

Electronic Supplementary Information

Photo-Enhanced Antibacterial Activity of ZnO/Graphene Quantum Dot Nanocomposites

Junli Liu^{a,b}, Mauricio D. Rojas-Andrade^b, Gustavo Chata^b, Yi Peng^b, Graham Roseman^b, Jia-En Lu^b,
Glenn L. Millhauser^b, Chad Saltikov^{c,*}, and Shaowei Chen^{b,*}

^a School of Materials Science and Engineering, Shaanxi University of Science and Technology, Xi'an, 710021, China

^b Department of Chemistry and Biochemistry, ^c Department of Microbiology and Environmental Toxicology, University of California, 1156 High Street, Santa Cruz, California 96064, USA

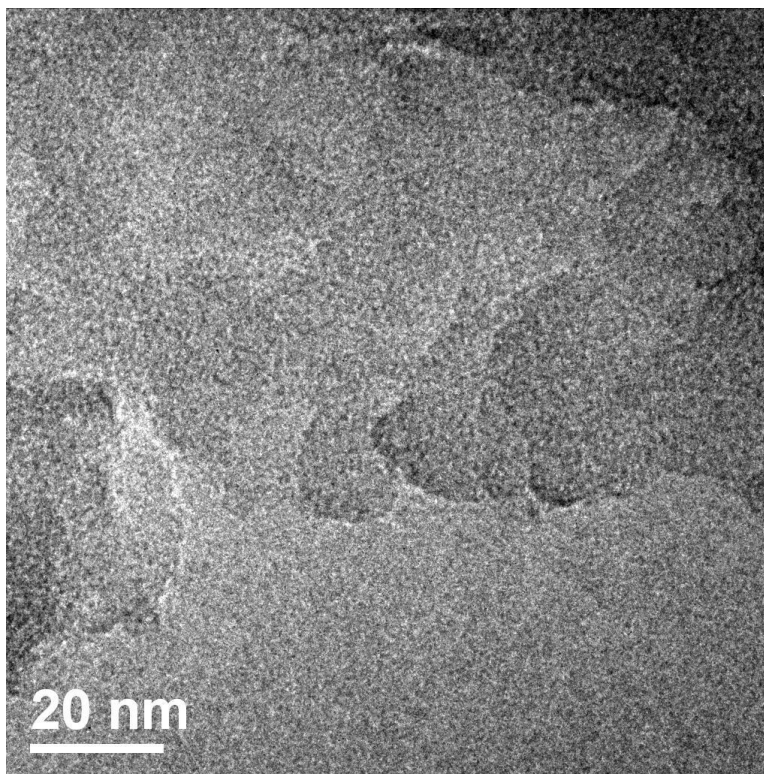


Figure S1. Representative TEM image of GQD. Scale bar 20 nm.

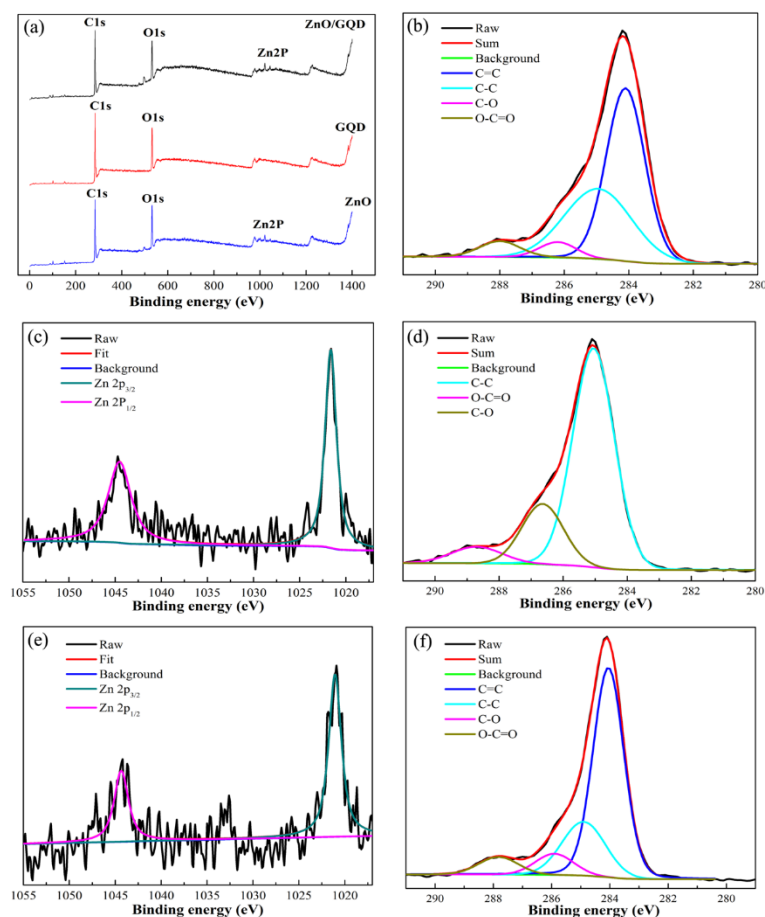


Figure S2. XPS spectra of ZnO, GQD and ZnO/GQD: (a) full scans; Zn 2p electrons of (c) ZnO and (e) ZnO/GQD; and C 1s electrons of (b) GQD, (d) ZnO and (f) ZnO/GQD nanocomposites. In panels (b)-(f), black curves are raw experimental data and colored curves are deconvolution fits.

From the C 1s spectra of (b) GQD and (f) ZnO/GQD, the sp² carbon can be identified at 284.1 eV, sp³ carbon at 285.0 eV, C in C-O at 286.2 eV, and C in C=O at 288.0 eV. Based on the integrated peak areas, sp² carbon was found to account for ca. 48% of all carbon. No sp² carbon can be seen in (d) ZnO.

For the (c) ZnO and (e) ZnO/GQD samples, the binding energies of Zn 2p electrons can both be found at 1021.7 eV (2p_{1/2}) and 1044.7 eV (2p_{3/2}), consistent with those of Zn(II) in ZnO.

In addition, the C/Zn atomic ratio was estimated to be 108.8:1 in ZnO and increases to 141.7/1 in ZnO/GQD, consistent with the formation of ZnO/GQD nanocomposites.

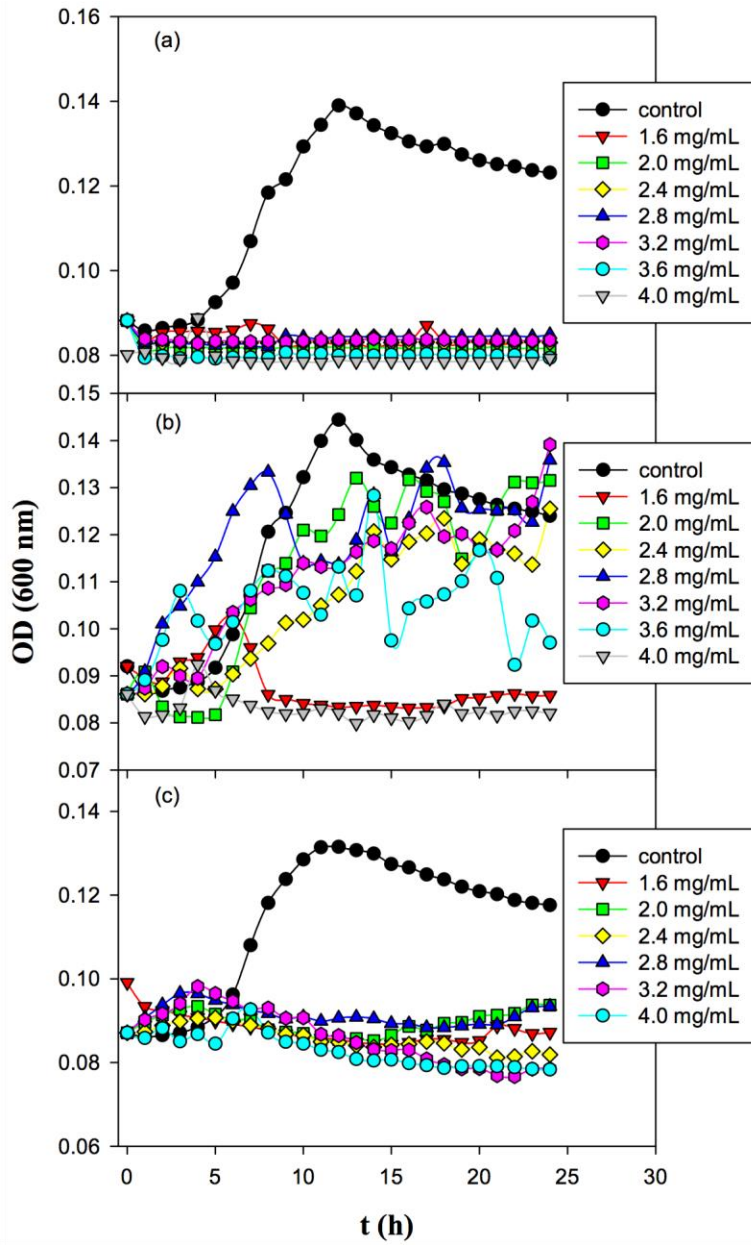


Figure S3. Growth curves of *S. aureus* in Mueller Hinton agar containing (a) ZnO; (b) GQD; and (c) ZnO/GQD nanocomposites for 24 h.

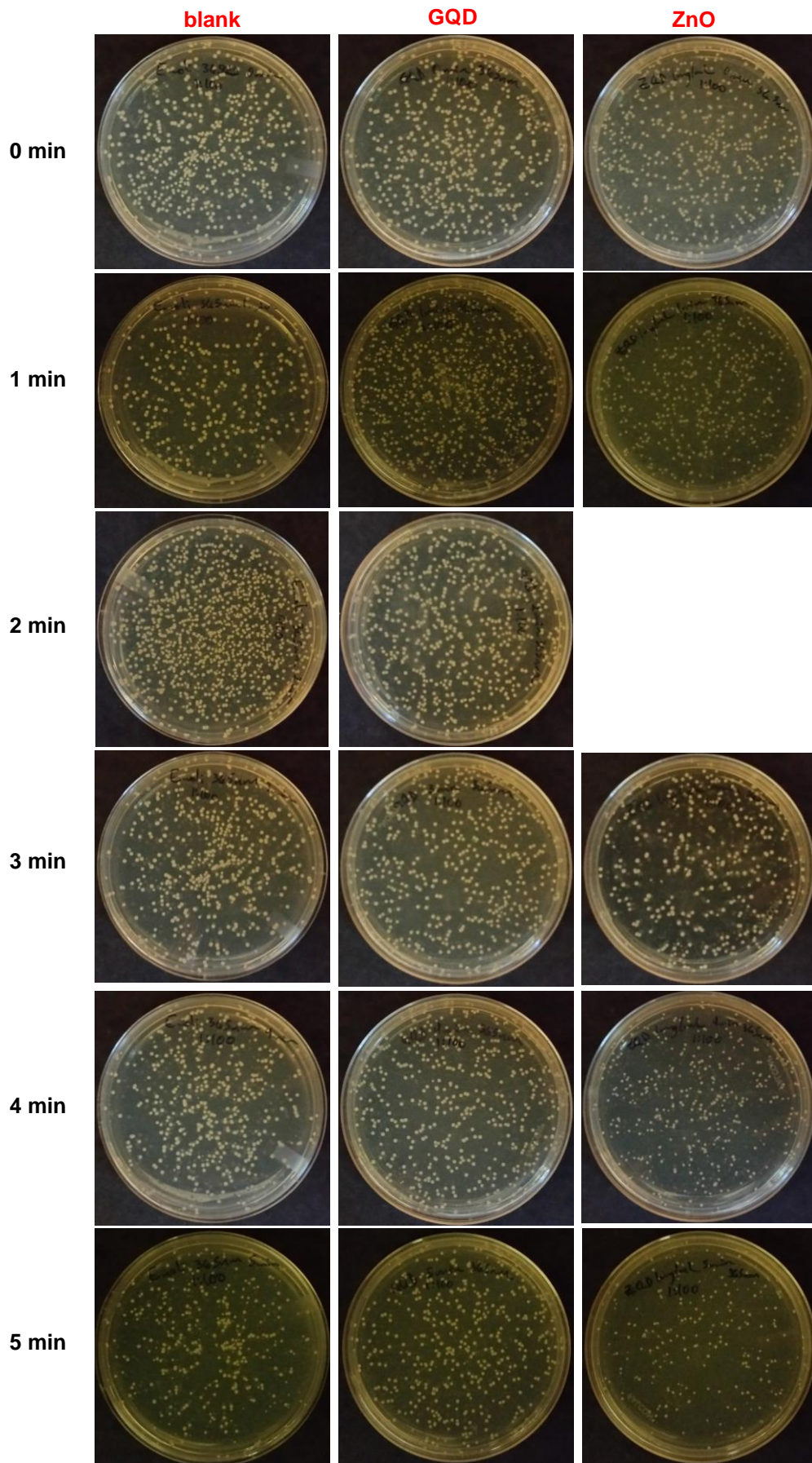


Figure S4. Photographs of *E. coli* colonies cultured in the absence (blank) and presence of GQD or ZnO under UV irradiation for up to 4 min.

Table S1. XPS analysis of the as-prepared ZnO, GQD and ZnO/GQD nanocomposites

PEAK	Position BE(eV) ±0.10 eV	FWHM (eV) ±0.20 eV	Raw area (cps eV)	Atomic Conc. (%)	C/Zn ratio	C=C in all carbon (%)
GQD						
C 1S (C=C)	284.1	1.19	11061.43	37.68	/	47.94
C 1S (C-C)	285.0	1.11	7008.44	23.88		
C 1S (C-O)	286.2	1.63	2627.323	8.95		
C 1S (O-C=O)	288.0	1.26	2373.198	8.09		
O 1S (C=O)	531.33	1.98	12253.65	15.81		
O 1S (-OH)	532.87	1.36	4331.841	5.59		
ZnO						
C 1S (C-C)	285	1.51	14440.76	51.85	108.77/1	0
C 1S (C-O)	286.7	1.55	6160.004	22.12		
C 1S (O-C=O)	288.8	1.18	858.74	3.08		
O 1S (Zn-O)	531.17	1.86	8825.302	12.00		
O 1S (-OH)	532.53	1.99	7525.425	10.24		
Zn 2P1/2	1021.7	1.91	2578.953	0.48		
Zn 2P3/2	1044.7	2.04	1209.086	0.23		
ZnO/GQD nanocomposites						
C 1S (C=C)	284.1	1.27	14441.92	53.61	141.73/1	67.42
C 1S (C-C)	285	1.42	3599.004	13.36		
C 1S (C-OH)	286	1.21	1491.501	5.54		
C 1S (C=O)	288	1.96	1887.717	7.01		
O 1S (Zn-O)	531.14	2.13	13534	19.03		

O 1S (OH)	531.25	1.57	636.27	0.89		
Zn 2P1/2	1021.7	1.93	1812.584	0.35		
Zn 2P3/2	1044.7	1.99	1089.276	0.21		