Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Oxidative and Membrane stress-mediated antibacterial activity of two dimensional RGO, WS_2 and composites of RGO-WS_2 nanosheets

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Figure :S1

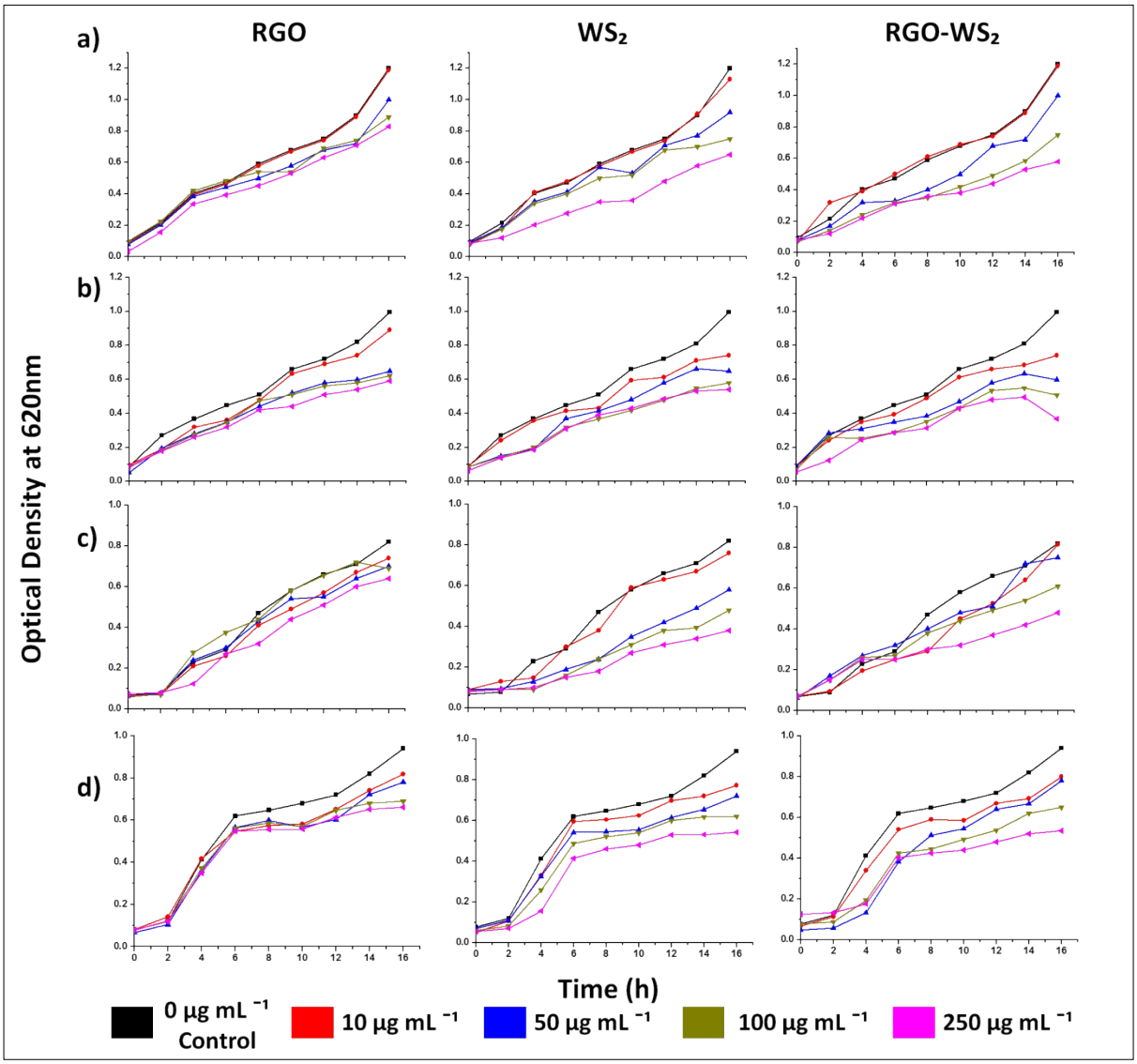

Figure S1. Growth kinetics of four bacterial strains a) *E. coli* DH 5α b) *B. subtilis* c) *S. typhimurium* d) *S. epidermidis* after exposed to RGO, WS_2 and RGO-WS_2 nano materials with concentrations of 0 (Control), 10, 50, 100 and 250 µg mL^{-1}.

To investigate the antibacterial effect RGO, WS_2 and RGO-WS_2 nanosheets against four bacterial strains *E. coli*, *S. typhimurium, B. subtilis* and *S. epidermidis* growth kinetics study experiment by measuring the growth kinetics after the exposure of the all bacteria with different concentration of three nanosheets along with a control (without nanomaterial) was carried out. The values of optical density at OD_{620nm} were monitored after each 2 h time interval (from lag phases to stationary phases) up to 18 h, by using Multiscan EX UV-VIS spectrometer (Thermo scientific, USA). The death phase of all the bacteria (including pathogenic) at 250 µg mL^{-1} concentration were shown after 18 h of incubation with WS_2 and RGO-WS_2 composite materials.

Figure :S2

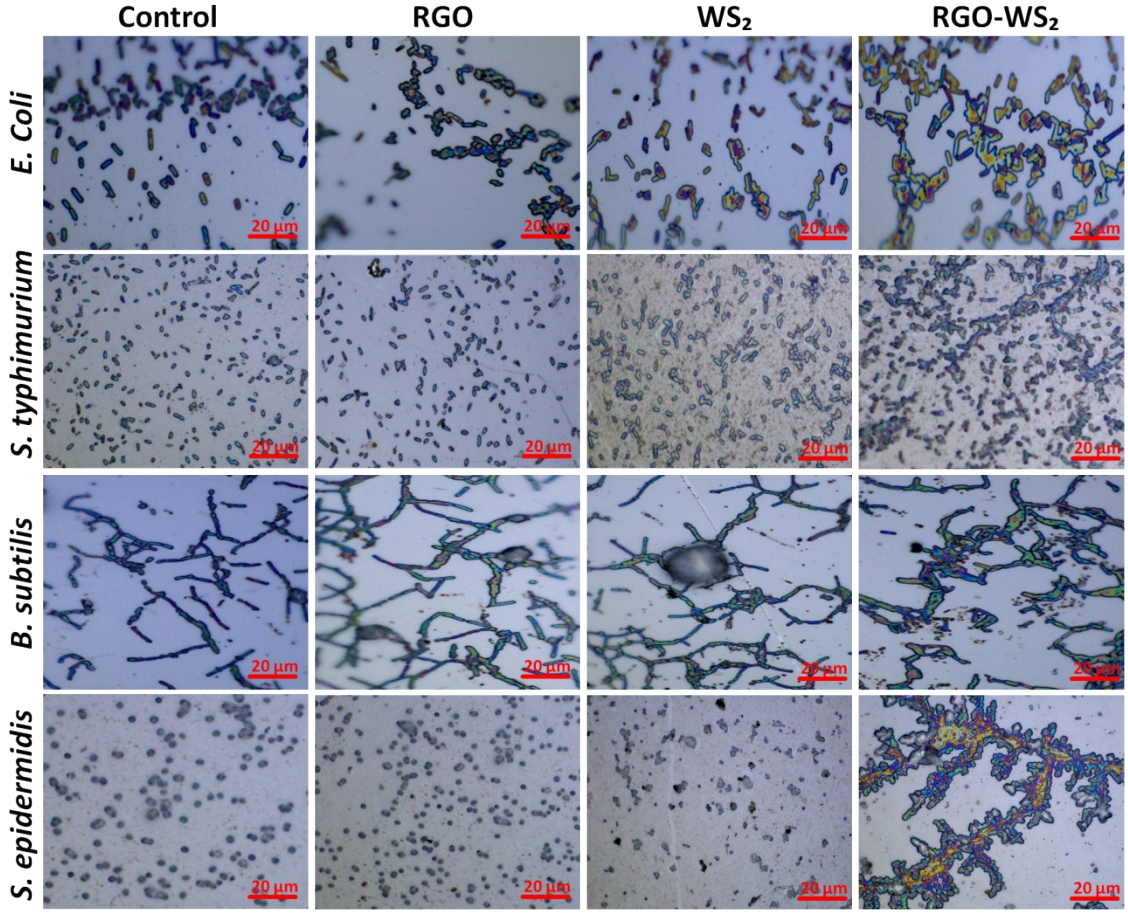

Figure S2. Optical microscopic images of distorted morphology of *E.coli, S. typhimurium, B. subtilis* and *S. epidermidis* after exposure of 0 (Control) and 100 µg mL^{-1} concentration RGO, WS_2 and RGO-WS_2 nanosheets for 2 h.

Production of superoxide radical anion ($O_2^{\cdot-}$) by RGO, WS_2 and composite of RGO-WS_2 nanosheets

The possibility of superoxide radical anion (O2•−) production was evaluated by monitoring the absorption of XTT (2, 3-bis (2-methoxy-4-nitro-5-sulfophenyl)-2H-tetrazolium-5- carboxanilide, Sigma Aldrich). XTT can be reduced by superoxide radical anion (O2•−) to form water soluble XTT-formazan with the maximum absorption at 470 nm. XTT (0.4 mM) was dissolved in phosphate buffered saline (PBS) solution at pH 7.0. Dispersions of RGO, WS_2 and RGO-WS_2 nanomaterials (100 μg mL^{-1}, 1 mL) in a PBS buffer (100 μg mL^{-1}) were mixed with 1 mL of 0.4 mM XTT separately. The mixtures were incubated in dark for 2 h - 6 h under shaking. Afterwards, the mixture was filtered through a 0.2 μm surfactant-free cellulose acetate membrane filter syringe filter (Hi-media, India) to remove the nanomaterials. Filtered solution (250 μL) was then placed in a 96-well plate. The change in absorbance at 470 nm was monitored on a Multiscan EX UV-VIS spectrometer (Thermo scientific, USA). XXT (0.4 mM) with Menandione (0.25 mM) (Sigma Aldrich) was used as a positive control.

Figure :S3

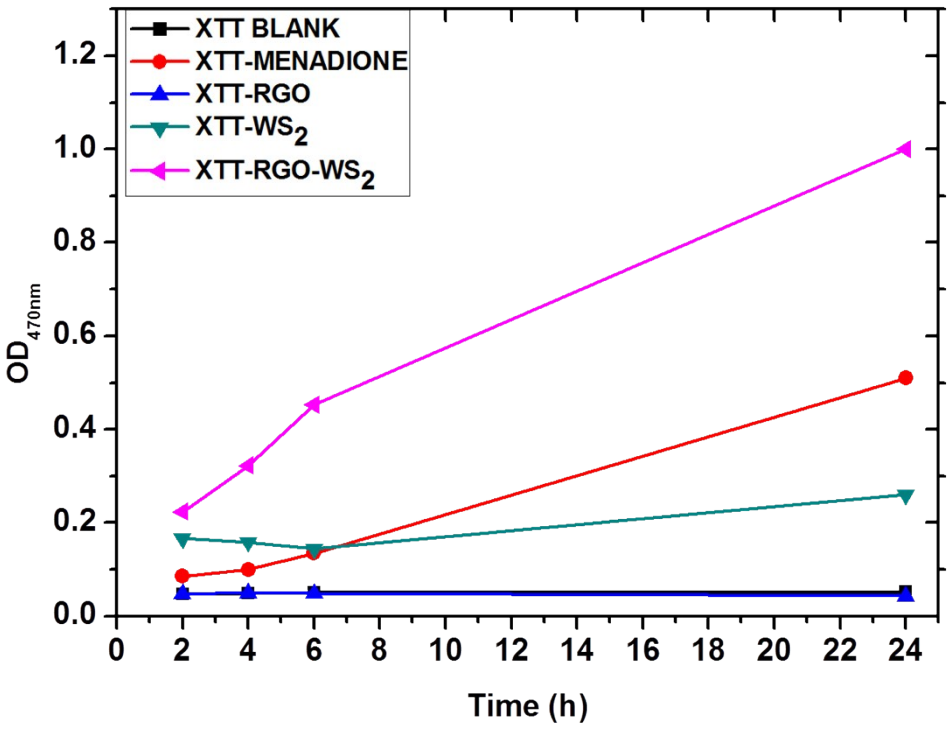

Figure S3. Production of superoxide radical anion ($O_2^{\cdot-}$) by RGO, WS_2 and RGO-WS_2 nanosheets. The dispersion concentration of the all three nanosheets was 100 mg mL^{-1}. The ($O_2^{\cdot-}$) production was monitored during the incubation of XTT with the RGO, WS_2 and RGO-WS_2 nanosheets at pH 7.0 in the dark for 2 to 24 h. Incubation of XTT with Menadione was performed as a positive control. XTT was used as a negative control.

Figure :S4

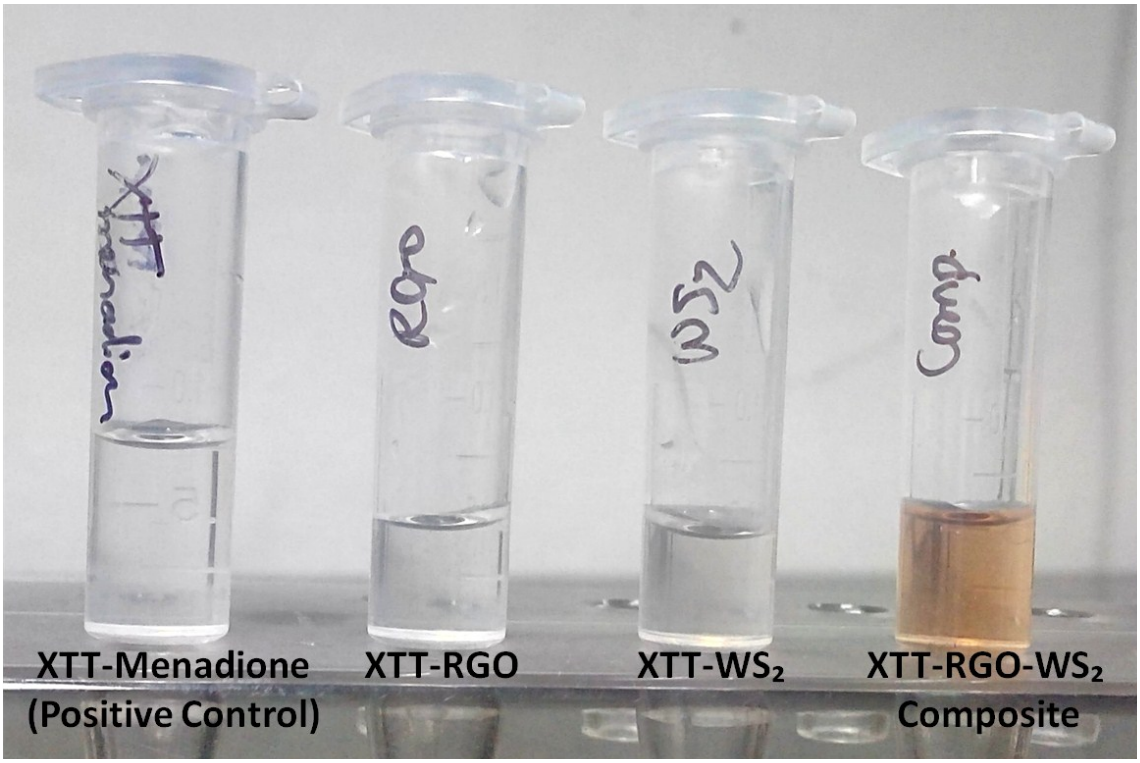

Figure S4. XTT reduction assay. XTT (0.4 mM) was mixed with dispersions of 100 μg mL^{-1} of RGO, WS2, RGO-WS_2 composite nanosheets after 6 h of dark incubation. XTT (0.4 mM) with menadione 250 μM) was used as a positive control.

Figure S5:

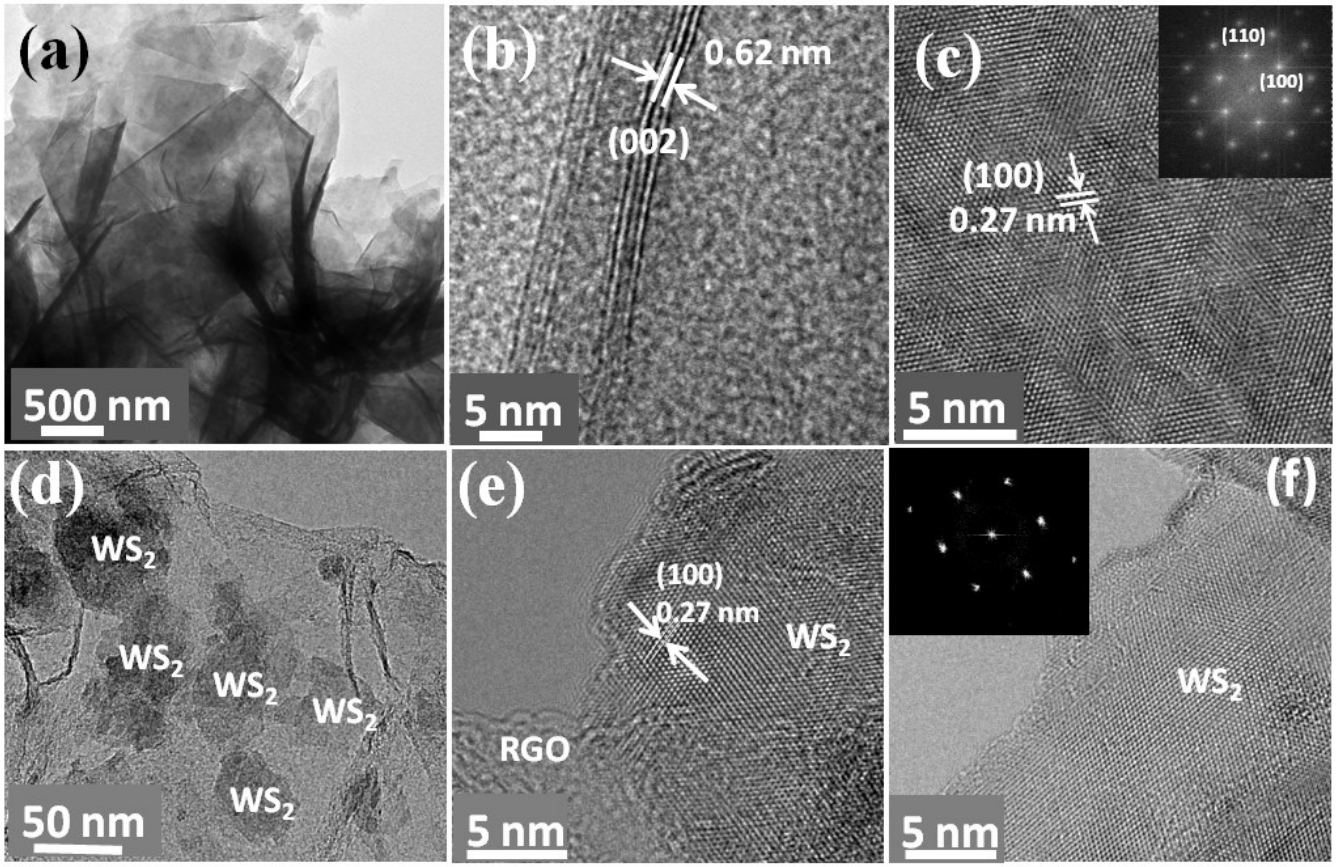

Figure S5: (a-c) Low magnification and high magnification TEM images of as synthesized few-layer WS_2 nanosheets. (d-f) Low magnification and high magnification TEM images of as synthesized rGO-WS_2 composite.

Figure S6:

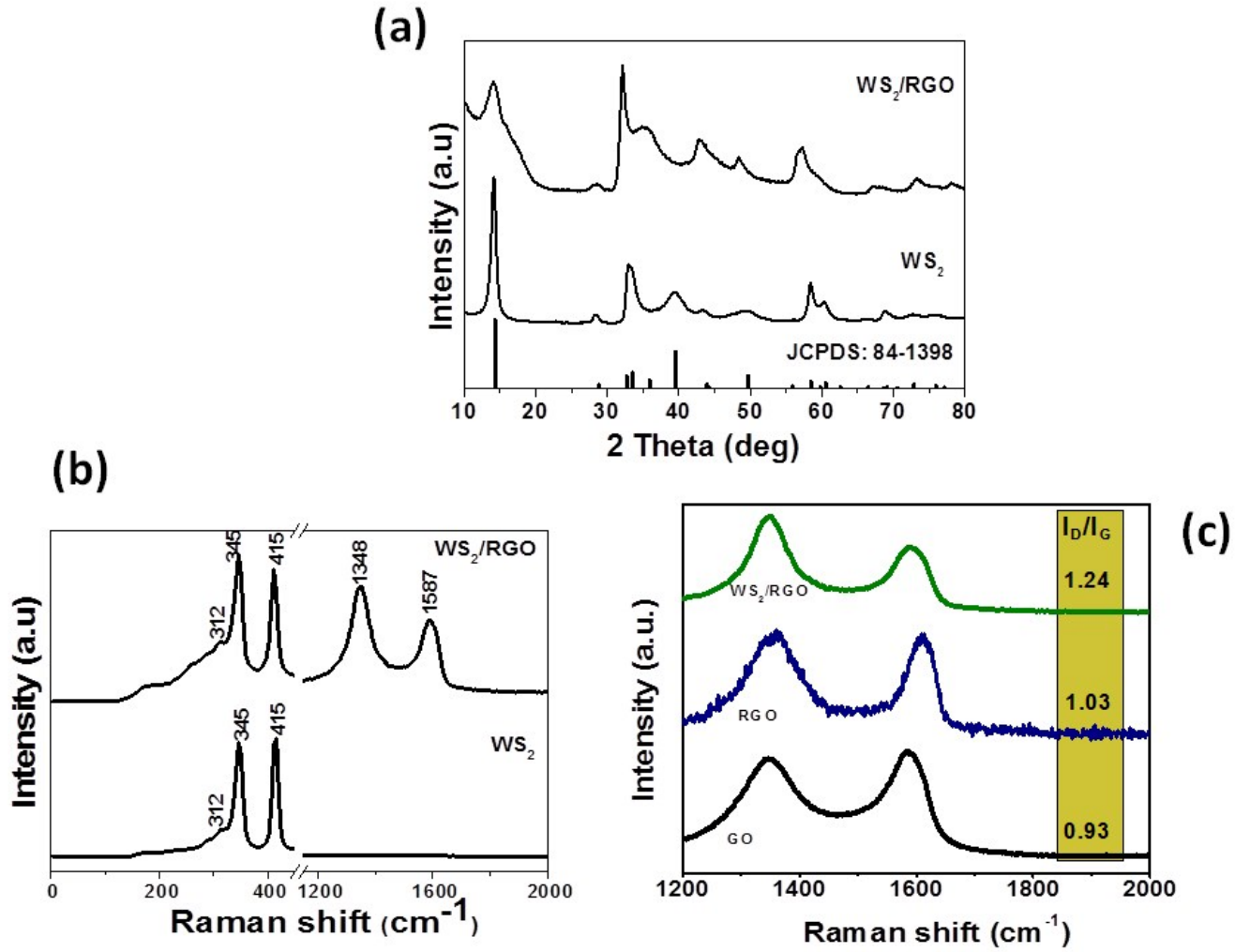

Figure S6: (a) Comparative X-RD data of WS_2 nanosheets and rGO-WS_2 composite.

Figure S7:

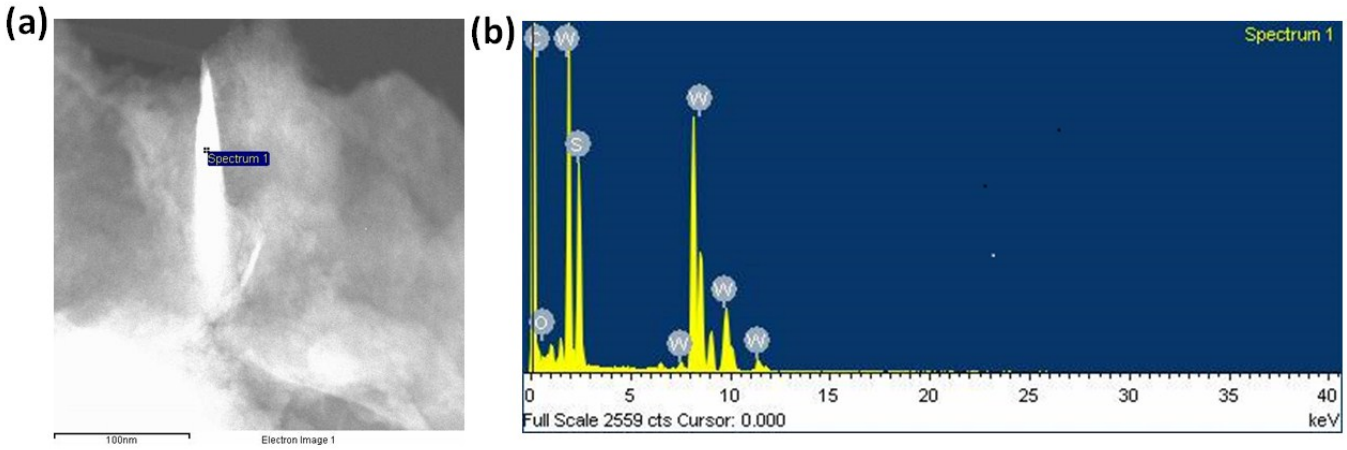

Figure S7: (a) SEM image of rGO-WS_2 and (b) EDAX of rGO-WS_2 composite.

Figure S8:

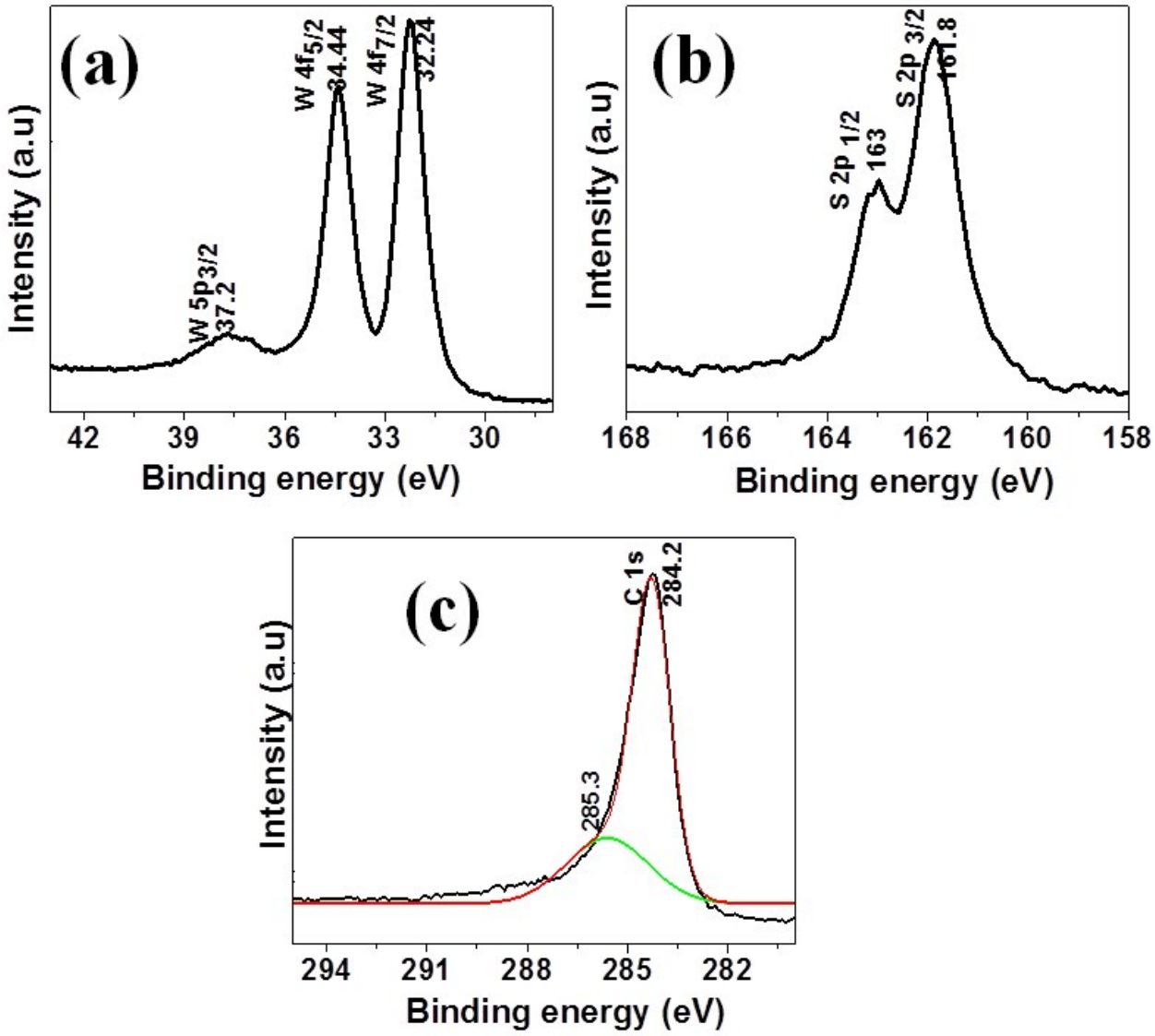

Figure S8: XPS of rGO-WS_2 composite.

Figure S9:

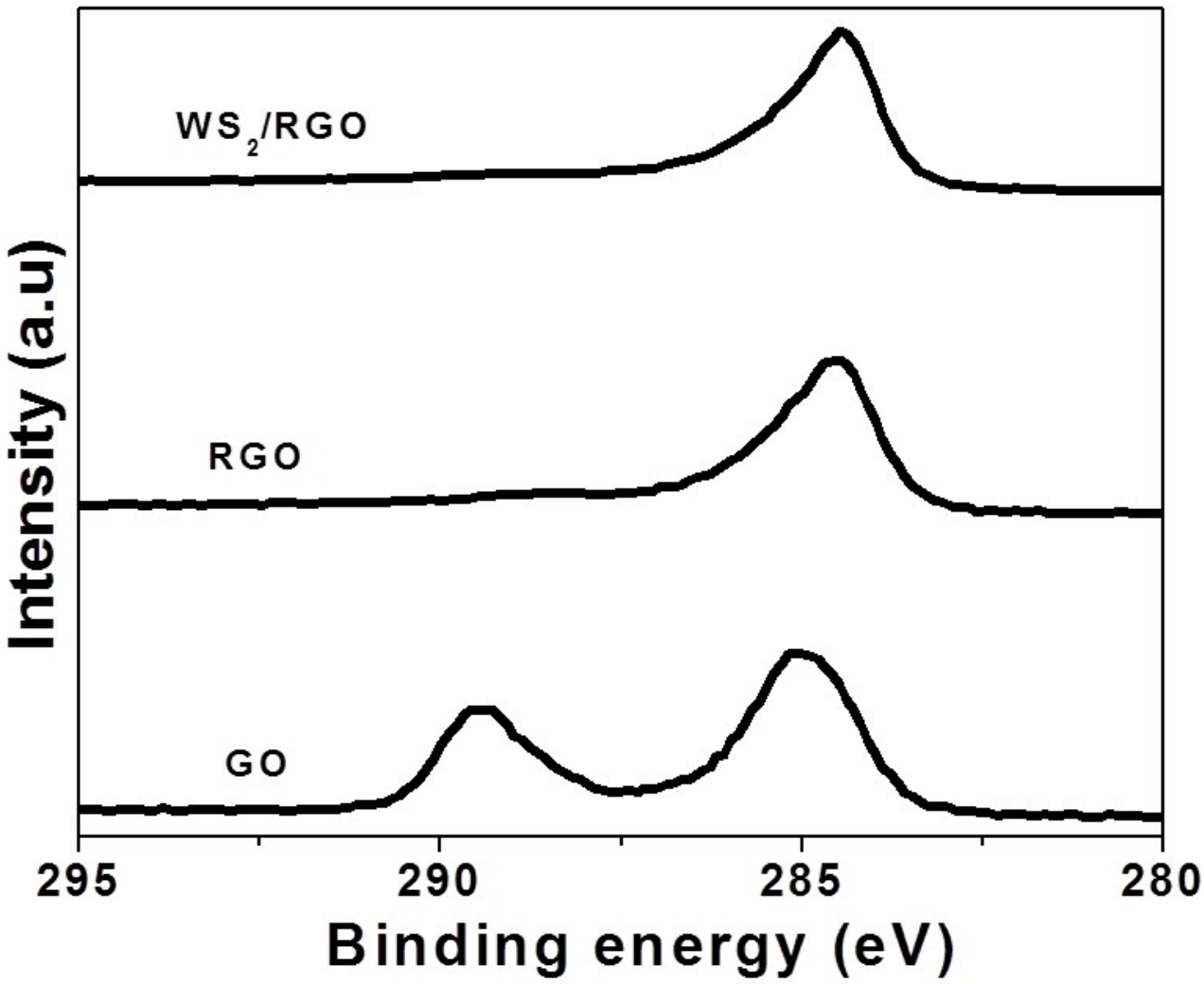

Figure S9: Compartive XPS data for GO, rGO, rGO-WS_2.