Supplementary Information

Energy generation from water flow over reduced graphene oxide surface in a paper-pencil device

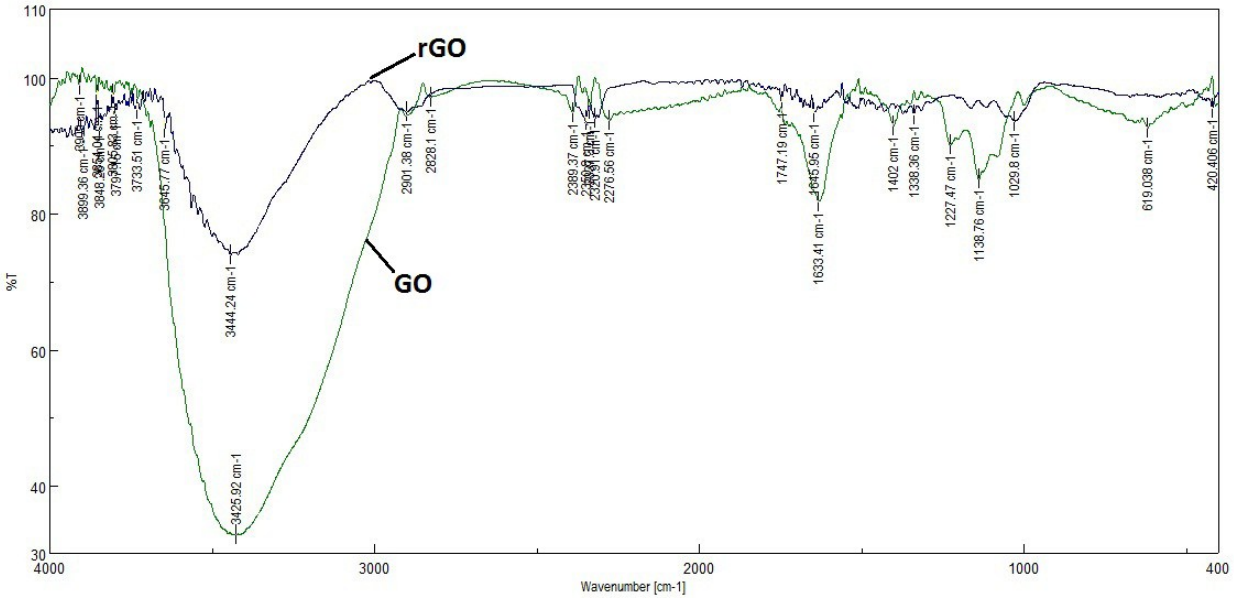

Fig. S1 FT-IR spectra of GO and rGO. The presence of ν(C=O) at 1633 cm-1 indicates the –COOH group or GO which is significantly reduced in rGO.

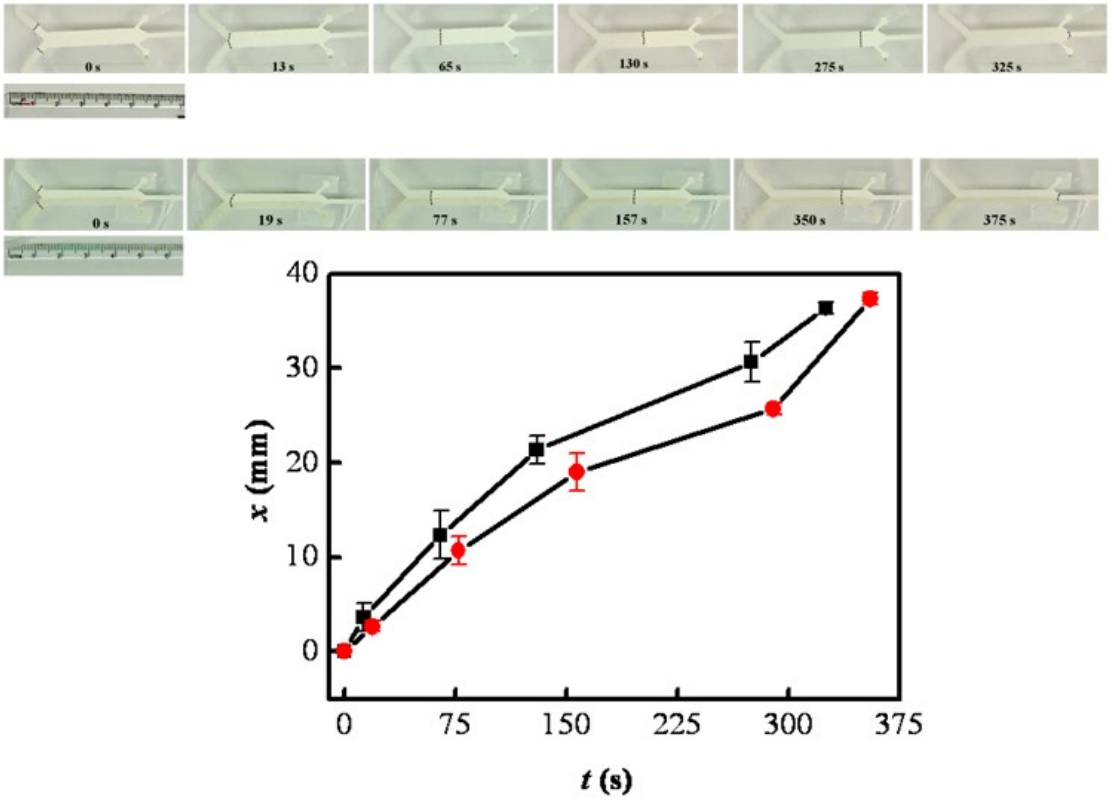

Fig. S2 Sequence of images showing the capillary-driven movement of DI-water with respect to time (a) before and (b) after rGO deposition on paper channel and corresponding (c) variations of displacement (x) with time (t) of DI-water through the paper and rGO deposited paper channel. The study indicates that that there is a negligible change in the flow rate after rGO deposition when tissue paper was used in comparison to nitrocellulose paper. The rate of DI-water flow with tissue paper as absorbent pad of size (l = 40 mm, w = 20 mm and h = 0.2 mm) was found to be ~ 10 µl/min while the flow rate was ~ 12.5 µl/min for nitrocellulose paper of similar dimensions. Thus, we considered tissue paper as absorbent pad for all the experiments in this study.

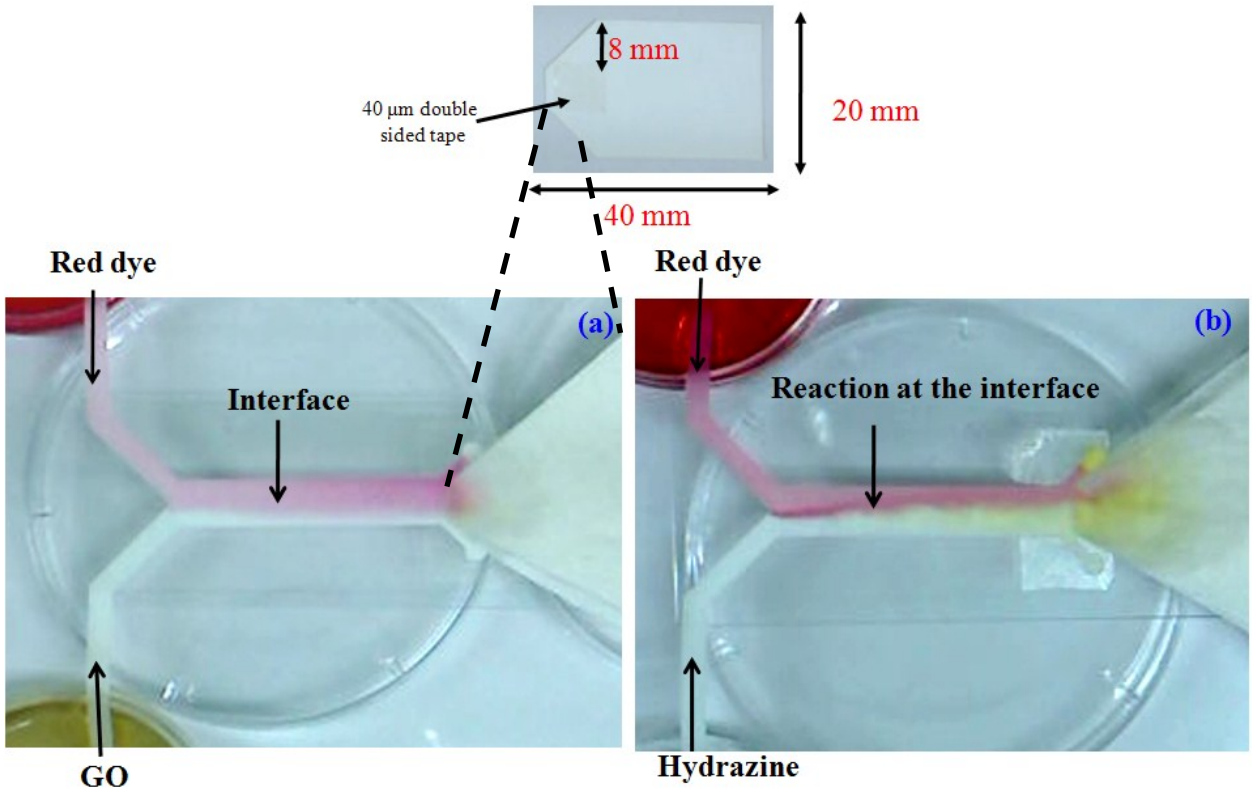

Fig. S3 The snapshot of (a) graphene oxide and red dye flow in Y-shaped paper channel showing the presence of interface formed between the two co-flowing fluids and (b) flow of red dye and hydrazine solution in the paper showing showing the shift in the interface between the two fluids. This is due to the reaction between hydrazine and dye molecules that fades the red color during transverse diffusion through interface. The inset shows the dimensions of tissue paper used as absorbent pad by using 40 µm thickness double sided tape to couple with the Y-shaped paper channel at the outlet.

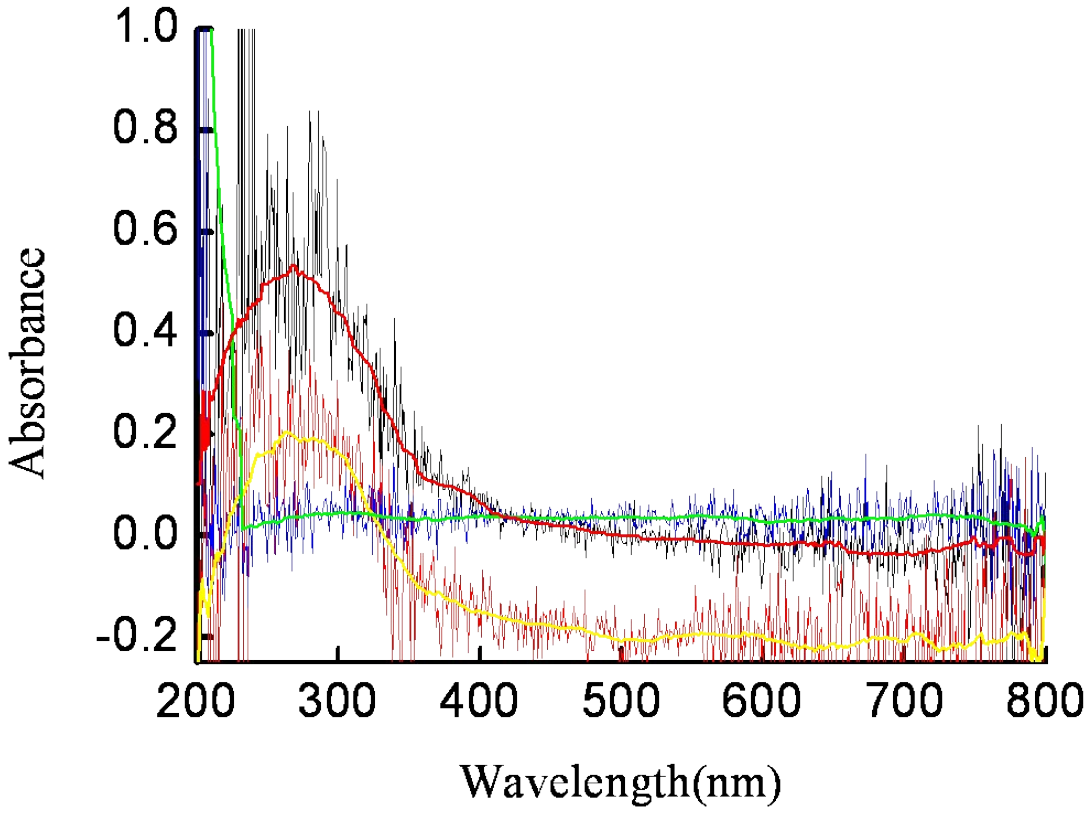

Fig. S4 UV-Vis spectroscopic analysis of the rGO deposited paper channel which shows a maximum absorption peak at about 270 nm, corresponding to π-π* transition of aromatic C-C bonds of rGO. The intensity of this peak decreases from cathode-side to anode-side indicating the possibility of rGO in gradient form across the channel width.

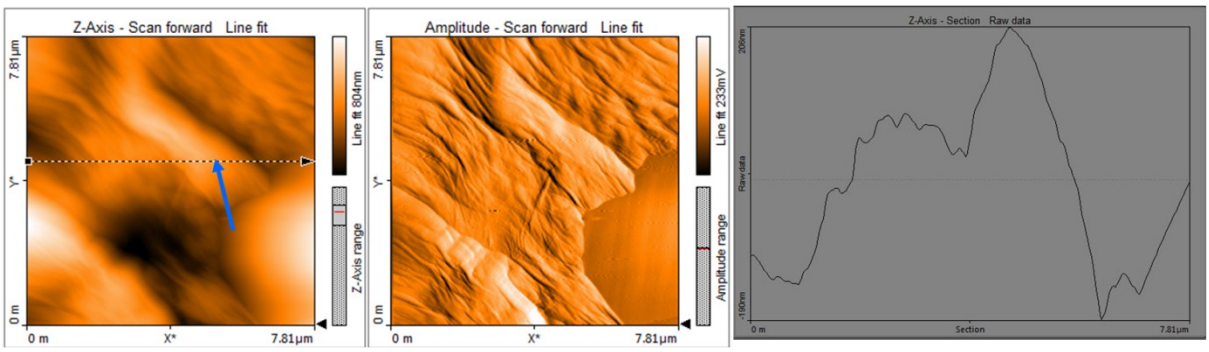

Fig. S5 The atomic force microscopy (AFM) image of rGO deposited paper surface by direct dipping methood. The height value is considered at the location indicated by an arrow in the image.

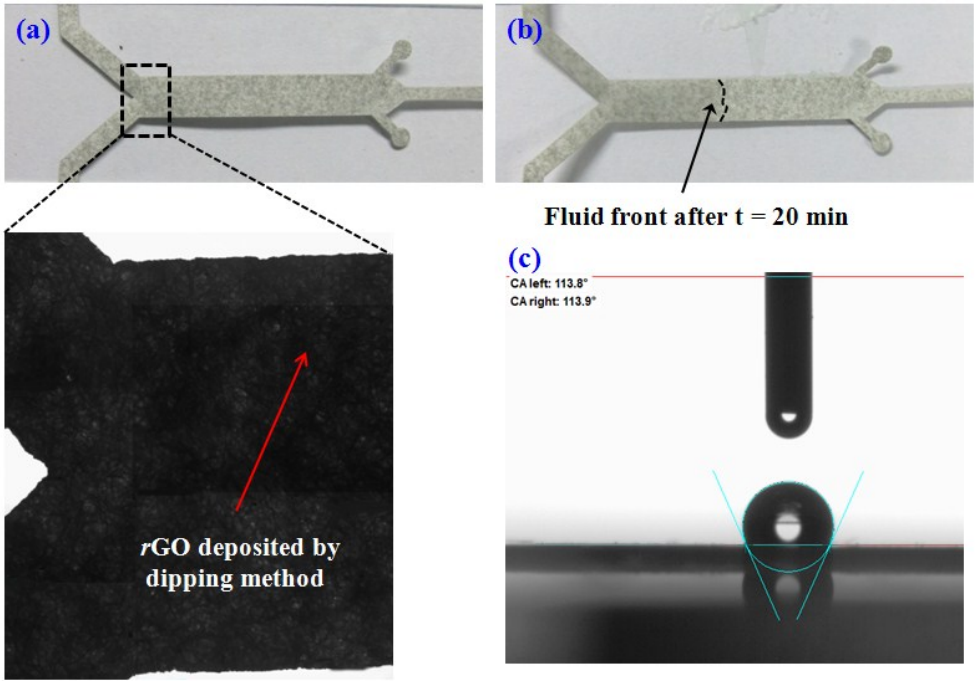

Fig. S6 The snapshots of Y-shaped paper channel showing (a) deposition of *r*GO by direct dipping method. (b) Due to excessive hydrophobic characteristics attained by the paper surface the fluid movement due to capillary action is hindered. The fluid front moves nearly half of channel length in t = 20 minutes. The inset shows the microscopic image of paper channel indicating dark color of *r*GO. (c) The contact angle measurement for the *r*GO deposited paper surface showing hydrophobic nature by direct dipping method.

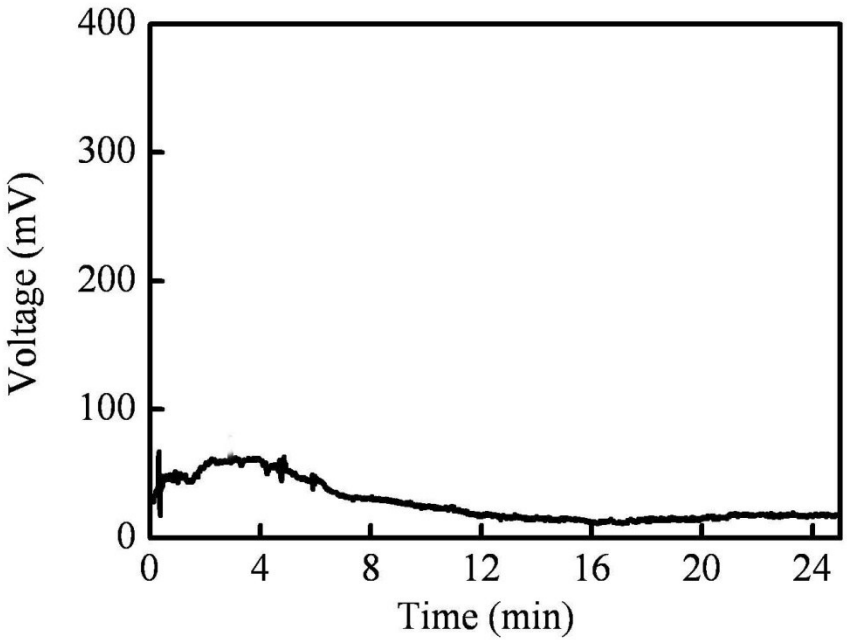

Fig. S7 Voltage output of ~ 20 mV for NaCl and DI water when rGO is absent on the channel.

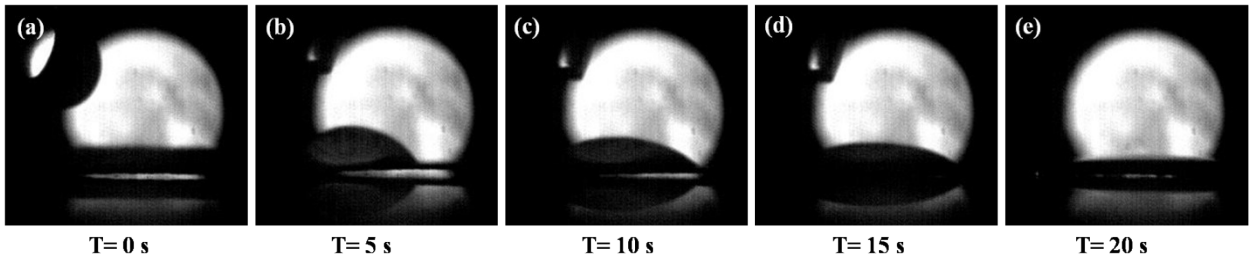

Fig. S8 CCD image sequence of a continuous flow of water droplet while flowing through the rGO deposited paper micro-fibres.

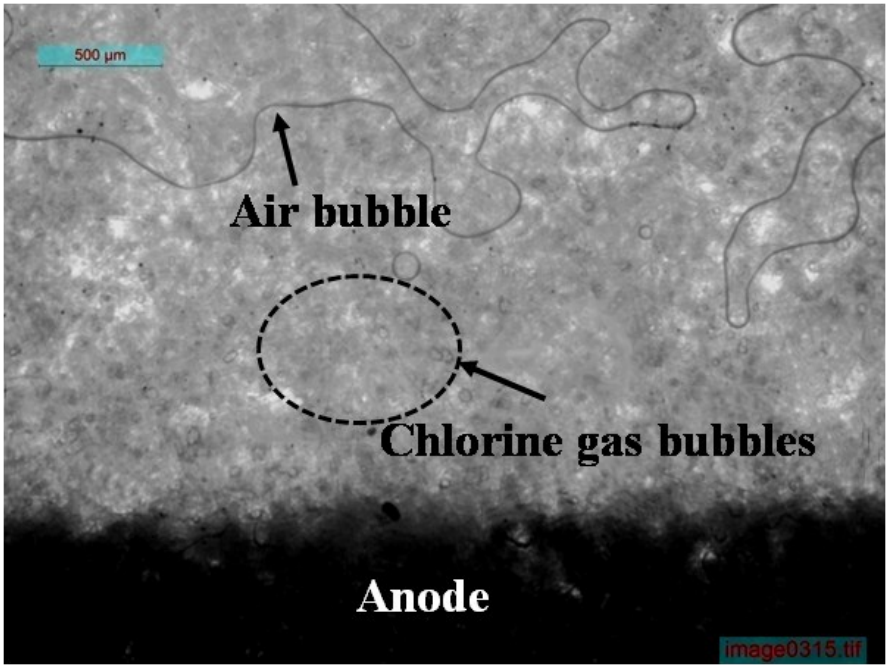

Fig. S9 The microscopic image showing the presence of chlorine gas bubbles trapped in paper channel surface.

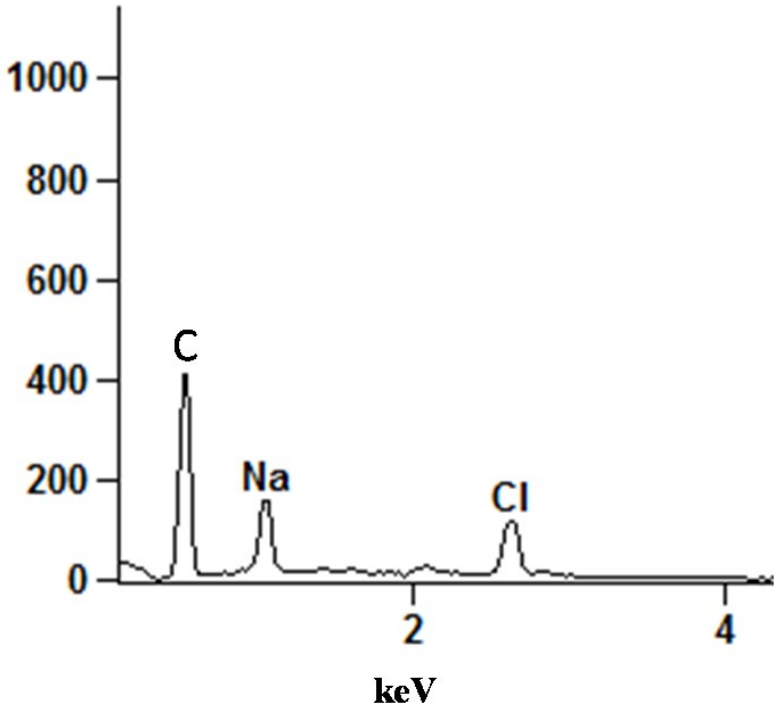

Fig. S10 EDS analysis of *r*GO deposited paper showing presence of adsorbed sodium (Na). The peak of chlorine is due to trapped chlorine bubbles.

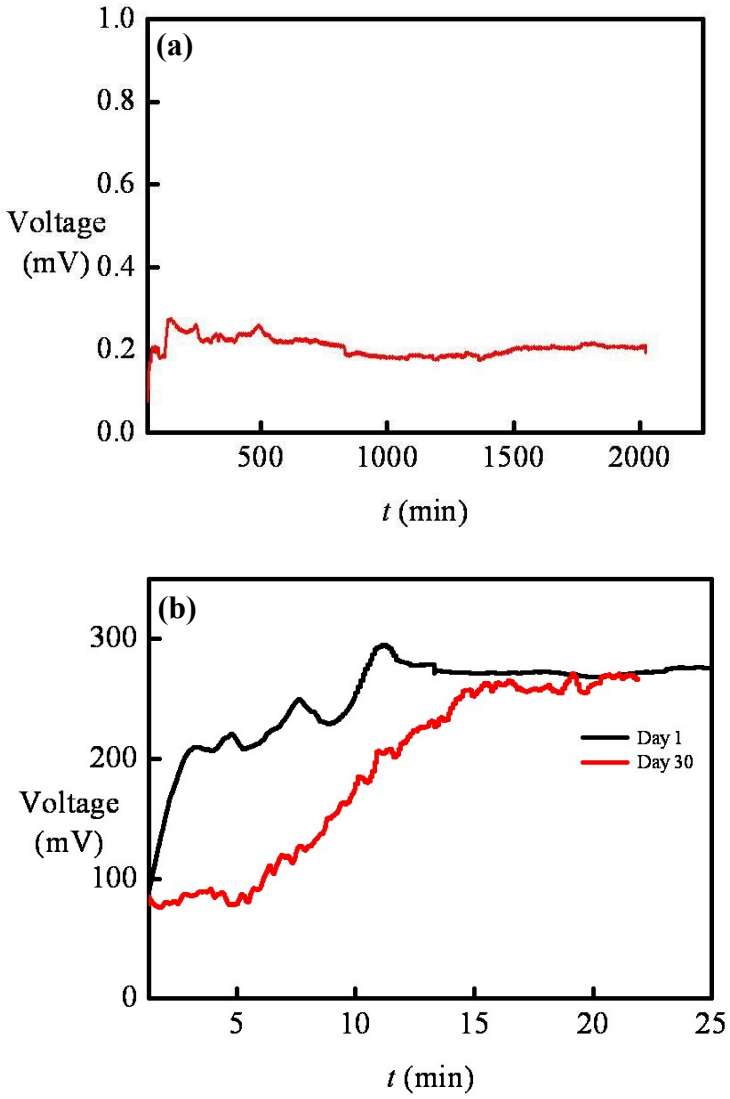

Fig. S11 (a) Voltage generation in rGO deposited paper-pencil device for prolong duration of time (~ 2000 minutes) and (b) Voltage generation in the *r*GO deposited device at day 1 and after 30 days. To determine the shelf life, two *r*GO deposited devices were fabricated. One of them was tested for voltage generation on day 1 and the other was tested with NI-DAQ for voltage after 30 days.