Interdisciplinaire (IRI, USR 3078), Université Lille1, Parc de la Haute Borne, 50 Avenue de Halley, BP 70478, 59658 Villeneuve d'Ascq, France.

[2]Aix-Marseille University, CNRS, LP3 UMR 7341, 13288, Marseille, France.

[3]Key Laboratory for Liquid-Solid Structural Evolution and Processing of Materials (Ministry of Education), Shandong University, Jinan 250061, China.

[4]Institute of Electronics, Microelectronics and Nanotechnology (IEMN), UMR-CNRS 8520, Université Lille 1, Cité Scientifique, 59655 Villeneuve d'Ascq, France.

[5] ALISTORE ERI, CNRS (FR3104)

The demand of electrochemical capacitors, so-called supercapacitors is rapidly growing for portable systems and hybrid electrical vehicles which require high power in short-time pulses. Graphene oxide (GO) as an electrode material has drawn much attention due to its unique electronic and mechanical properties[1,2]. For example, it has been demonstrated that partially reduced graphene oxide (rGO), by adding hydrobromic acid into graphene oxide solution, reveals an improvement in wettability of rGO matrix, penetration of an aqueous electrolyte, and pseudo-capacitive effects[3].

Nanodiamonds (ND) have been widely investigated for their electrochemical properties and potential applications in various fields[4-5]. In this work, nanodiamonds have been investigated as potential intercalating material into graphene oxide nanosheets as well as their ability to partially reduce graphene oxide to rGO[6].

Graphene oxide (GO) was synthesized from graphite powder using a modified Hummers method[7]. The reduced graphene oxide/nanodiamonds (rGO/ND) was prepared by heating aqueous solutions of GO and NDs with different ratios (rGO/ND: 1/1, 2/1, 4/1, 10/1) at 100°C for 60-96 h. The obtained rGO/ND was characterized by scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray photoelectron spectroscopy (XPS), micro-Raman spectroscopy, and UV/Vis measurements. The electrochemical measurements were recorded by cyclic voltammetry and chronoamperometric (CA) experiments.

The characterization shows that GO matrix is partially reduced to rGO under these conditions of synthesis, while diamond nanoparticles intercalated into the rGO sheets. These results significantly improve the dispersibility of the rGO/ND matrix in polar solvents such as ethanol and nonpolar solvents such as DMF. The suspensions are stable for several weeks. Fig.1 shows an example of the morphology of rGO/ND ratio 10/1 observed by SEM. The porous structure of rGO/ND nanocomposite is clearly seen. The nanodiamonds (small white dots) are homogeneously dispersed in the porous rGO matrix.

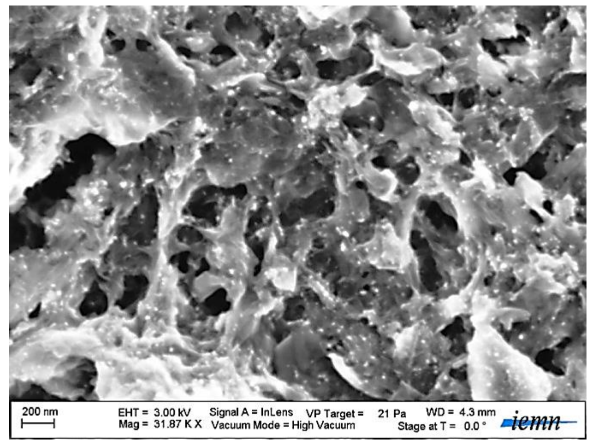

Fig. 1. SEM image of rGO/ND ratio 10/1

The supercapacitor behavior of rGO/ND was investigated in a three-electrode system comprised of rGO/ND casted on Pt foil as a working electrode, another Pt foil as a counter electrode and Ag/AgCl/3M KCl as a reference electrode. The cyclic voltammetry (CV) and galvanostatic charge/discharge tests were performed in 1M H_2SO_4 in the potential window of 0 to 0.8 V. Capacitance measurements reveal that rGO/ND (10/1) displays the highest specific capacitance as compared to the others. The calculated specific capacitance of rGO/ND (10/1) from the cyclic voltammogram recorded at the scan rate of 20 mV/s is 224 F/g. This value agrees with the specific capacitance obtained from galvanostatic discharge profile: 285 and 245 F/g at the current density of 1 and 2 A/g, respectively. Furthermore, rGO/ND shows good cycling stability. The electrochemical performance of rGO/ND is comparable to those reported elsewhere[8-12].

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