Supporting Information

High performance supercapacitor electrode material based on vertically aligned PANI grown on reduced Graphene oxide/$Ni(OH)_2$ hybrid composite

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Materials and instruments

Analytical grade urea, aniline, $Ni(NO_3)_2$, H_3PO_4, H_2SO_4, and ethanol was purchased from Merck, India. Graphite flake was purchased from Loba chemie, Mumbai. Nafion was purchased from Aldrich. The GC electrode used was of 6 mm outer diameter and 3 mm inner diameter. All the chemicals were used as received without any further purification.

The XRD analysis was carried out using PW1710 diffractometer, a Philips, Holland, instrument. The morphological analysis was carried out using FESEM (Carl Zeiss-SUPRATM 40), TEM (TECNAI G2-20S-TWIN) analysis. BET surface area and pore size distribution analysis was carried out using Quanta chrome autosorb instrument. Raman study was carried out by using Agiltron R3000 Raman spectrometer with 785 nm excitation laser. All the electrochemical characterizations were carried out in Biologic SP-150 instrument.

Electrode preparation

The electrochemical characterizations (cyclic voltammetry, galvanostatic cycling and electrochemical impedance spectroscopy) were carried out in a three electrode system with 2 M KOH as supporting electrolyte. 1% nafion in ethanol was used as binder for the fabrication of sample onto the GC electrode (working electrode) and a platinum foil was used as counter electrode. All the characterizations were with reference to saturated calomel electrode.

Raman spectra

The raman spectra of the rGO/$Ni(OH)_2$ and rGO/$Ni(OH)_2$/PANI was carried out at an excitation wave length of 785 nm and is shown in Figure. S1. For rGO/$Ni(OH)_2$ the broad peak at 420 cm^{-1} and 595 cm^{-1} can be attributed to the $Ni(OH)_2$. The peak at 1300 cm^{-1} and 1600 cm^{-1} of rGO/$Ni(OH)_2$ composite can be attributed to the D band and G band of the reduced graphene oxide, respectively with an intensity ratio (I_D/I_G) of 1.89. The D band and G band in rGO indicates the presence of sp^3 C and sp^2 carbon, respectively in the reduced graphene oxide and the intensity of I_D/I_G determines the defect in graphene lattice. The high intensity of the D band compared to the G band signify the presence of reduced graphene oxide, while a reverse intensity order occurs for graphene oxide.[1] In case of the rGO/$Ni(OH)_2$/PANI the D band and G band shifts to 1332 and 1605 cm^{-1}, respectively. The shifting is an indication of some charge transfer amongst the carbon material and other compounds in

the composite. The additional peaks at 517, 595, 1170, 1508 cm^{-1} in rGO/$Ni(OH)_2$/PANI composite are the characteristic peaks of PANI.[2]

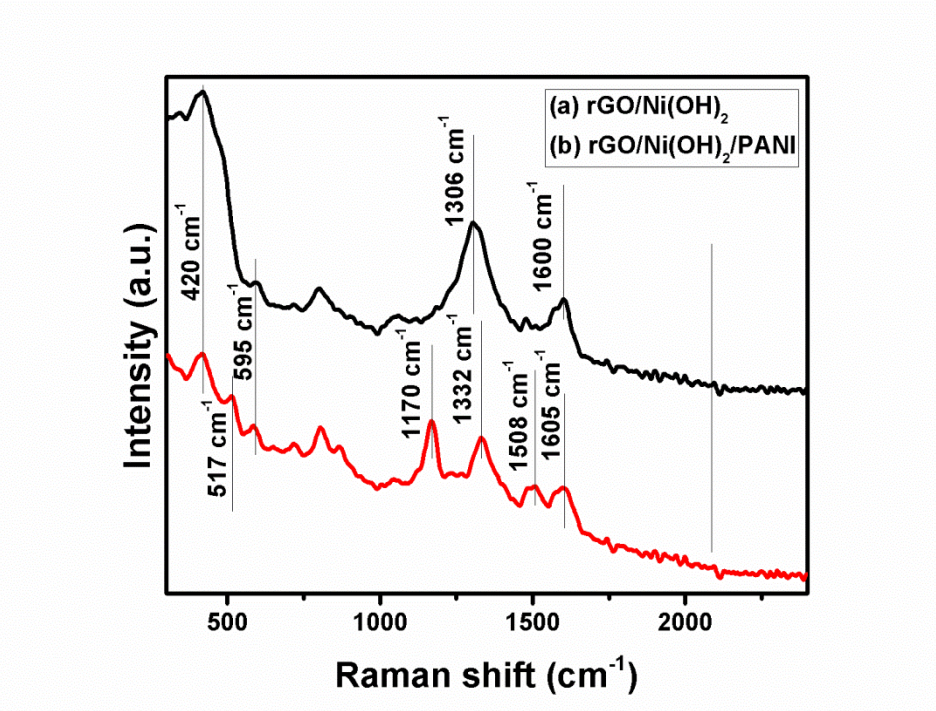

Figure S1. RAMAN spectra of rGO/$Ni(OH)_2$ and rGO/$Ni(OH)_2$/PANI

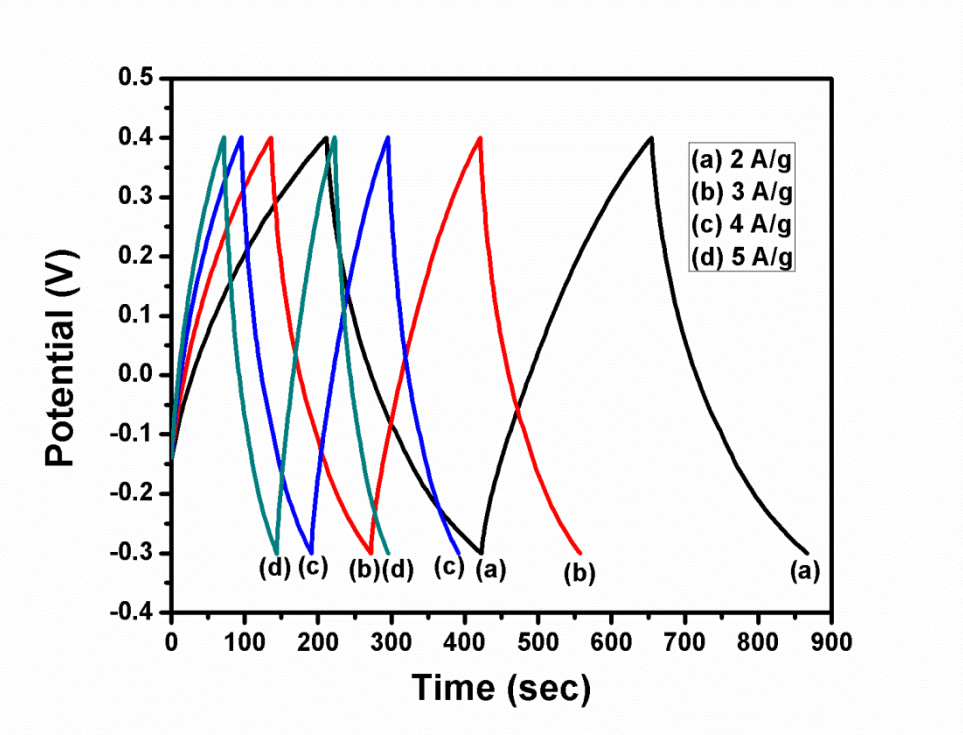

Fig. S2 GCD plots of rGO/$Ni(OH)_2$/PANI at different current densities of 2, 3, 4 and 5 A/g.

The GCD plots of the rGO/$Ni(OH)_2$/PANI at different current densities of 2, 3, 4, 5 A/g is shown in Fig. S2 within the potential range of (-)0.3- 0.4 V. The various specific capacitances, energy densities and power densities obtained are shown in Table S1.

Table S1. specific capacitances, energy densities and power densities of $Ni(OH)_2$, $rGO/Ni(OH)_2$ and $rGO/Ni(OH)_2$/PANI at different current densities.

Current density (A/g)	2	3	4	5
Sp. Capacitance of $rGO/Ni(OH)_2$/PANI (F/g)	604	583	546	516
Sp. Capacitance of $rGO/Ni(OH)_2$ (F/g)	359	341	305	281
Sp. Capacitance of $Ni(OH)_2$ (F/g)	238	220	199	156
Energy density of $rGO/Ni(OH)_2$/PANI (Wh/kg)	41.1	39.65	37.16	35.1
Energy density of $rGO/Ni(OH)_2$ (Wh/kg)	24.45	23.2	20.8	19.15
Energy density of $Ni(OH)_2$ (Wh/kg)	16.17	14.97	13.5	10.6
Power density W/kg	700	1050	1400	1750

References

1. M. Hilder, B. Winther-Jensen, D. Li, M. Forsyth, D. R. MacFarlane, *Phys. Chem. Chem. Phys*., 2011, **13**, 9187.

2. C. Liu, J. Zhang, G. Shi, F. Chen, *J. Appl. Polym. Sci*., 2004, **92**, 171-177.