Electronic Supplementary Material (ESI) for RSC Advances.

Electronic Supplementary Information

SWCNT/$BiVO_4$ Composites as Anode Materials for Supercapacitor Application

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Experimental Section

Ammonium metavanadte, sodium dodecyl sulphate (SDS) and glycerol were purchased from Merck, India and used without further purification. Bismuth nitrate pentahydrate, polyvinlidene fluoride (PVDF), N-methyl-2-pyrrolidinone (NMP and activated carbon (AC) were purchased from Himedia, India whereas SWCNTs were purchased from Aldrich. All were used as received without further purification.

Synthesis of $BiVO_4$

3 mmol of SDS was dissolved in 40 mL of solvent (glycerol and ultrapure water with volume ratio 1:1) in a flask at room temperature. 1 mmol of $Bi(NO_3)_3.5H_2O$ and 1 mmol NH_4VO_3 was added to the above clear solution under constant stirring in sequence. After stirring for 5 min, the solution was transferred into a stainless steel autoclave with a Teflon liner and heated at 160 °C for 18 h. After cooling to room temperature, the reaction mixture was centrifuged and the pellet was washed with water and ethanol. Finally, the product was dried at 70 ºC for *ca*. 5 h.

Synthesis of SWCNT/$BiVO_4$ composite

Loading of SWCNTs with $BiVO_4$ was done by ultrasonication. Briefly, 0.2 g of prepared $BiVO_4$ was ultrasonically dispersed in 30 mL of ethanol, followed by addition of 5 wt% of SWCNT. The whole reaction mixture was treated ultrasonically for 8 h. The product was obtained after centrifugation. It was washed and dried at 70 ºC. Similar methodology was performed to load 10, 20, 25, 50 and 75 wt% of SWCTs with $BiVO_4$.

Characterization

Powder X-ray diffraction (XRD) measurements were performed with PANalytical X'pert Pro MPD having a Cu Kα radiation (λ = 0.154 nm) source over the 2θ range of 15–70°. The surface morphologies of the sample were investigated by Field Emission Scanning Electron Microscopy (FE-SEM) on a Zeiss Ultra FEG 55 instrument at 20 kV operating voltage. The sample was deposited onto the conductive carbon tapes, which were placed over the top of FE-SEM Cu stubs. The BET surface areas were analyzed by nitrogen (N_2) adsorption at liquid N_2 temperature with a Micromeritics ASAP 2020 nitrogen adsorption apparatus. All the samples were degassed at 120 °C for 12 h prior to the N_2 adsorption measurements.

Electrode preparation and Electrochemical Measurement

For electrochemical measurement, the active electrode was prepared by mixing electroactive material (80 wt %), AC (15 wt %) and PVDF (5 wt %) with 0.4 mL of NMP to form a slurry which was coated and dried on a small piece of graphite plate (area of coating, 1 cm^2). CV and galvanostatic charge-discharge (CD) studies of the composites were carried out using Bio-Logic VMP3 Galvanostat/Potentiostat Instruments in 2 M NaOH electrolyte at room temperature. For electrochemical characterization Pt as counter and Hg/HgO as reference electrode was used.

Field Emission Scanning Electron Microscopy Image

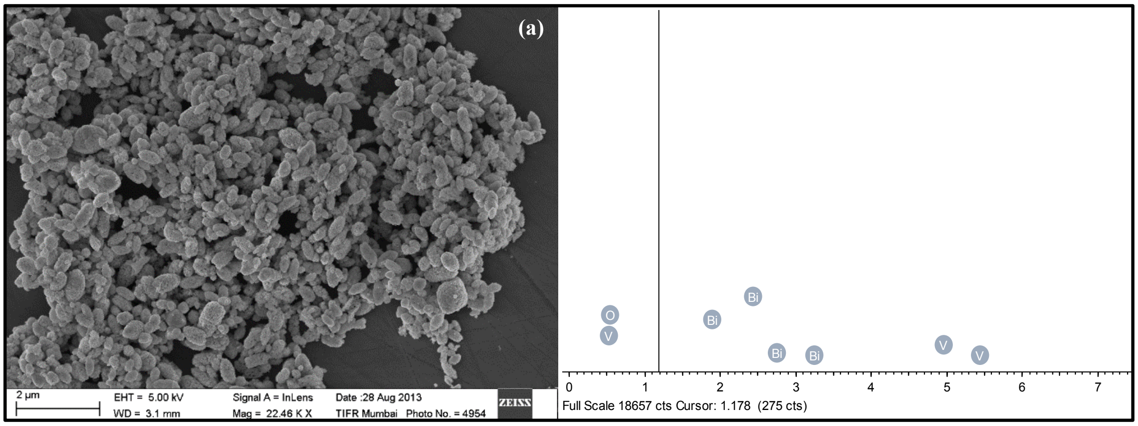

Fig. S1 *(a) FE-SEM image (b) EDX pattern with a quantitative atomic ratio of solvothermally synthesized* $BiVO_4$

BET Surface Area Analysis

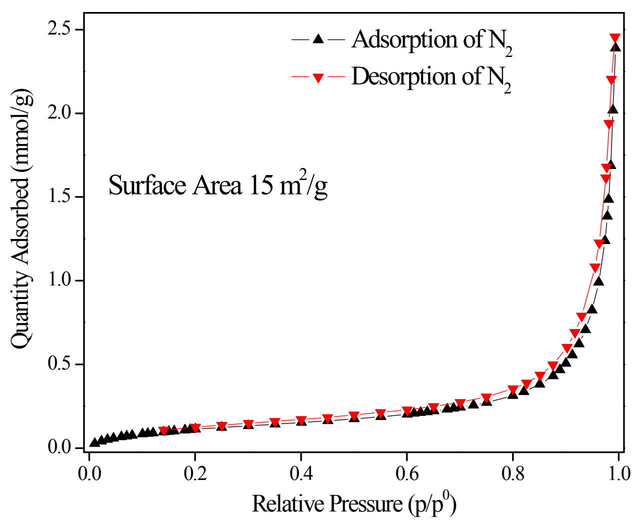

Fig. S2 *Nitrogen adsorption–desorption isotherms of* $BiVO_4$

Cyclic Performance of $BiVO_4$ *w.r.t.* number of cycle

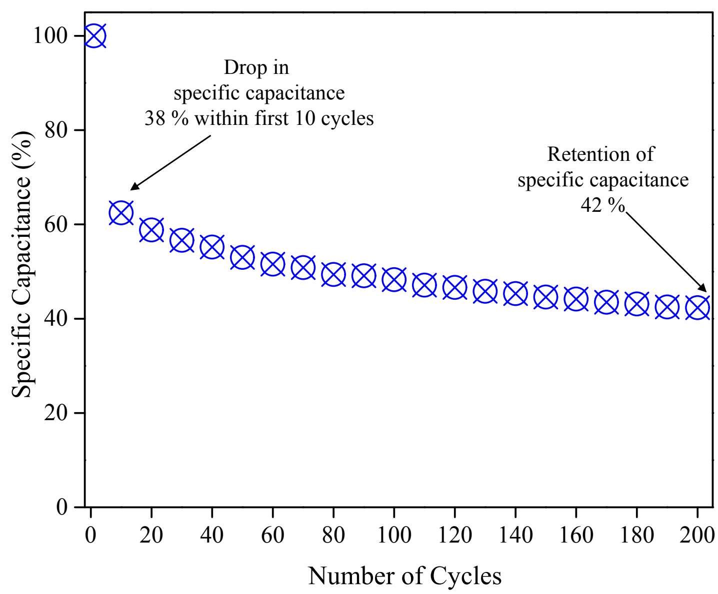

Fig. S3 *Cyclic performance in terms of specific capacitance of $BiVO_4$ measured at 1.0 A g^{-1} up to 200 cycles*

Powder X-ray diffraction pattern of $BiVO_4$, S1, S2 and S3 samples

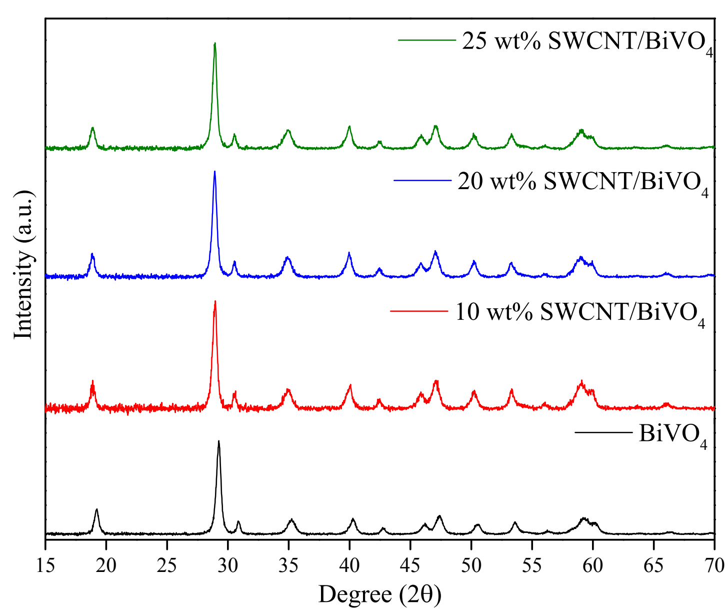

Fig. S4 *Powder X-ray diffraction pattern of $BiVO_4$, S1, S2 and S3 in 15° - 70° 2θ range*

Field Emission Scanning Electron Microscopy Image

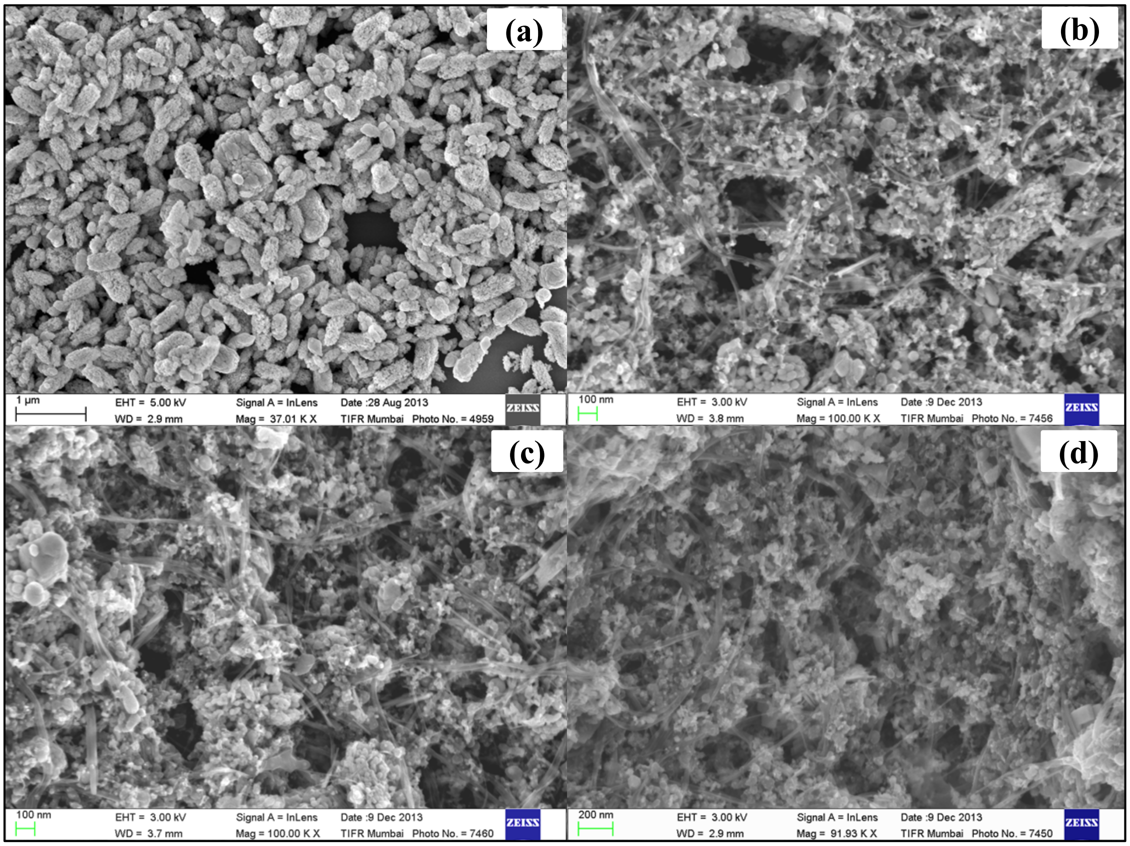

Fig. S5 *FE-SEM images of $BiVO_4$ and SWCT/$BiVO_4$ hybrid prepared by ultrasonication method (a) S0, (b) S1, (C) S2 and (d) S3*

BET Surface Area Analysis for S1, S2 and S3 samples

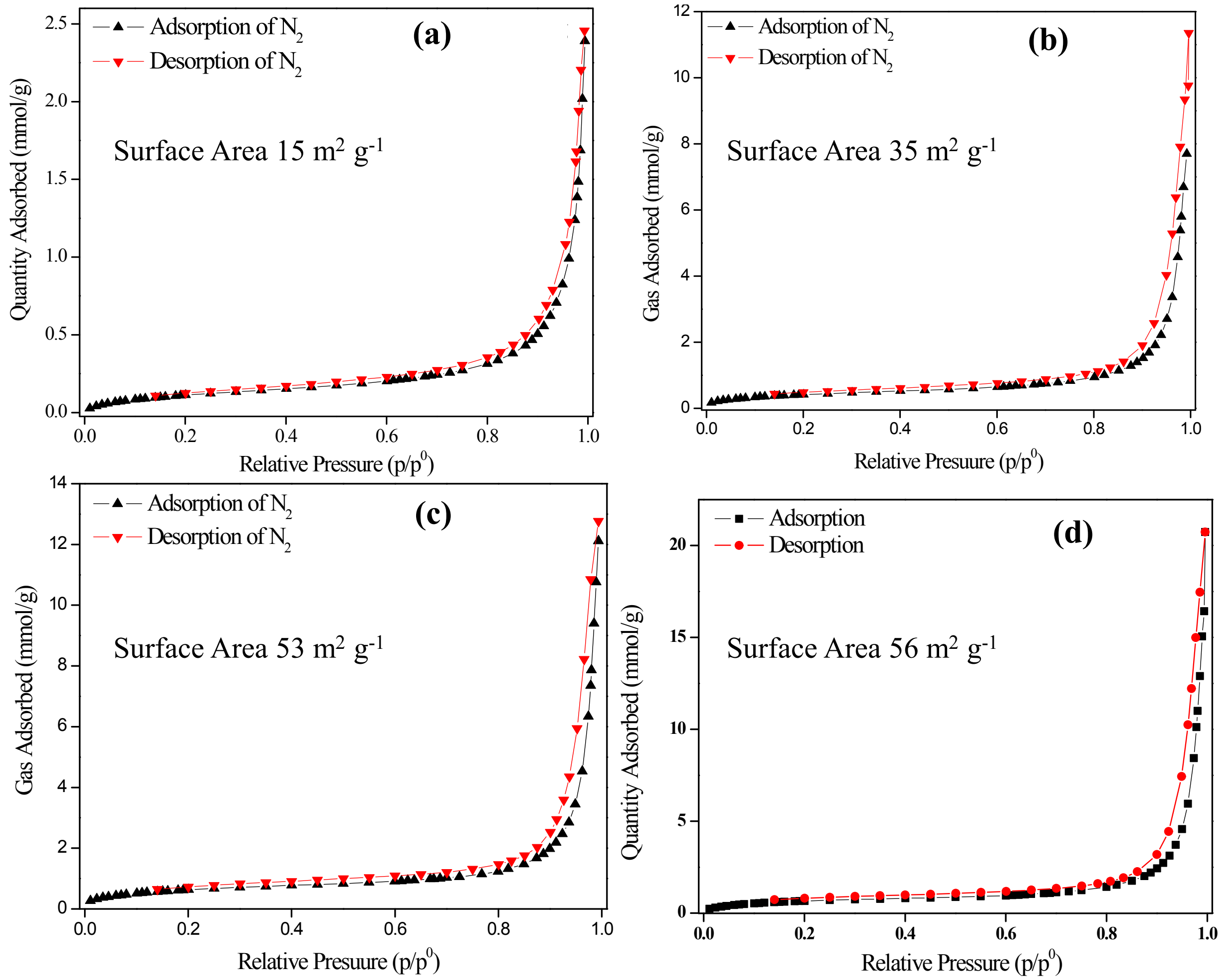

***Fig. S6** Nitrogen adsorption–desorption isotherms of (a) $BiVO_4$, (b) S1, (c) S2 and (d) S3 prepared via ultrasonication route*

Table S1: Loading amount of Electrode Material

Electrode Material(s)	Loading Mass (g)
$BiVO_4$	0.005
5 wt% SWCNT/$BiVO_4$	0.004
10 wt% SWCNT/$BiVO_4$	0.002
20 wt% SWCNT/$BiVO_4$	0.002
25 wt% SWCNT/$BiVO_4$	0.002
50 wt% SWCNT/$BiVO_4$	0.002
75 wt% SWCNT/$BiVO_4$	0.004

Cyclic Voltammetry for S1, S2 and S3 sample

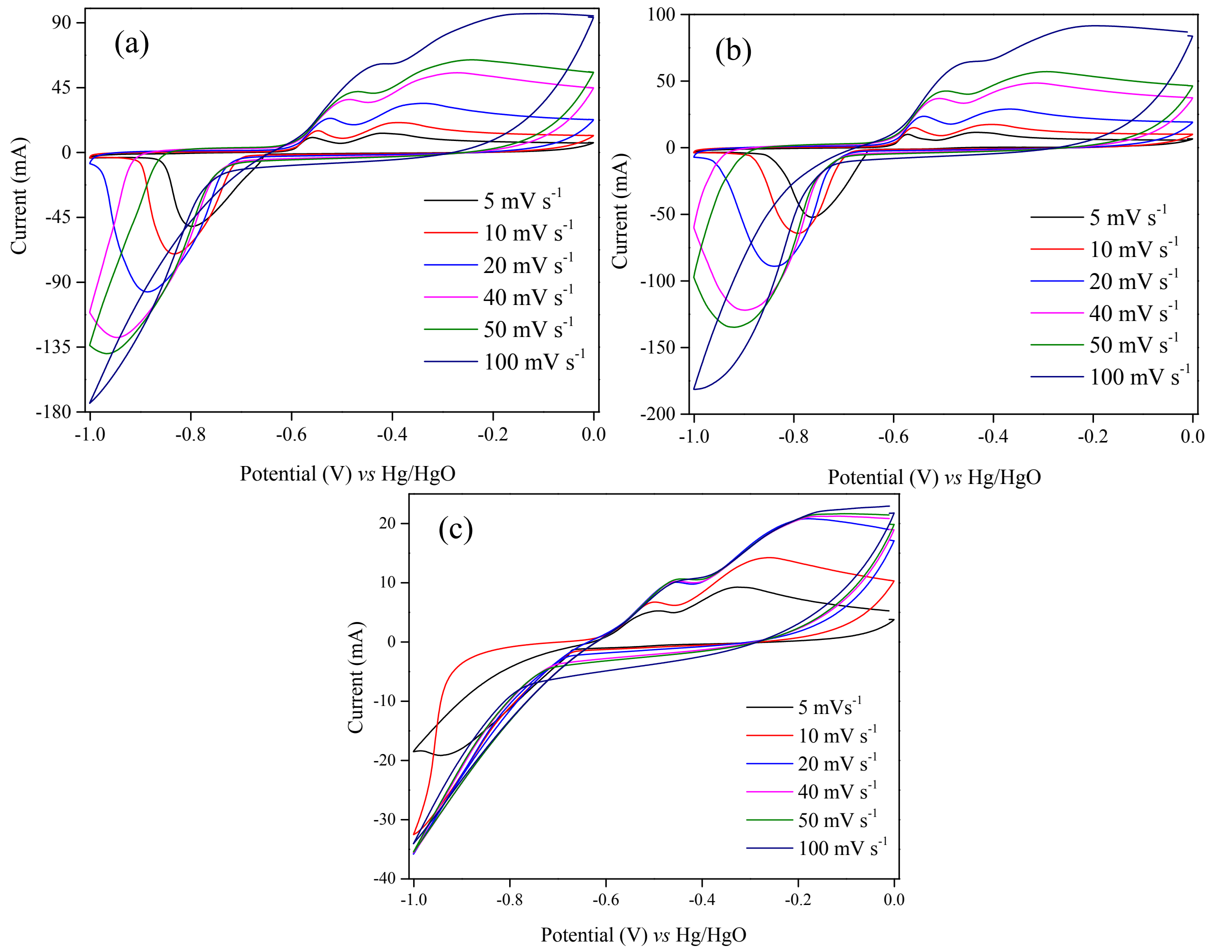

Fig. S7 *CV profile of (a) S1, (b) S2 and (c) S3 at various scan rates*

Coulombic Efficiency *w.r.t.* number of cycles

Coulombic efficiency of the electroactive material can be calculated by equation 1

$$\eta = \left(\frac{t_D}{t_C}\right)100 \tag{1}$$

where t_D and t_C are discharging and charging time, respectively.

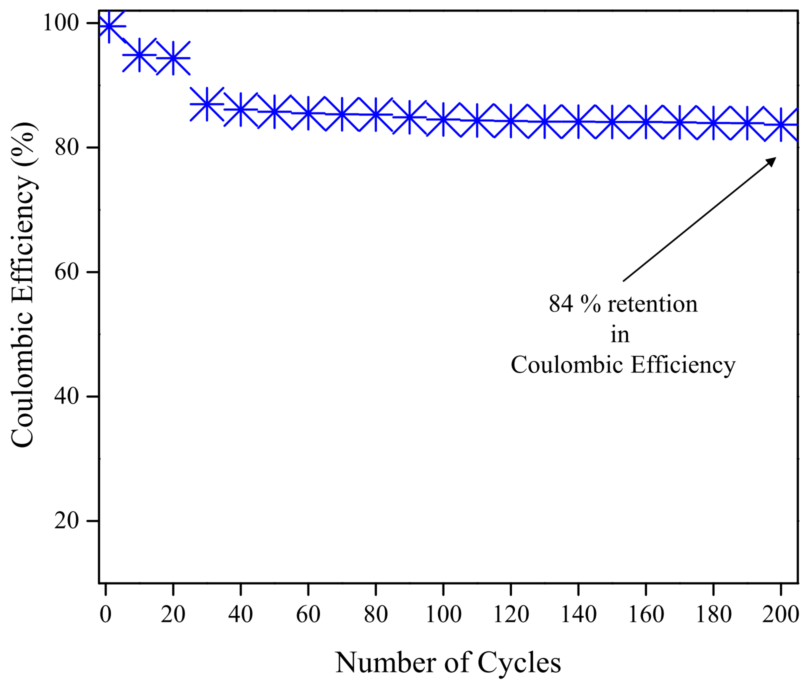

Fig. S8 *Cyclic performance in terms of coulombic efficiency of 20 wt % SWCNT/$BiVO_4$ measured at 2.5 A g^{-1}*

Cyclic Voltammetry for 5, 50, 75 wt% and SWCNT at various scan rates

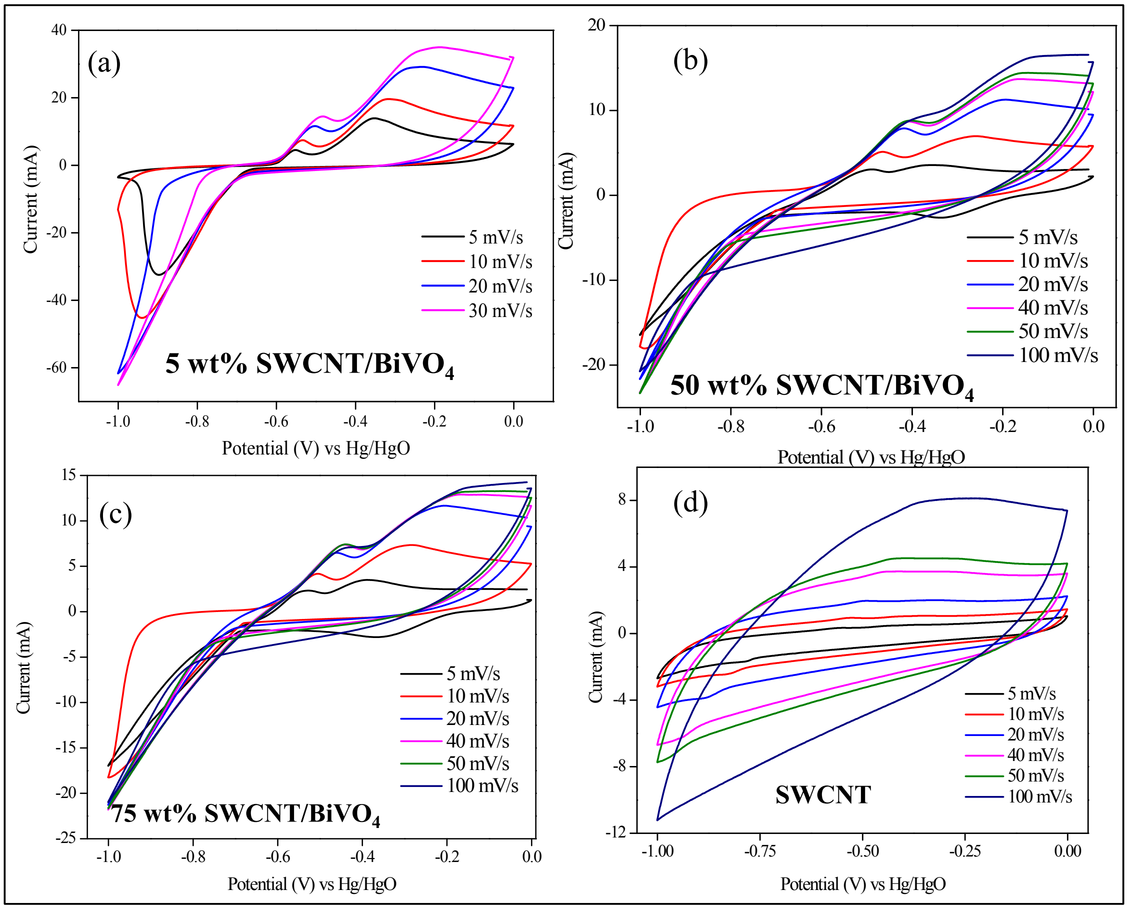

Fig. S9 *CV profile of (a) 5, (b) 50 (c) 75 wt% SWCNT/BiVO$_4$ and (d) SWCNT at various scan rates*

Galvanostatic charge-discharge profiles for 5, 50 and 75 wt% SWCNT/$BiVO_4$ composites

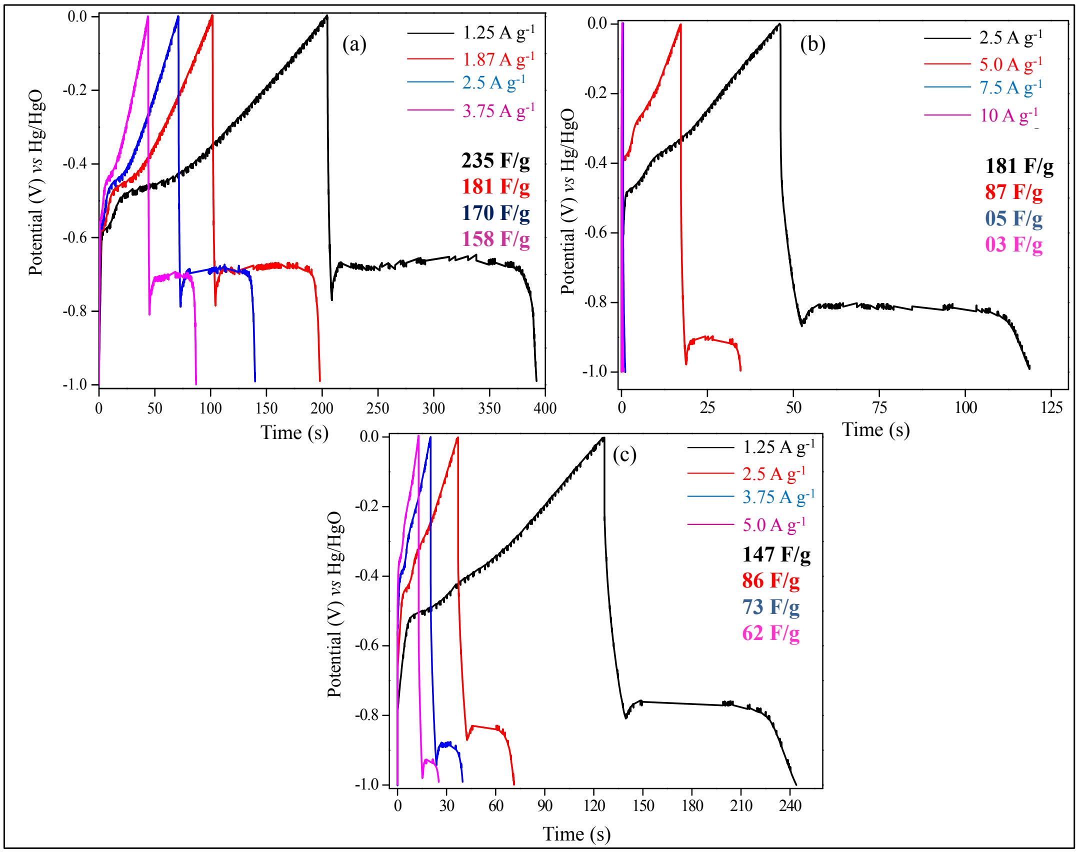

Fig. S10 *CV profile of (a) 5, (b) 50 and (c) 75 wt% SWCNT/$BiVO_4$ at current densities*

Table S2: Value of Specific Capacitance at different loading levels of SWCNT at different current densities

The specific capacitance value of the samples at various current densities was calculated from the charge-discharge curves by using the relation

$$C = \frac{I\Delta t}{m\Delta V}$$

where I, Δt, m and ΔV represent current, discharge time, mass of the electroactive material, scan rate and potential window, respectively.

Electroactive Material	**BET Surface Area (m^2 g^{-1})**	**Specific Capacitance (F g^{-1})**	**Current Density (A g^{-1})**
$BiVO_4$	15	97	2.0
5 wt% SWCNT/$BiVO_4$	26	170	2.5
10 wt% SWCNT/$BiVO_4$	35	350	2.5
20 wt% SWCNT/$BiVO_4$	53	395	2.5
25 wt% SWCNT/$BiVO_4$	56	224	2.5
50 wt% SWCNT/$BiVO_4$	58	181	2.5
75 wt% SWCNT/$BiVO_4$	65	86	2.5