Electronic Supplementary Material (ESI) for Nanoscale.

Supporting information

Enhanced electrochemical performance by unfolding few wings of graphene nanoribbons of multiwalled carbon nanotubes as anode material for Li ion battery application

Madhumita Sahoo and S. Ramaprabhu*

Alternative Energy and Nanotechnology Laboratory (AENL), Nano-Functional Materials and Technology Centre (NFMTC), Department of Physics, Indian Institute of Technology Madras, Chennai, Tamil Nadu, 600036, India.

*Email: ramp@iitm.ac.in

SEM image of parent P-MWNT (Fig. S5a) shows carbon nanotubes of few micrometer length with no impurity such as amorphous carbon or unused catalyst particles.

In the synthesis procedure of PENT, the oxidation upto a certain layer was controlled by the amount of $KMnO_4$. Four different amounts, 10%, 25%, 50% and 75% $KMnO_4$ were used to optimize the conditions for the achievement of the desired structure. Fig. S3(A) shows the XRD of PENT-10 (PENT-X; X represents % of $KMnO_4$) and PENT-25 respectively in (a) and (b) with not any visible changes in the C(002) peak for PENT-10, while a little disorder can be seen in the base of the peak for PENT-25, showing negligible disorder in the structure and thus little effect of oxidation.

Fig. S5(a) shows the TEM image of PENT-25 showing exfoliation of only one upper layer. The image of Fig. S5(b) shows the TEM of PENT-75, exhibiting complete opening up of MWNT as GNR.

Parent multiwalled carbon nanotubes showed a SSA of ~ 66 $m^2\ g^{-1}$ (Fig. S3B) and discharge capacity of 848 mAh g^{-1} in the first cycle at a current density of 16.74 mA g^{-1}, which reduced to 446 mAh g^{-1} in the next cycle due to the formation of SEI layer giving ~47 % irreversible loss. MWNT shows 214 mAh g^{-1} at the current density of 67 mA g^{-1} current density after 30 cycles (Fig. S1). PENT with a SSA of ~ 1.5 times higher than P-MWNT outperform the reported 1-D-2-D hybrid carbon composites together with the completely opened up GNR. Table S1 shows the different contribution of functional groups present in deconvoluted C1s spectrum of PENT.

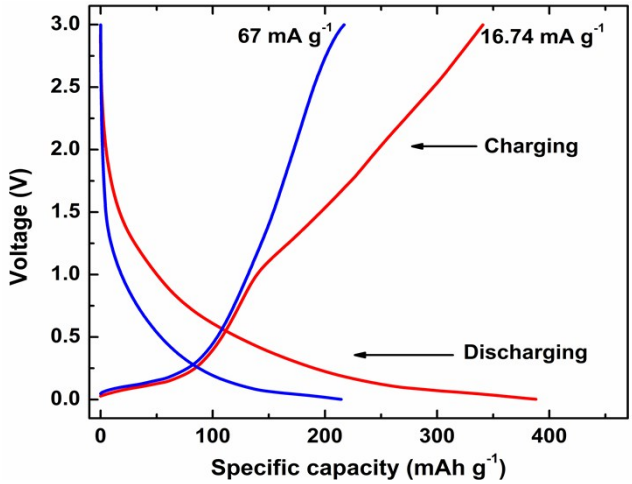

Fig. S1. Charge-dischrage profile for multiwalled carbon nanotubes (MWNT).

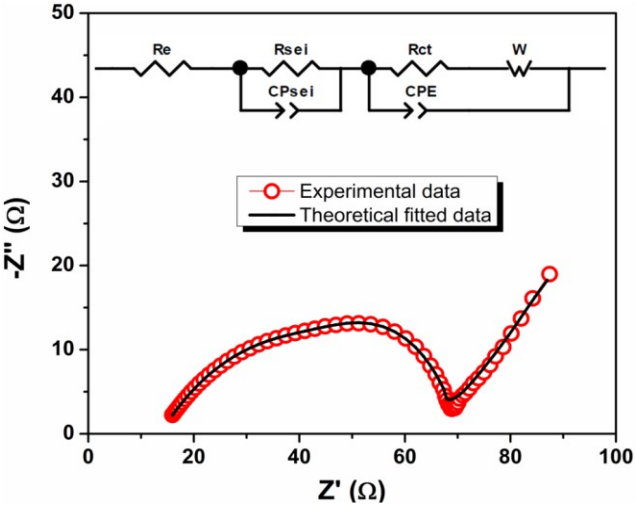

Fig. S2. Impedance spectra study from 100 kHz to 0.01 mHz with a sine wave of amplitude 5 mV.

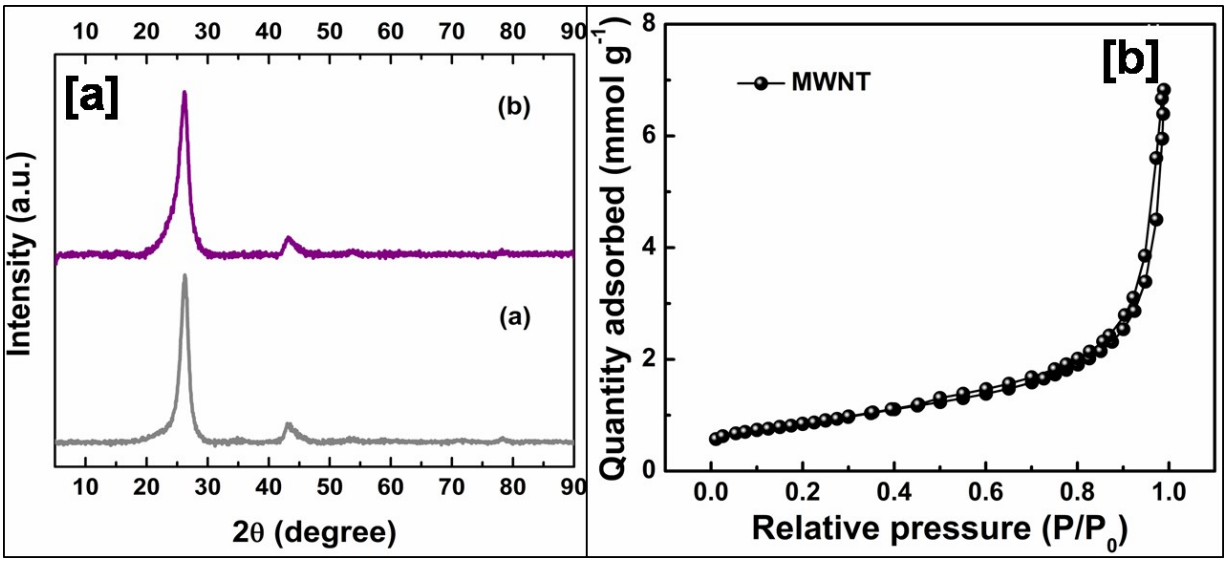

Fig. S3. [a] X-ray diffraction patterns of exfoliated multiwalled carbon nanotubes oxidized at (a) 10% and (b) 25% amount of $KMnO_4$. [b] Nitrogen adsorption–desorption isotherm for purified multiwalled carbon nanotubes giving SSA as ~66 m^2 g^{-1}.

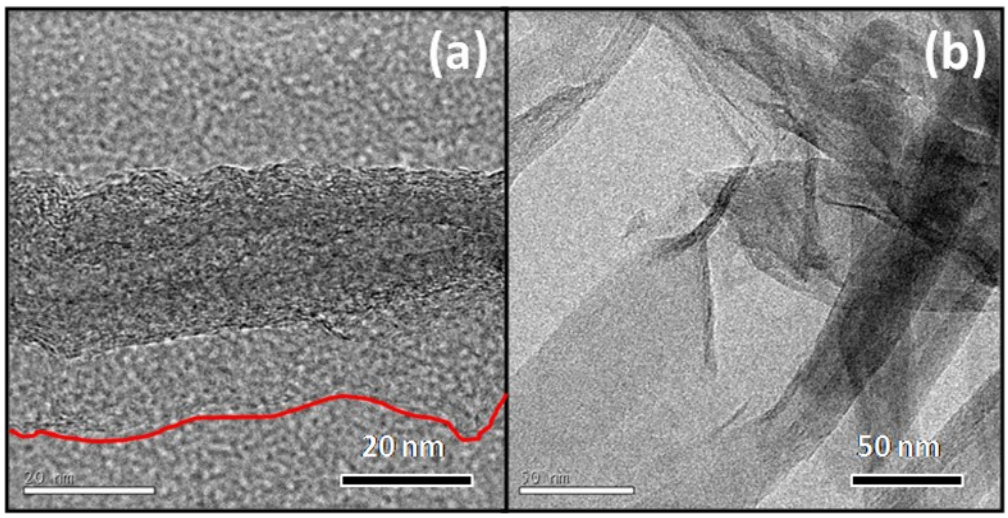

Fig. S4. TEM images of multiwalled carbon nanotubes exfoliated (a) least and (b) most amount of $KMnO_4$.

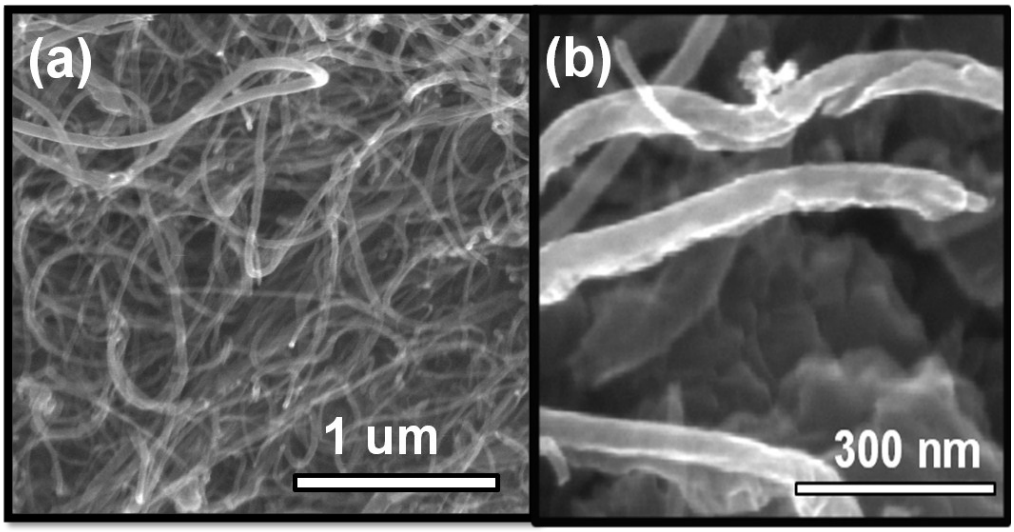

Fig. S5: Scanning electron microscopy images of (a) MWNT and (b) PENT.

Table S1: Deconvoluted peak details for C 1s of PENT.

Deconvoluted peaks of C 1s	**C=C**	**C-OH**	**C=O**	**O-C=O**	**π-π***
Position (eV)	***284.5***	***286.1345***	***287.9***	***289.62***	***291.4***
Percentage composition (%)	***67.78***	***16.53***	***7.54***	***5.11***	***3.03***