

SUPPORTING INFORMATION

Spectromicroscopic Observation of a Live Single Cell in a Biocompatible Liquid-Enclosing Graphene System

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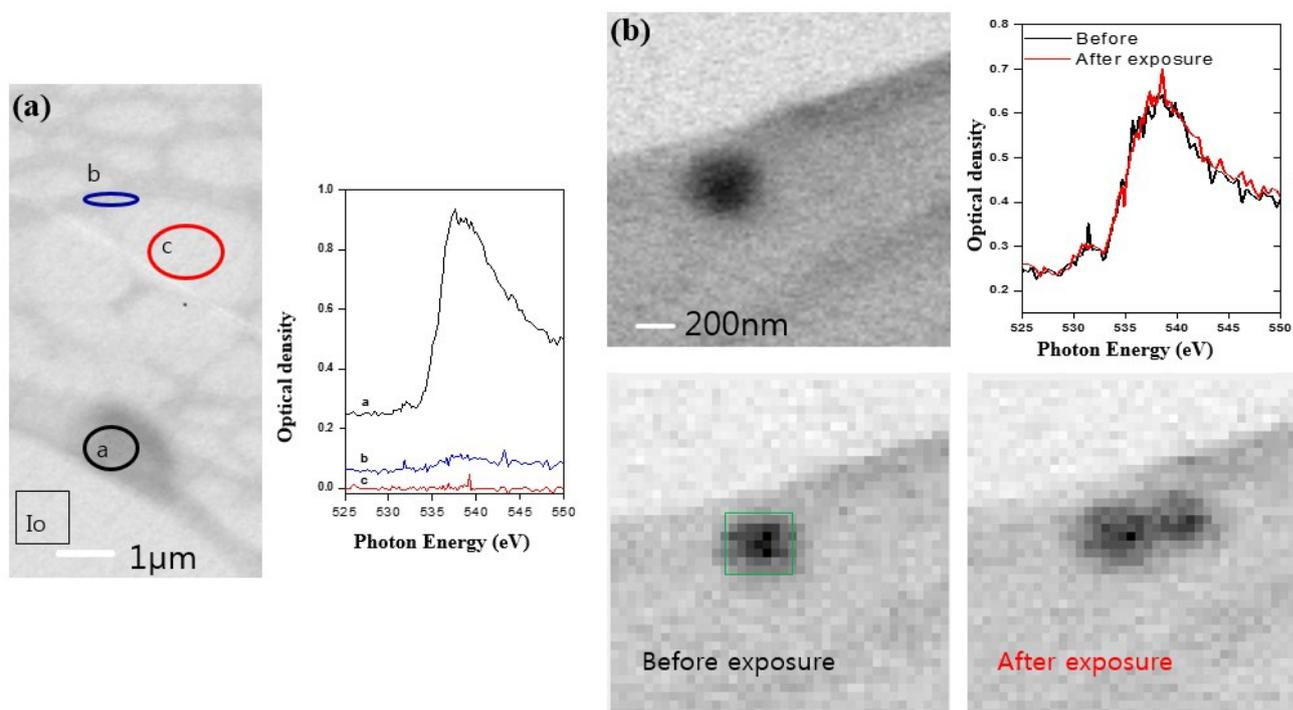


Fig. S1 Effect of X-ray exposure on water pockets. (a) Spectra a and b reflect the regions containing “water” and “minuscule amount of water”, respectively. Region c is just blank. (b) X-ray is exposed on a circular water pocket at 538 eV for 10 minutes (very long time of exposure). The water pocket splits into two pockets with no change in spectra.

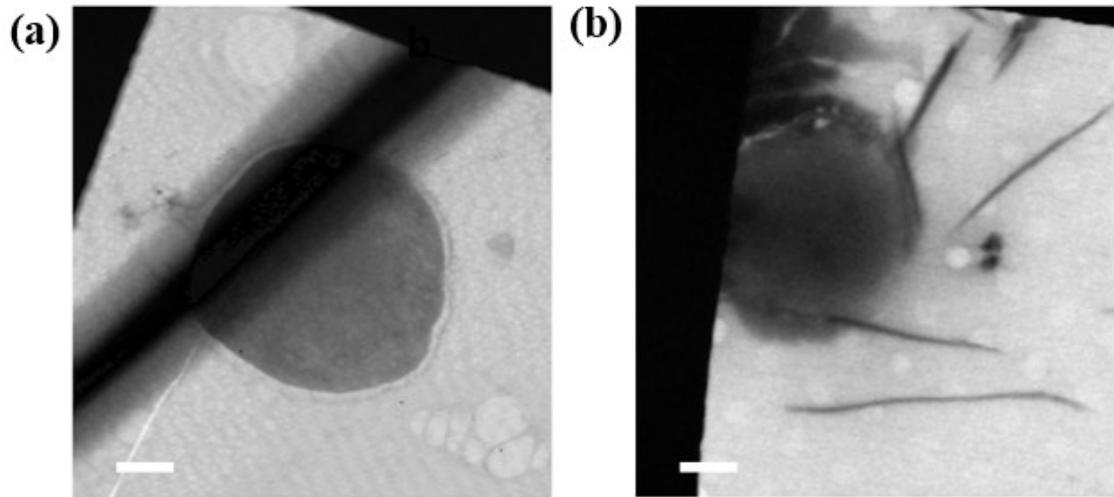


Fig. S2 STXM image of colo 205 cell covered with graphene membranes which were transferred to (a) holey and (b) quantifoil holey carbon film. Images are obtained at 520 eV. Although both cells are still in a wet condition, cells are collapsed or crushed. Scale bars, 5 μ m.

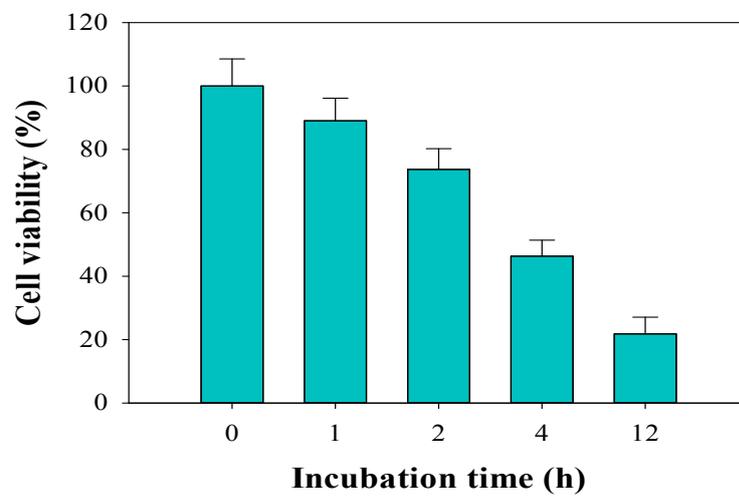


Fig. S3 Cell viability of colo 205 cells after incubation at 37 °C without oxygen supply for up to 12 h (number of experiments n = 7).

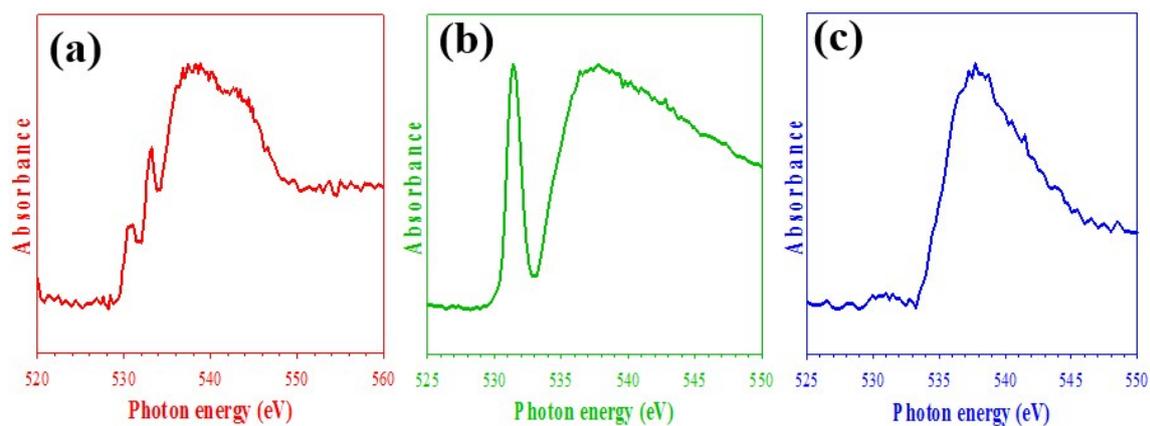


Fig. S4 Three reference XAS spectra of (a) ROS, (b) pristine colo 205 cell, and (c) background oxygen for the chemical composition map. The spectrum (a) was obtained from ROS pocket released from the cell after optimum incubation, while (b) was obtained from the center of pristine cell but the spectra are severely saturated in the energy region > 536 eV. The spectrum (c) was taken from the liquid solution encapsulated within graphene membrane with no cancer cells. Here, we used the term “oxygen background” to distinguish it from the non-standard shape due to the saturated absorption in the range of the energy corresponding to “water” absorption. Remnants of air in the chamber or water trapped under graphene may contribute to the increase of “background”. Water is prone to be trapped in stems of the lacey carbon network.

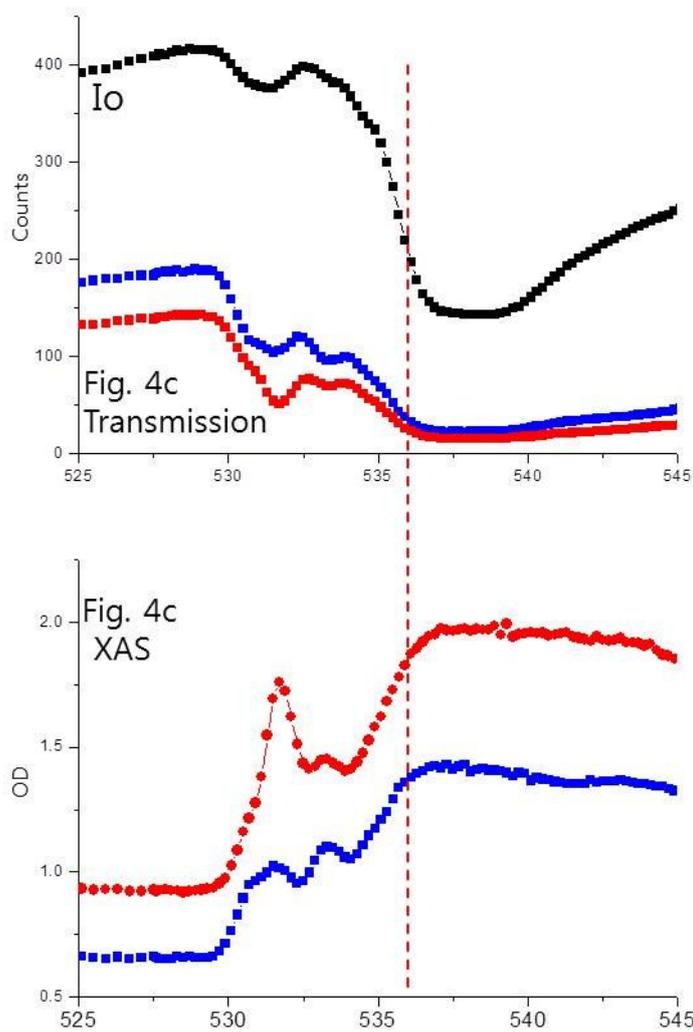


Fig. S5 Saturation of Spectra. The spectra (Fig. 4c) are saturated in the energy region $>536\text{eV}$. The raw transmission including I_0 exhibits the saturated absorption for $>536\text{ eV}$. The black curve shows the incident photon flux I_0 , while the blue and red curves show the flux passed respectively through center and edge of 2h incubated cell.

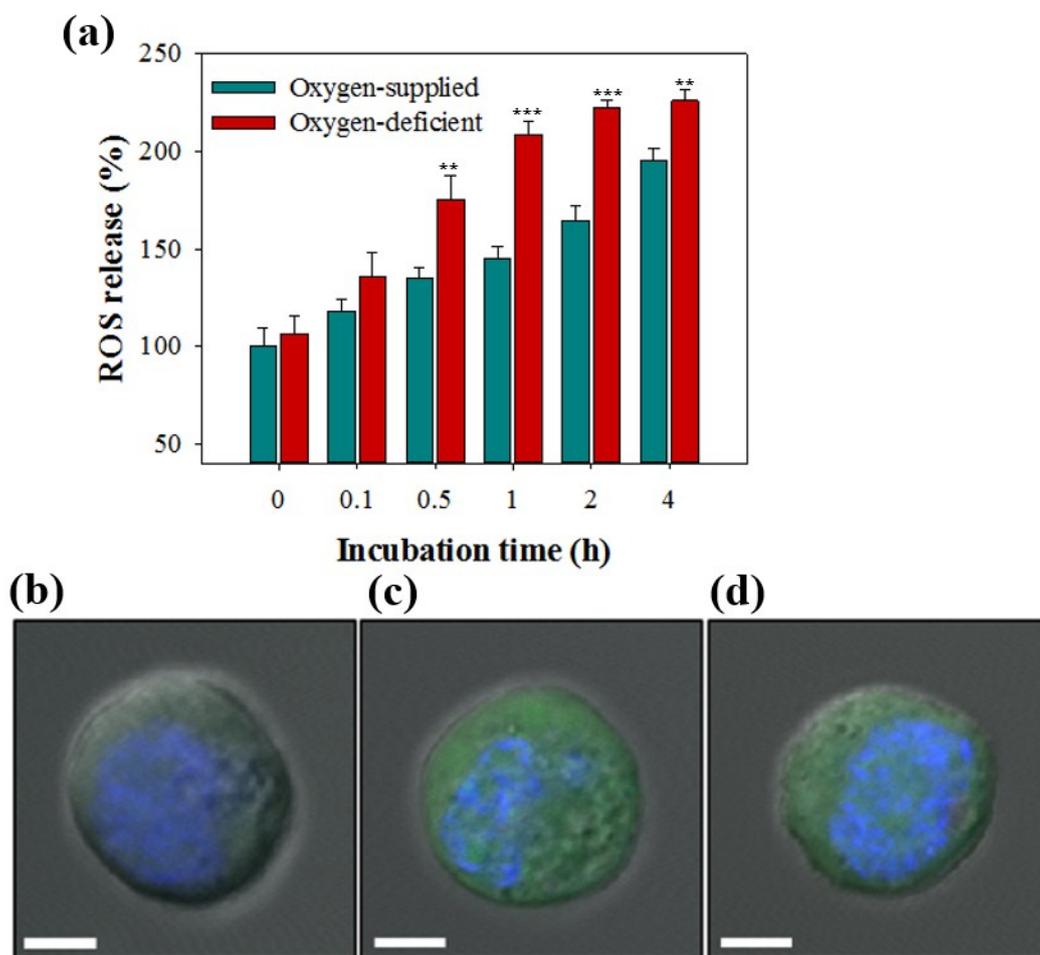


Fig. S6 (a) Time-dependent ROS release assay of the colo 205 cells by ROS detection reagent in hypoxic condition and (b-d) confocal microscope images after 0, 1 and 2 h incubation of colo 205 cell in hypoxic condition. The level of ROS released from colo 205 cells after incubation with or without oxygen supply. The values of ** $P < 0.01$, and *** $P < 0.0001$ in comparison with the oxygen-supplied cases are considered to be statistically significant ($n = 3$). Confocal microscope images of colo 205 cell (b) without incubation, (c) after 1 h incubation, and (d) after 2 h incubation in hypoxic condition at 37 °C. Green fluorescence and blue fluorescence are for ROS and nuclei, respectively. Scale bars, 5 μ m.

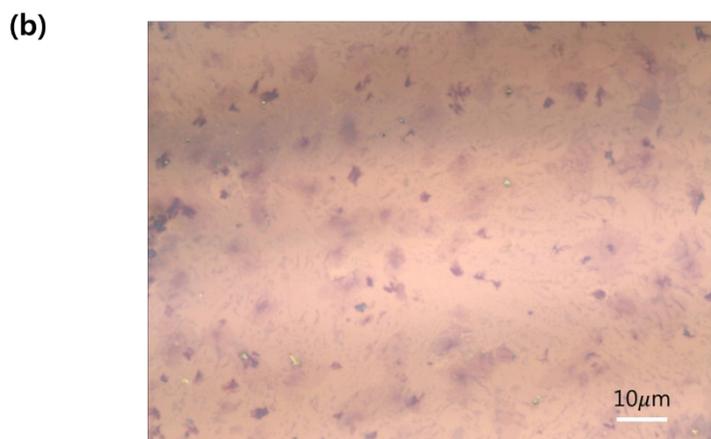
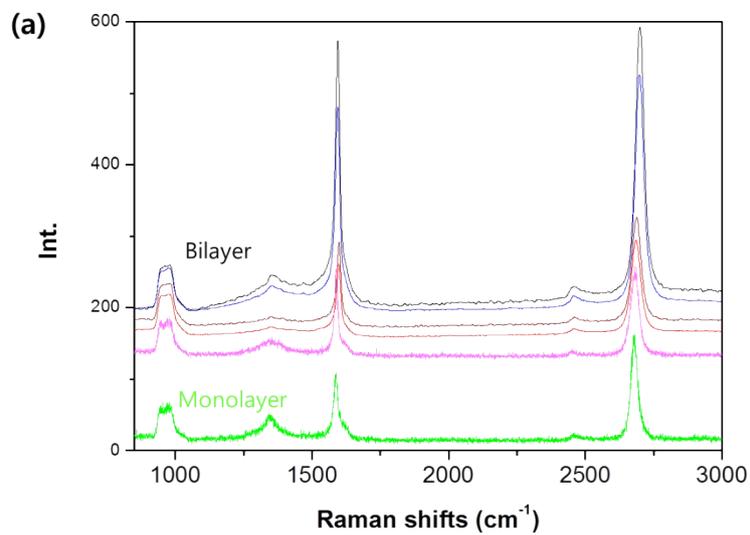


Fig. S7 (a) Raman spectra obtained at many different spots on the CVD graphene. In most of spectra, the intensity ratio of 2D peak to G peak (~ 1.3) shows slightly smaller than that of monolayer graphene (~ 1.6). **(b)** According to the optical microscope image, multilayer graphene islands were overgrown on the overall bilayer graphene.

TOC

