Supplementary Information for

A dual electrochemical microsensor for simultaneous imaging of oxygen and pH over rat kidney surface

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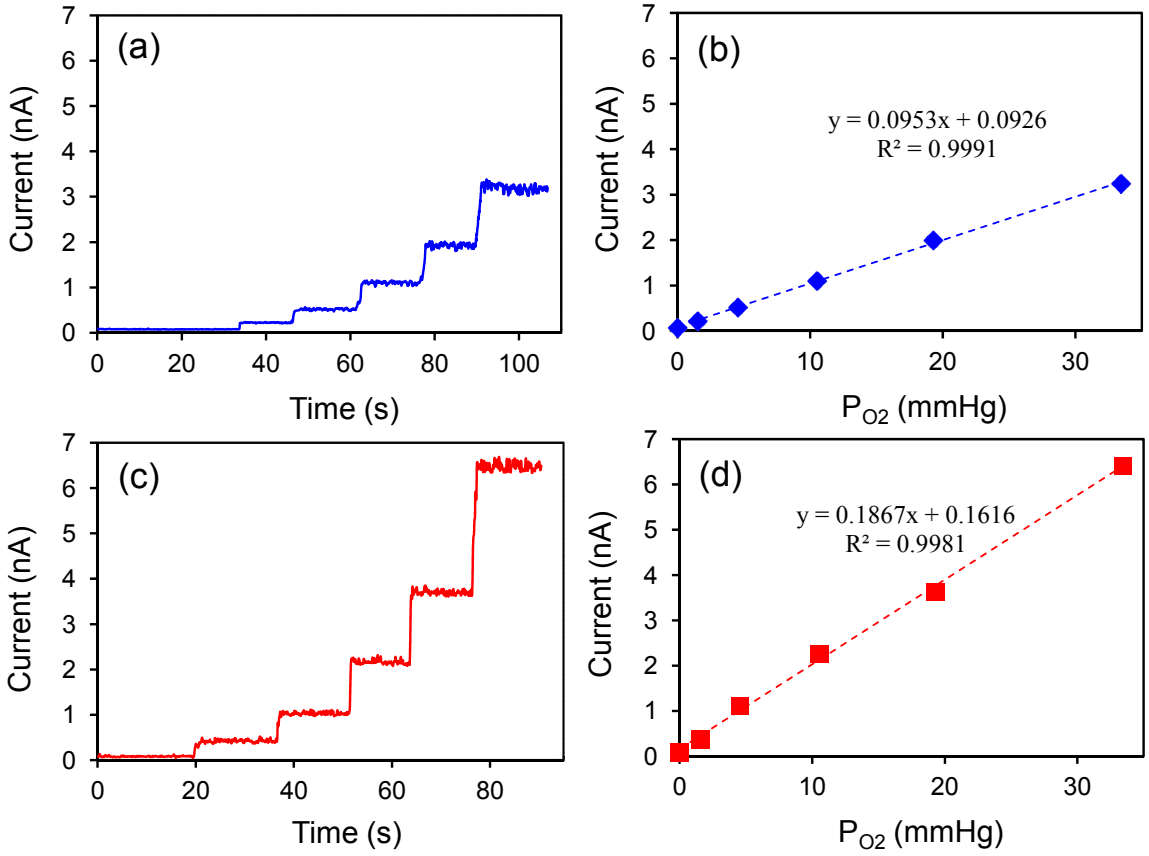

Fig. S1. Dynamic current changes (a,c) and corresponding calibration curves (b,d) of WE1 responding to varying P_{O2} in PBS solution (pH =7.4). WE1 is Pt black deposited planar Pt disk (a,b) without or (c,d) with poly-FED coating. Each Pt disk diameter of the dual electrode is 10 μm.

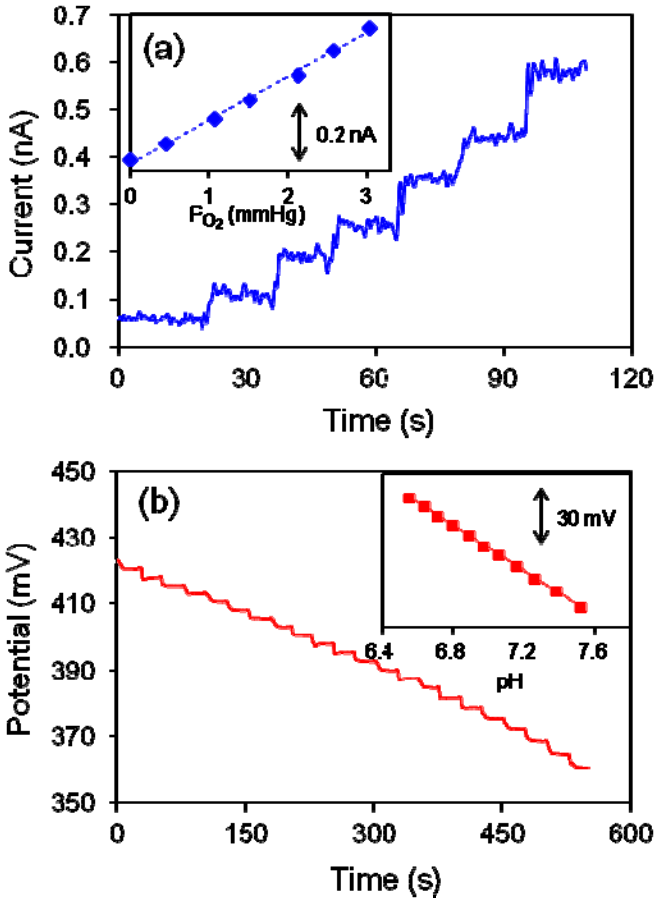

Fig. S2. The typical dynamic response curves of (a) WE1 and (b) WE2 to small changes of (a) P_{O2} and (b) pH. The applied potential to WE1 was −0.6 V vs. Ag/AgCl. (a) Current of WE1 was recorded with the successive additions of an O_2 standard solution into a deaerated 4 mM PBS solution. (b) Potential of WE2 was measured in universal buffer with the successive injections of a saturated NaOH solution to alter the solution pH. Insets show the corresponding calibration curves. (a) WE1 sensitivity to P_{O2} is 166.8 pA $mmHg^{-1}$; (b) potential response slope per pH of WE2 is −59.197 mV pH^{-1}.

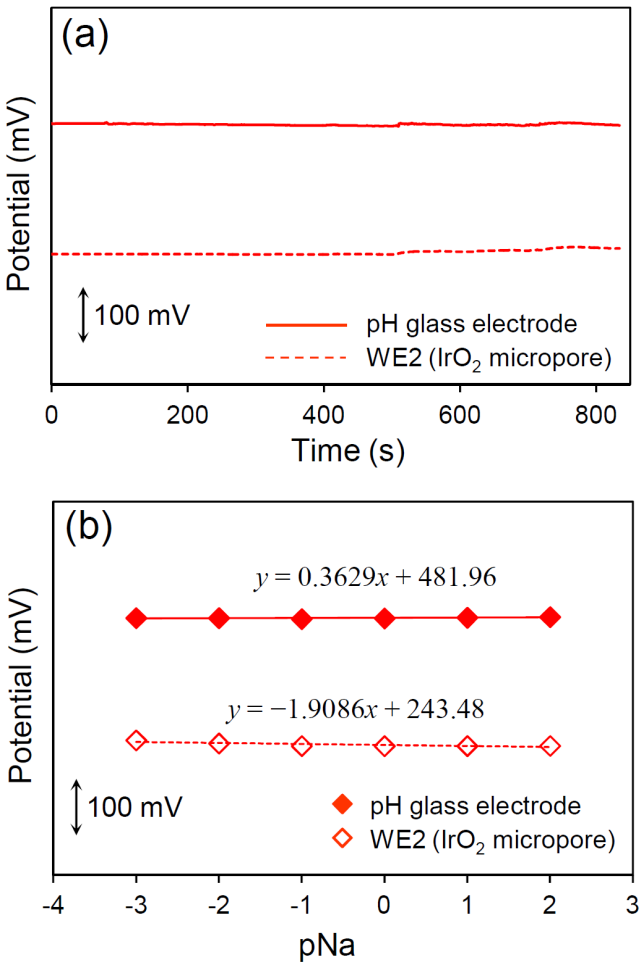

Fig. S3. (a) Dynamic potential changes of WE2 of dual sensor and commercial pH glass electrode (Istek, Korea) responding to sodium ion concentration. The sodium ion concentration was increased from 0.01 mM to 1.0 M in a universal buffer solution. (b) Corresponding calibration curves.

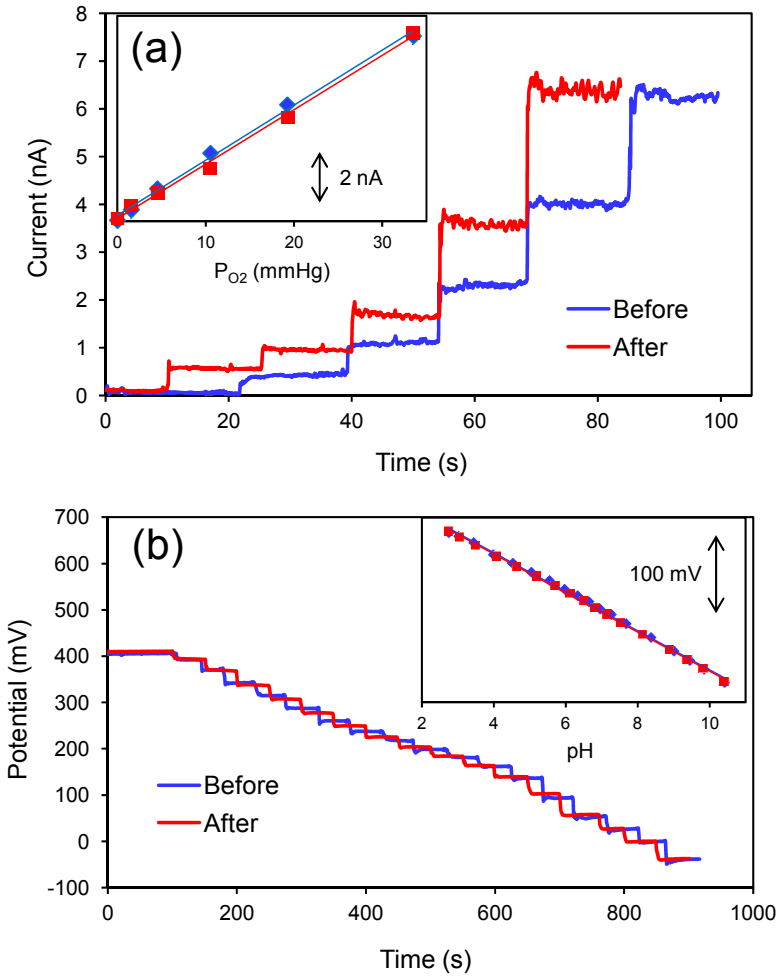

Fig. S4. Comparison of dynamic response curves of WE1 and WE2 to (a) P_{O2} and (b) pH before and after 2.5 h kidney tissue imaging experiment. The applied potential to WE1 was −0.6 V vs. Ag/AgCl. (a) Current of WE1 was recorded with the successive additions of an O_2 standard solution into a deaerated 4 mM PBS solution. (b) Potential of WE2 was measured in universal buffer with the successive injections of a saturated NaOH solution to alter the solution pH. Insets show the corresponding calibration curves. (a) WE1 sensitivities to P_{O2} are 187.3 and 187.5 pA $mmHg^{-1}$ before and after tissue imaging, respectively; (b) potential response slopes per pH of WE2 are −58.133 and −58.130 mV pH^{-1} before and after tissue imaging, respectively.

Table S1. Comparison of the sensor performances between our dual O_2/pH microsensors vs. previously reported single amperometric O_2 microsensor or single potentiometric pH sensor used for biological samples.

Amperometric O_2 microsensor				Potentiometric IrO_x-based pH sensor				References
Sensitivity (pA $mmHg^{-1}$)	Response time, $t_{90\%}$ (s)	Linear range (mmHg)	Electrode size (diameter in μm)	Sensitivity (mV pH^{-1})	Response time, $t_{90\%}$ (s)	Linear range (pH unit)	Electrode area (mm^2)	
168.4± 33.8	0.17 ± 0.05	~ 100	10	58.3 ± 1.5	0.43 ± 0.09	2 ~ 11	0.0000785	Current work
0.6 ~ 3	-	-	1.5 ~ 4					6
2 ~ 6	-	-	1					7
294.7	~37.5	~ 33	25					8
266.3 ± 0.6	Sub-seconds	37 ~ 149	127					9
1.62 ± 0.04	2.6 ± 0.5	~ 150	3 in diameter 4.2 in length					10
1.00 ± 0.27	-		9.6 ± 3.1					12
2550 ± 20	-	~ 702	200					13,14
				63.5 ± 2.2	< 5	2 ~ 10	-	21,22
				57.8 ± 1.5	< 5	6.5 ~ 8.2	80	23
				77.6 ± 2	6	4 ~ 11	0.0004	24
				55 ~ 70	6 ~ 15	4 ~ 11	0.008	25
				59.5 ~ 69	< 2	3 ~ 12	-	26
				74.4 ± 0.0008	< 2	4 ~ 11	0.0044	27
				63 ± 5	-	6 ~ 8.5	0.012	28
				68 ~ 76	2.3	6 ~ 8	0.0004	29
				72.9 ± 0.9	-	3 ~ 11	0.00012, 0.0003	30