Supporting Information

Grafoil-Scotch Tape-Derived Highly Conducting Flexible Substrate and its Application as a Supercapacitor Electrode

Roby Soni^{ab}, Alka Raveendran, and Sreekumar Kurungot^{ab}*

^aPhysical and Materials Chemistry Division, CSIR-National Chemical Laboratory, Pune, 411008, India. ^bAcademy of Scientific and Innovative Research (AcSIR), New Delhi, 110054, India.

Calculations

MnO2 loading: The amount of MnO2 deposited through electrodeposition was calculated by

Faraday's equation,¹

 $w = \frac{MxIxt}{nF}....(1)$

where, w = weight of MnO₂ deposited in grams;

M= molecular weight of MnO₂ (g mol⁻¹)

I= current applied (A)

t= time period for which the current is passed (s)

n= number of electrons involved in redox reaction

F= 96485 (Faraday constant)

Capacitance: The capacitance was calculated from the charge-discharge curves at a current density of 0.5 A g⁻¹. The following equation was used for calculating the specific capacitance, C_s :

Specific capacitance,² $C_S = \frac{I X \Delta t}{\Delta V} x 2$ F g⁻¹(2)

where, 'I' is the current density (A g⁻¹), ' Δ t' is the discharge time, ' Δ V' is the potential window.

The equation has been multiplied by 2 for obtaining capacitance of the single electrode (or material).

Current density, $I = 0.5 \text{ A g}^{-1}$

$$\Delta t = 620.8$$

$$\Delta V = 0.8 V$$

$$Cs = \frac{0.5 \times 620.8}{0.8} \times 2 = 776 \text{ F g}^{-1}$$

The formulae below are used for the calculation of the areal and volumetric capacitances for the single electrode in a symmetric device:

Volumetric capacitance,² C_V = $\frac{I X \Delta t}{\Delta V X v} x^2$ F cm⁻³.....(3)

Here, 'v' is the volume of the electrode in cm^3 .

Device volume = 0.019 cm^3

Areal capacitance,² $C_A = \frac{I X \Delta t}{\Delta V X A} X2$ F cm⁻²(4)

Here, 'A' is the area of the electrode in cm^2 .

Area of the electrode = 1 cm^2

The energy density and power density are calculated using the following equations:

Volumetric energy density, $E_d = \frac{(Cv\Delta V^2)}{2}$ Wh cm⁻³(5)

Volumetric power density = $\frac{E_d}{\Delta t}$ W cm⁻³(6)

Maximum Volumetric power density³ = $\frac{\Delta V^2}{4R X v}$ Wcm⁻³(7)

The equations used for constructing Ragone plot are:

Specific energy density,⁴ $E = \frac{(Cs\Delta V^2)}{8}$ Wh kg⁻¹(8) Specific power density, $P = \frac{E}{\Delta t}$ W kg⁻¹(9)



Fig. S1. The effect of current density on the capacitance was studied by analyzing the changes in morphology occurring on applying different deposition current densities. (a) FESEM image of SGM where the deposition current density was 2 mA cm⁻²; the image shows highly porous thin-walled partly interconnected fibrous MnO_2 . (b) FESEM image of SGM with a deposition current density of 4 mA cm⁻²; a highly inter-connected, porous, and fibrous grass-like morphology can be observed here and the profusely inter-connected fibers along with porosity can help in achieving high capacitance. (c) FESEM image of the MnO_2 deposited at a current density of 6 mA cm⁻², where the network gets thicker and the open spaces can be seen disappearing compared to the deposition carried out at low current densities. (d) At a high current density of 8 mA cm⁻², the MnO_2 coalesces into spherical structures resulting in a dense thick MnO_2 film.



Fig. S2. FESEM images of SGM taken with increasing the deposition time for achieving higher MnO_2 loadings with the deposition current density of 4 mA cm⁻². For 28 s, the image (a), the MnO_2 forms an inter-connected fibrous structure; however, with the increase in deposition time, the films become more dense and thicker with eventual fading of the porosity as can be seen in the images (b), (c) and (d). Moreover, cracks can also be observed at higher loadings.



Fig. S3. Selected area electron diffraction patterns (SAEDs): (a) SAED of the anodized grafoil shows hexagonal structure very similar to the multilayer graphene sheets; (b) the SAED pattern of SGM-28 shows diffused rings inferring to the highly amorphous nature of the MnO_2 .



Fig. S4. XPS analysis of the samples: (a) survey XPS spectrum of SGM-28 showing the characteristic peaks of the MnO_2along with the peak for the carbon originating from the grafoil; (b) Mn 2p XPS, where the binding energy of the peaks corresponding to $Mn 2p_{3/2}$ and $Mn 2p_{1/2}$ appear at 642.04 and 654.5 eV, respectively.



Fig. S₅.CV profiles of SGM-28 recorded at $5 \text{ mV} \text{ s}^{-1}$ for the non-anodized and anodized SG depicting the increase in the capacitance for the anodized SG.



Fig. S6. SEM images of SGM-28 taken after running the durability test for 20000 cycles. The fibrous network of SGM-28 can be seen well retained even after the durability analysis.

References:

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