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Supporting information

Highly Stable and Conductive PEDOT:PSS/Graphene Nanocomposites for Biosensor Application in Aqueous Medium

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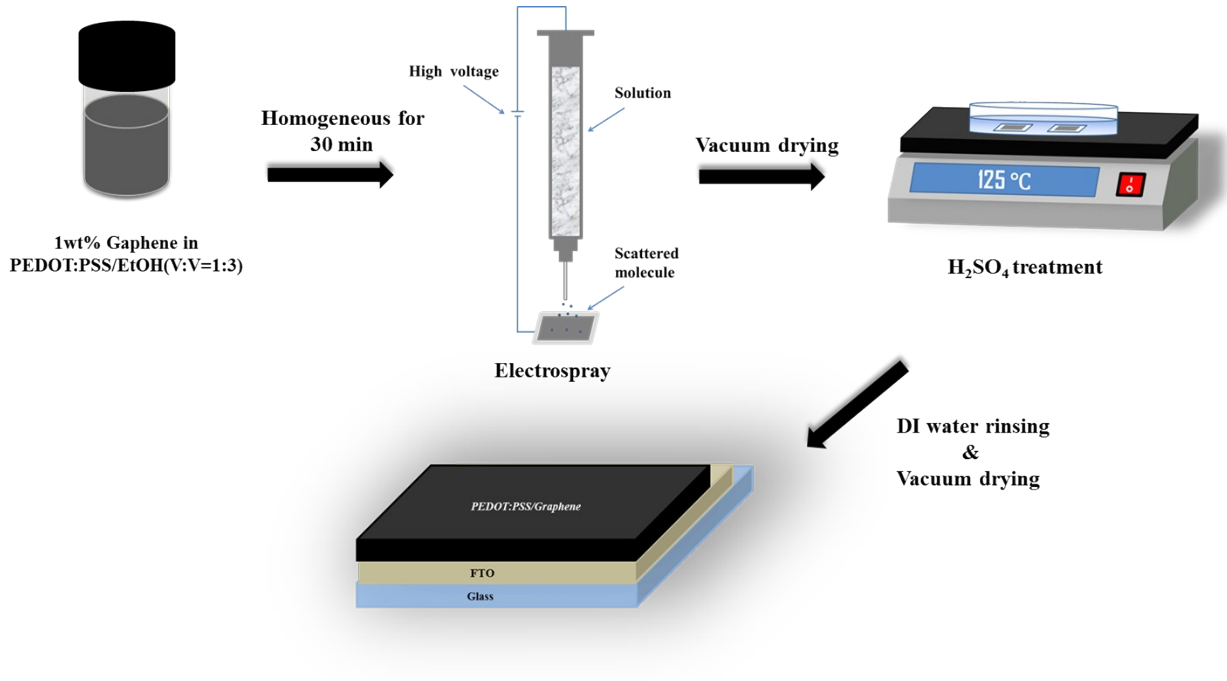


Figure S1: Schematic illustration of the fabrication of PPG_{AT} onto FTO coated glass substrate.

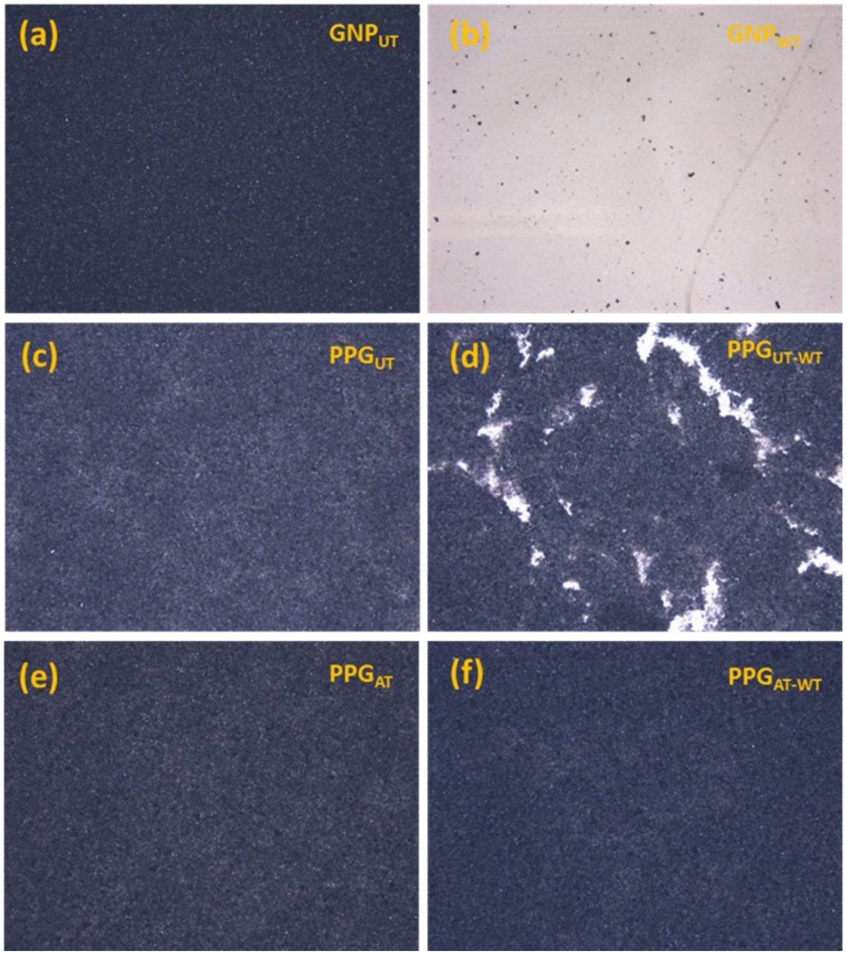


Figure S2: Optical microscopic images (Magnification: ×100) of (a) GNP$_{UT}$, (b) GNP$_{WT}$, (c) PPG$_{UT}$, (d) PPG$_{UT-WT}$, (e) PPG$_{AT}$, and (f) PPG$_{AT-WT}$.

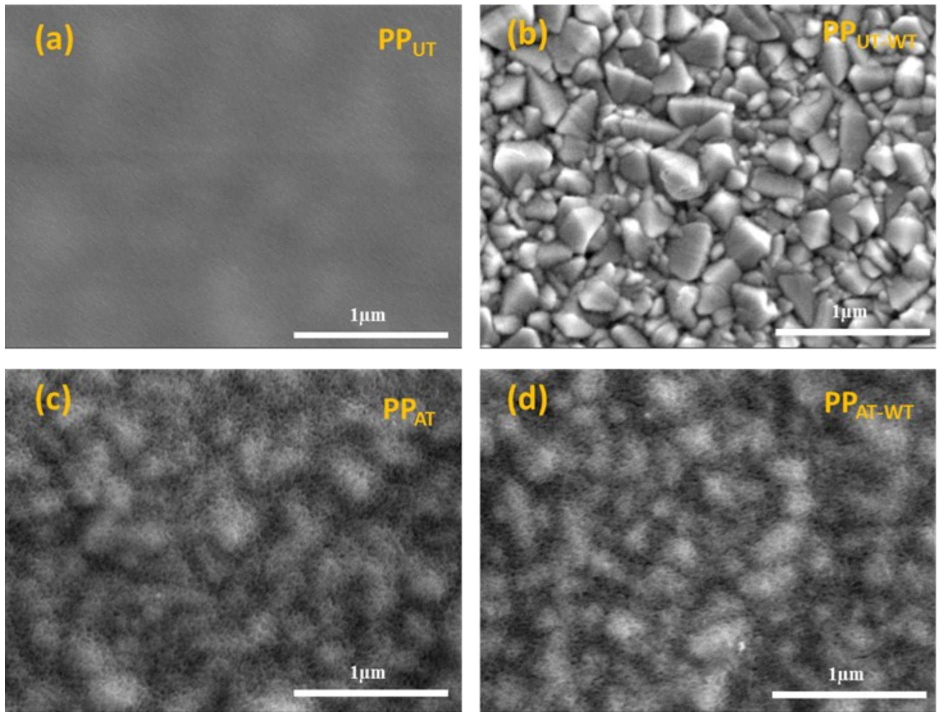


Figure S3: SEM images of (a) PP_{UT}, (b) $PP_{UT\text{-}WT}$, (c) PP_{AT}, and (d) $PP_{AT\text{-}WT}$.

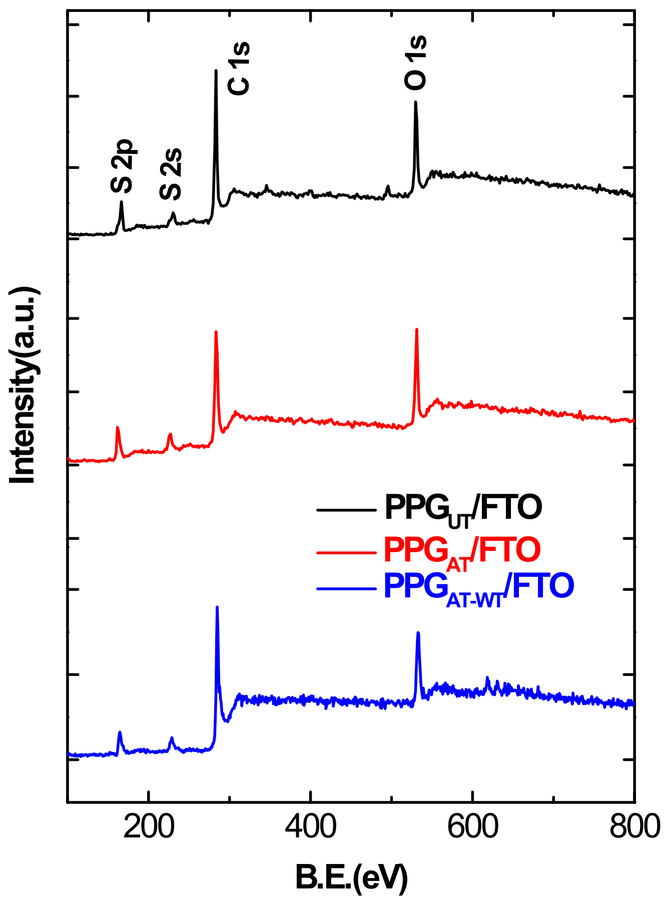


Figure S4: Survey XPS spectra of different samples.

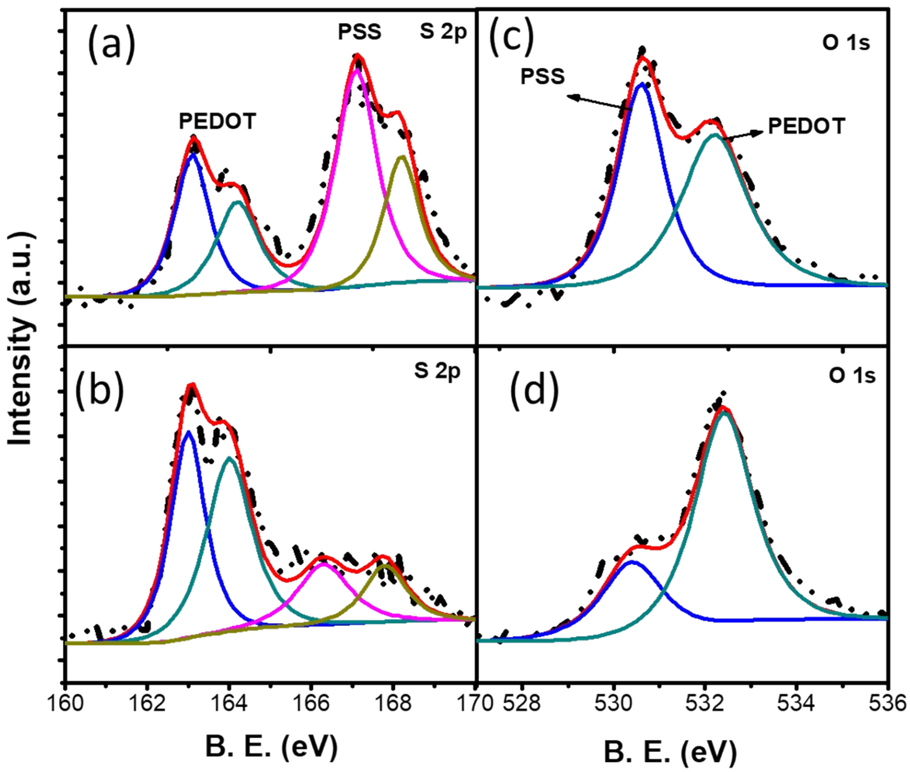


Figure S5: Core-level S 2p peaks of (a) PP_{UT} and (b) PP_{AT} and O 1s peaks of (c) PP_{UT} and (d) PP_{AT} electrode. The dotted lines indicate the experimental data and the solid lines denote the fitted curves.

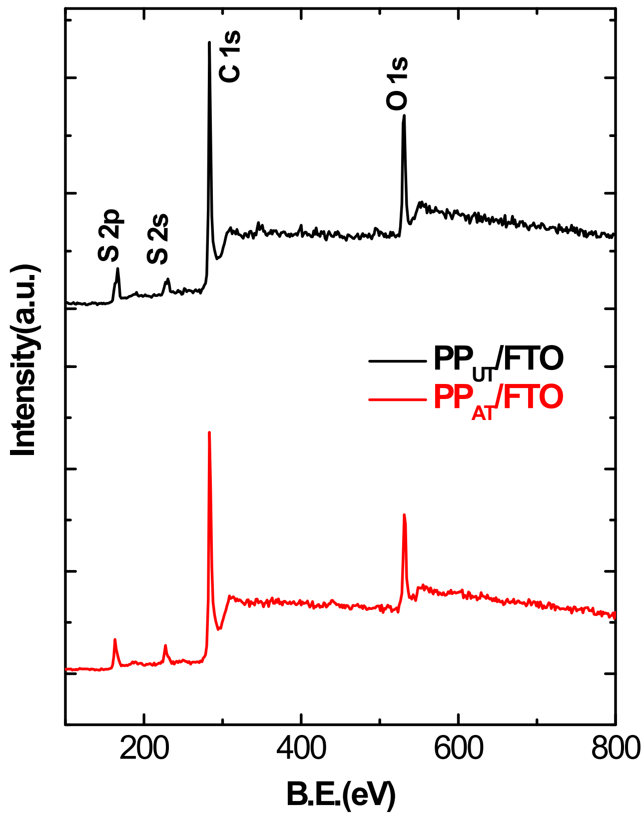


Figure S6: Survey XPS spectra of PP_{UT} and PP_{AT} electrodes.

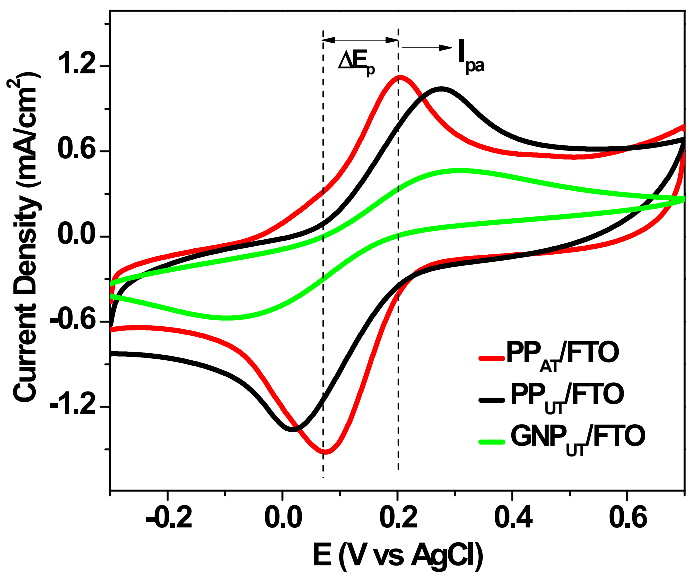


Figure S7: CVs of GNP_{UT}/FTO, PP_{UT}/FTO, and PP_{AT}/FTO electrodes in PBS (pH 7.0) containing $[Fe(CN)_6]^{3-/4-}$ (5 mM each) at a scan rate of 100 mV/s.

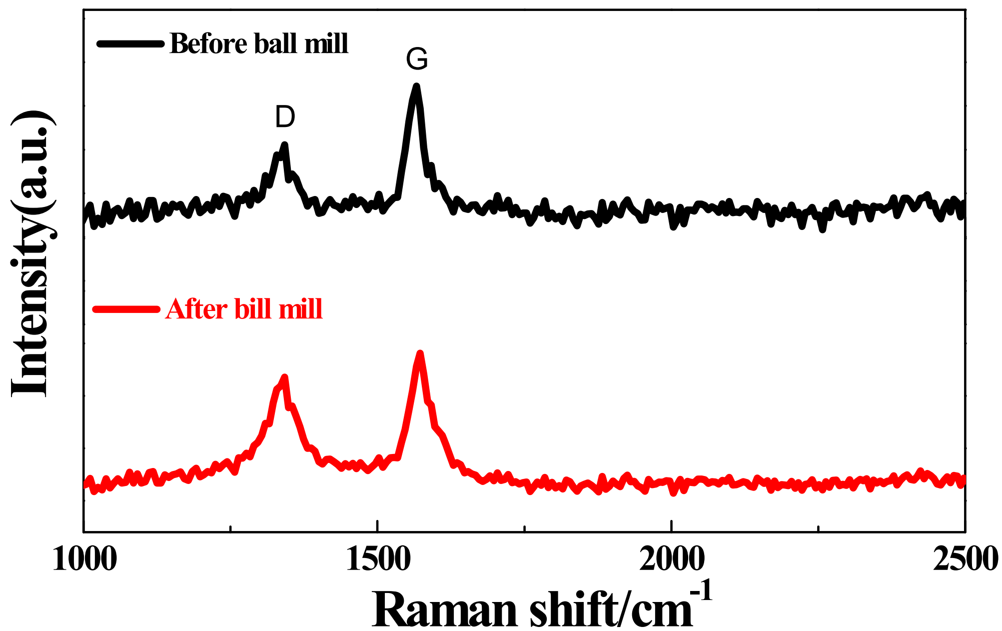


Figure S8: Raman spectra of GNPs before and after ball milling.

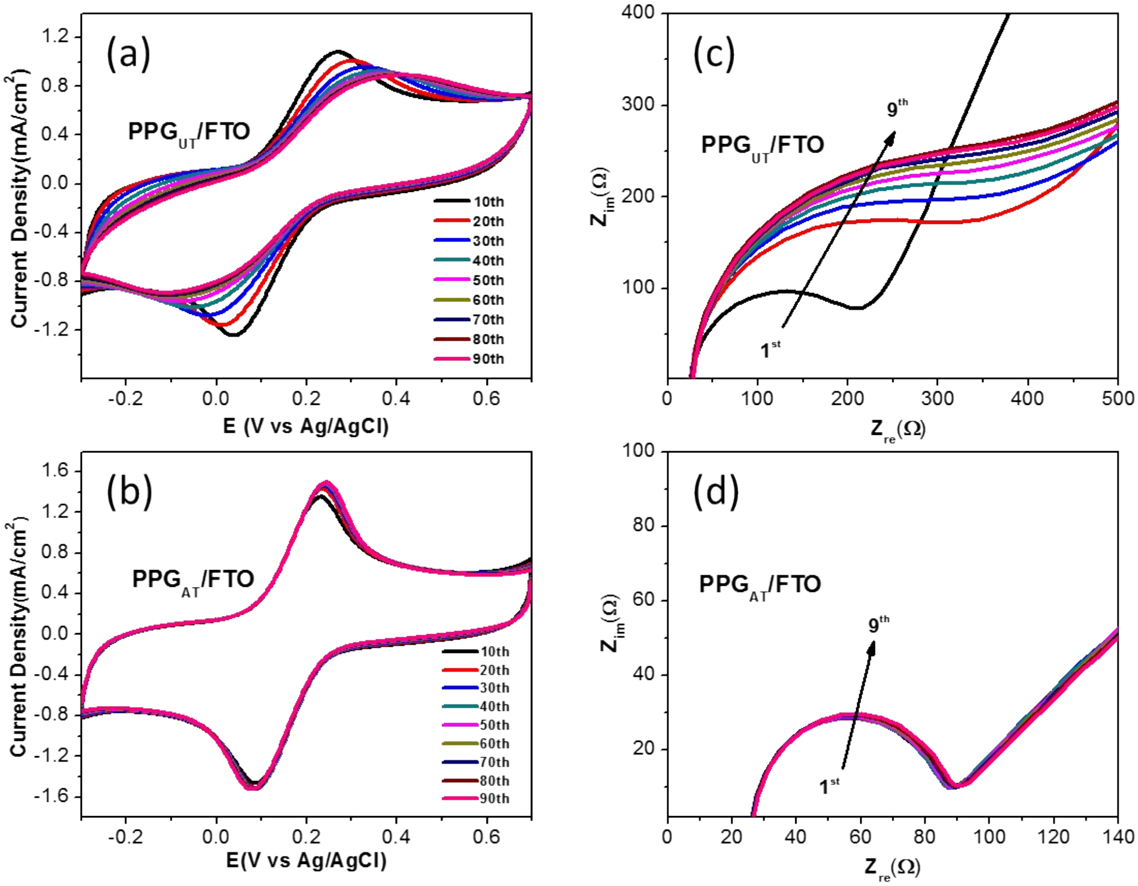


Figure S9: Consecutive CVs (scan rate 100mV/s) (10^{th} - 90^{th}) of (a) PPG_{UT}/FTO and (b) PPG_{AT}/FTO electrodes and repetitively measured EIS plots of (c) PPG_{UT}/FTO and (d) PPG_{AT}/FTO electrodes in PBS (pH 7.0) containing $[Fe(CN)_6]^{3-/4-}$ (5 mM each). Each of the EIS plot was measured after performing 10 consecutive CV sweeping in the potential range between -0.3 to +0.7 V at a scan rate 100 mV/s.

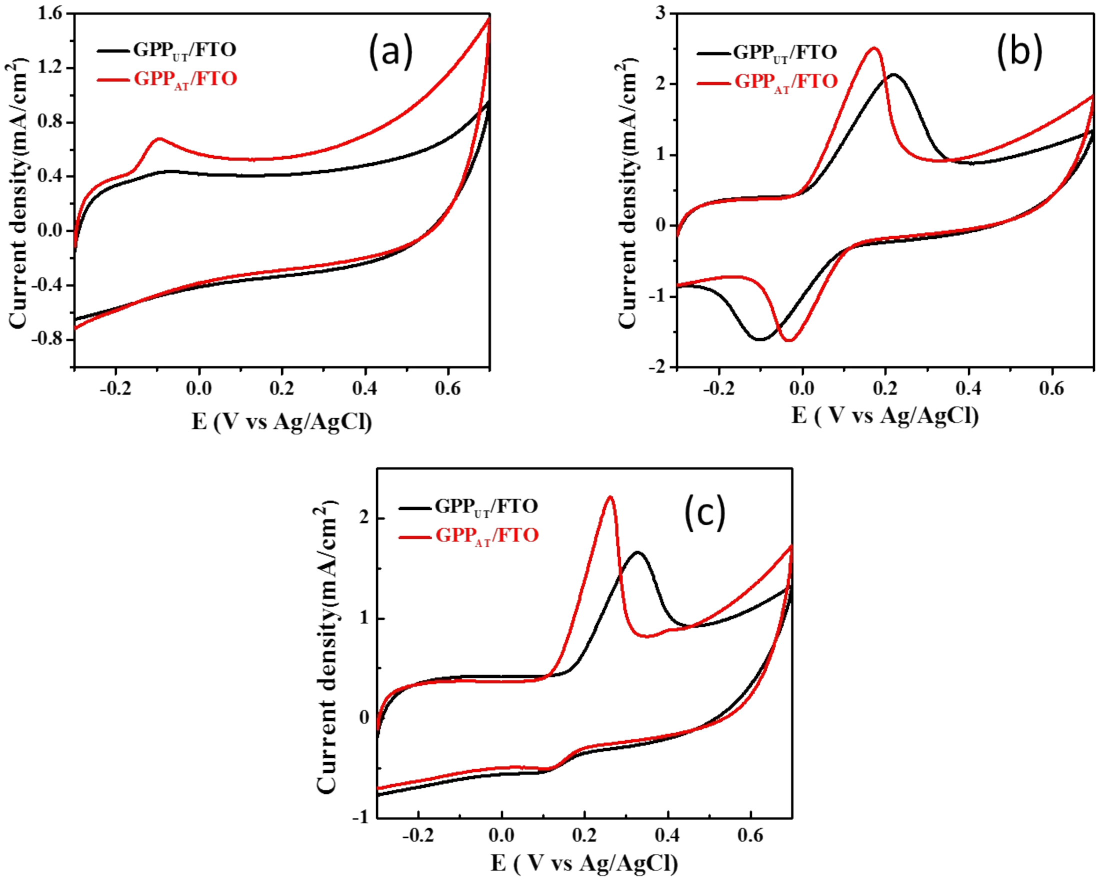


Figure S10: CVs of PPG$_{UT}$/FTO and PPG$_{AT}$/FTO electrodes in PBS (pH 7.0) containing (a) 1 mM AA, (b) 1 mM DA, and (c) 1 mM UA at a scan rate 100 mV/s.

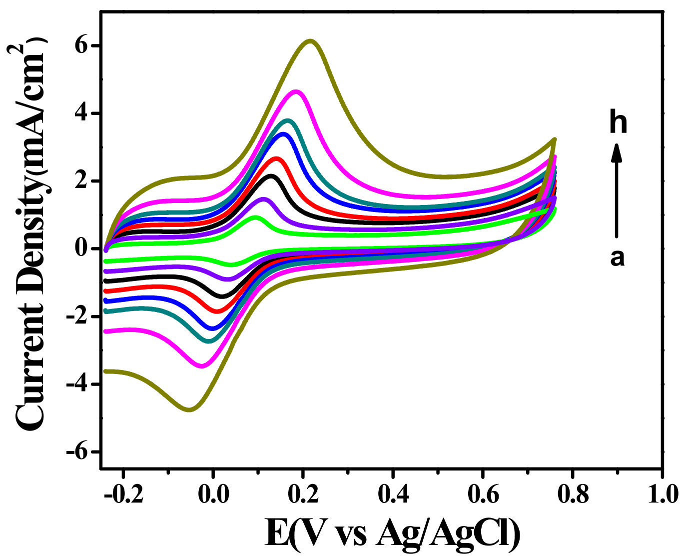
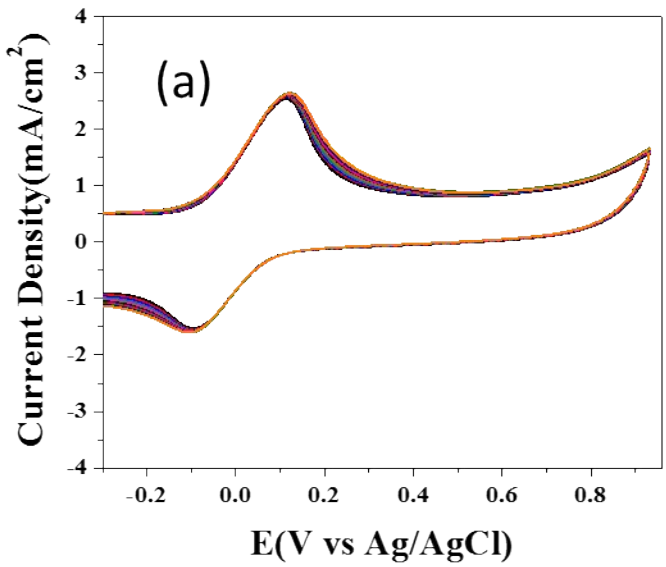


Figure S11: CVs of 1 mM DA (in PBS, pH 7.0) at PPG_{AT}/FTO with varying scan rates (a→h: 25, 50, 75, 100, 125, 150, 200, 300 mV/s).



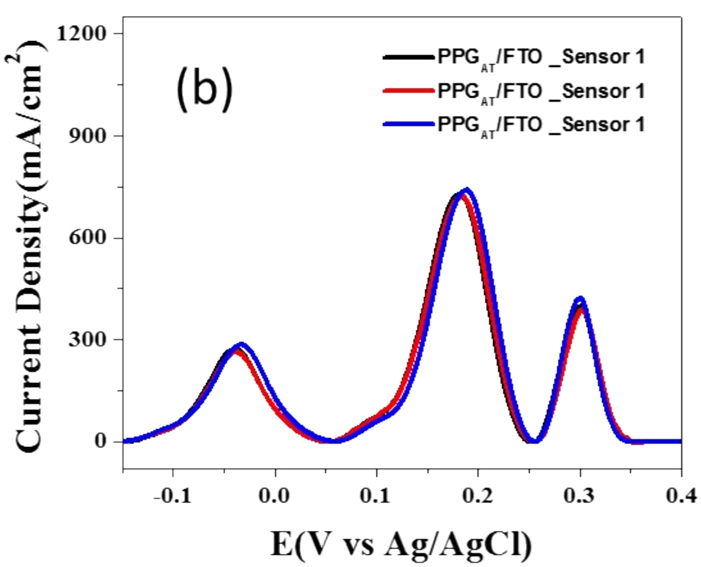


Figure S12: (a) Consecutive CVs of 1 mM DA (in PBS, pH 7.0) at the PPG_{AT}/FTO sensor at a scan rate of 100 mV/s. (b) DPV responses of three different PPG_{AT}/FTO sensor in a mixture solution of AA (2 mM), DA (30 μM), and UA (30 μM).

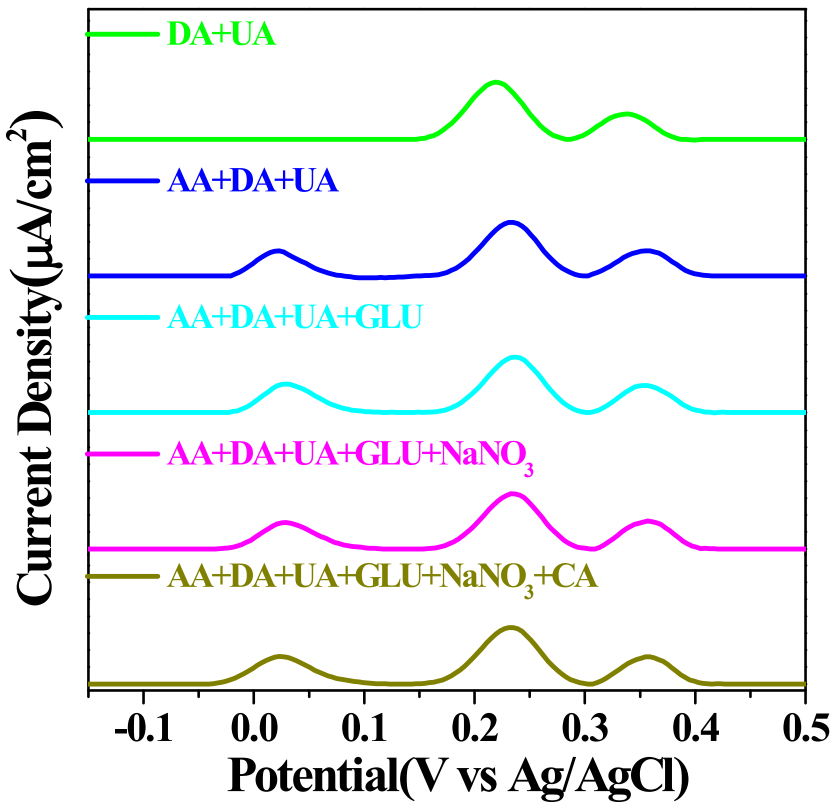


Figure S13: DPV responses of DA and UA (30 μM each) at PPG_{AT}/FTO sensor in the absence and presence of AA (2 mM), glucose (1 mM), $NaNO_3$ (1 mM) and CA (1 mM).

Table S1: Comparison of the sensing performance of PPG_{AT}/FTO sensor for DA detection with some reported nanocomposites based sensors.

Electrode	**Method**	**Linearity (μM)**		**Detection limit(μM)**		**Ref.**
		Electrochemistry based sensor				
[a] SPGNE	DPV	0.5~2000		0.12		[S1]
[b] GO-BAMB-$Co(OH)_2$/GCE	DPV	3~100		0.4		[S2]
[c] AGONF	CV	2~30		[c] 2.2		[S3]
[d] TGONF				[d]2.5		
[e] GLY-GQDs-Ce (IV)	DPV	0.03~16.7		0.025		[S4]
[f] rGO–Co_3O_4/GCE	CA	0~30		0.389		[S5]
[g] GR/p-AHNSA/SPCs	SWV	0.05~150		0.003		[S6]
[h] PA/GO/GCE	DPV	0.05~10		0.016		[S7]
[i] CdTe QDs-Gr/GCE	DPV	1~500		0.33		[S8]
Tyrosinase/NiO/ITO	CV	2~100		1.04		[S9]
Graphene nanobelts/GCE	DPV	2~200		0.58		[S10]
GO-MWCNT/MnO_2/AuNP/GCE	CA	0.5~2500		0.17		[S11]
Nitrogen doping graphene/GCE	DPV	0.5~170		0.25		[S12]
[j] P($TBA_{0.50}Th_{0.50}$)	EIS	7.8~125		0.3		[S13]
rGO/CPE	DPV	2.0~2×10^4		0.136		[S14]
Poly(thionine)/GCE	DPV	5~30		0.7		[S15]
Graphene/Au/GCE	DPV	5~1000		1.86		[S16]
Fe_3O_4/rGO/GCE	DPV	0.5~100		0.12		[S17]
Acid treated GPP/FTO	DPV	1~30		0.105		**This work**
		Other technologies based sensor				
-	UV absorbance	0.05~6.00	μg/mL	0.045	μg/mL	[S18]
-	Capillary Electrophoresis	0.001~0.3	μM	0.10	nM	[S19]
-	Chemiluminescence	0.1~40	nM	0.03	nM	[S20]
-	[k] LC-MS-MS	50~4000	μg/L	2.5	μg/L	[S21]
-	[l] LacOF	5~125	pg/mL	2.1	pg/mL	[S22]
-	[m] HPLC-FD	0.031~2.50	μg/mL	0.031	μg/mL	[S23]
-	[n] HPLC-ED	5~125	pg/mL	5.2	pg/mL	[S22]
-	Fluorescent	0.1~20	μM	40	nM	[S24]
-	Neurochemical Probe	0.25~1	μM	-	-	[S25]
-	[o] GQD-Fluorescent	0.005~1.2	μM	0.0025	μM	[S26]

[a]Screen printing graphene electrode; [b]1,4-bis(aminomethyl)benzene (BAMB) and cobalt hydroxide ($Co(OH)_2$) at graphene oxide (GO); [c]Alanine functionalized GO nanoflakes; [d]Tyrosine functionalized GO nanoflakes; [e]Photoluminescent glycine functionalized graphene quantum dots; [f]Cobalt oxide nanograindecorated reduced graphene oxide; [g]Graphene (GR) and poly 4-amino-3-hydroxy-1-naphthalenesulfonic acid modified screen printed carbon sensor; [h]Phytic acid/graphene oxide; [i]Quantum dots CdTe and graphene; [j]Polymerization of 3-Thienylboronic acid and copolymer Thiophene; [k] Liquid chromatography-mass spectrometry- mass spectrometry; [l] Laccase-Optical fiber biosensor; [m] High Performance Liquid Chromatography with fluorimetric detection; [n] High Performance Liquid Chromatography with electrochemical detection.[o] graphene quantum dot-Fluorescent.

Reference

S1. J. Ping, J. Wu, Y. Wang and Y. Ying, *Biosens. Bioelectron*., 2012, **34**, 70-76.

S2. A. Ejaz, Y. Joo and S. Jeon, *Sens Actuators B Chem*., 2017, **240**, 297-307.

S3. M. Kumar, B. E. K. Swamy, M. H. M. Asif and C. C. Viswanath, *Appl. Surf. Sci*., 2017, **399**, 411-419.

S4. R. Liu, R. Yang, C. Qu, H. Mao, Y. Hu, J. Li and L. Qu, *Sens Actuators B Chem*., 2017, **241**, 644-651.

S5. A. Numan, M. M. Shahid, F. S. Omar, K. Ramesh and S. Ramesh, *Sens Actuators B Chem*., 2017, **238**, 1043-1051.

S6. M. Raj, P. Gupta, R. N. Goyal and Y.-B. Shim, *Sens Actuators B Chem*., 2017, **239**, 993-1002.

S7. D. Wang, F. Xu, J. Hu and M. Lin, *Mater Sci Eng C Mater Biol Appl*., 2017, **71**, 1086-1089.

S8. H. W. Yu, J. H. Jiang, Z. Zhang, G. C. Wan, Z. Y. Liu, D. Chang and H. Z. Pan, *Anal. Biochem*., 2017, **519**, 92-99.

S9. A. Roychoudhury, S. Basu and S. K. Jha, *Biosens. Bioelectron*., 2016, **84**, 72-81.

S10. P. K. Kannan, S. A. Moshkalev and C. S. Rout, *Nanotechnology*, 2016, **27**, 075504.

S11. D. Rao, X. Zhang, Q. Sheng and J. Zheng, *Microchim. Acta*., 2016, **183**, 2597-2604.

S12. Z. H. Sheng, X. Q. Zheng, J. Y. Xu, W. J. Bao, F. B. Wang and X. H. Xia, *Biosens. Bioelectron.*, 2012, **34**, 125-131.

S13. M. Dervisevic, M. Senel and E. Cevik *Mater Sci Eng C Mater Biol Appl.*, 2017, **72**, 641-649.

S14. A. Benvidi, S. Dalirnasab, S. Jahanbani, M. D. Tezerjani, M. M. Ardakani, B.-B. F. Mirjalili and R. Zare, *Electroanalysis*, 2016, **28**, 1625-1633.

S15. A.J.S. Ahammad, X.B. Li, M.M. Rahman, K.-M. Noh, J.-J. Lee, *Int. J. Electrochem. Sci.*, 2013, **8**, 7806-7815.

S16. J. Li, J. Yang, Z. Yang, Y. Li, S. Yu, Q. Xu and X. Hu, *Anal Methods.*, 2012, **4**, 1725-1728.

S17. T. Peik-See, A. Pandikumar, H. Nay-Ming, L. Hong-Ngee and Y. Sulaiman, *Sensors*, 2014, **14**, 15227-15243.

S18. L. Guo, Y. Zhang, Q. Li, *Anal Sci*, 2009, **25**, 1451-1455.

S19. H. Li, C. Li, Z.Y. Yan, J. Yang, H. Chen, *J. Neurosci. Methods*, 2010, **189**, 162-168.

S20. X. Xu, H. Shi, L. Ma, W. Kang, S. Li, *Luminescence*, 2011, **26**, 93-100.

S21. A. El-Beqqali, A. Kussak, M. Abdel-Rehim, *J. Sep. Sci*, 2007, **30**, 421-424.

S22. L.I. Silva, F.D. Ferreira, A.C. Freitas, T.A. Rocha-Santos, A.C. Duarte, *Talanta*, 2009, **80**, 853-857.

S23. G.E. De Benedetto, D. Fico, A. Pennetta, C. Malitesta, G. Nicolardi, D.D. Lofrumento, F. De Nuccio, V. La Pesa, *J. Pharm. Biomed. Anal*, 2014, **98**, 266-270.

S34. A. Yildirim, M. Bayindir, *Anal. Chem*, 2014, **86**, 5508-5512.

S25. H.N. Schwerdt, M.J. Kim, S. Amemori, D. Homma, T. Yoshida, H. Shimazu, H. Yerramreddy, E. Karasan, R. Langer, A.M. Graybiel, M.J. Cima, *Lab Chip*, 2017, **17**, 1104-1115.

S26. X. Zhou, X. Gao, F. Song, C. Wang, F. Chu, S. Wu, *Appl. Surf. Sci*, 2017, **423**, 810-816.