Supplementary Information

Vapor grown carbon fiber combined with polyaniline and gold nanoparticles in composite bielectrodes and its application in glucose fuel cells

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I. Procedure of enzyme activity measurement

GOx activity of the synthesized composite was determined by measuring the absorbance of upper solution of the composite matrix from centrifugation after immobilization using Glucose Oxidase Activity Assay Kit MAK 097 purchased from Sigma-Aldrich. In detail, 2 mg PANI/VGCF (or AuNPs/VGCF) was dissolved in 500 μL DI water followed by adding 1 mg GOx while shaking at 200 rpm for 1 h at 0 ℃. 1 μL GA was added to the mixture which was shaken continuously overnight. Then the mixture was centrifuged gently. Sample preparation was finished when upper solution was obtained. H₂O₂ standards were prepared first with 0 (blank), 1, 2, 3, 4, and 5 nmol per tube standards in 1 mL buffer. Dilute samples and standards were measured by colorimetric method. First, mixtures including GOx Assay Buffer (36 μL), GOx Developer (2 μL), Fluorescent Peroxidase Substrate (2 μL), GOx Substrate (10 μL) were added to the samples and standards. After 5 minutes, the initial measurement (T_{initial}) was taken. For colorimetric assays, measurements were taken every minute at the absorbance of 570 nm (A_{570}^{initial}) using a UV spectrometer (UV-1800, Shimadzu, Kyoto, Japan). The final measurement (A_{570}^{final}) for calculating the enzyme activity would be the penultimate reading or the value before the most active sample was near or exceeds the end of the linear range of the standard curve. The time of the penultimate reading was T_{final}.

II. Calculation of GOx immobilized on PANI/VGCF (or AuNPs/VGCF) composite

The amount of GOx immobilized on PANI-VGCF (or AuNPs/VGCF) composite was determined by subtracting the amount of GOx in the upper solution of composite matrix from centrifugation after immobilization from the total amount. For this purpose, we first calculated the upper solution enzyme activity using the following equation.
where B was the amount (n mole) of H$_2$O$_2$ generated between T$_{\text{initial}}$ and T$_{\text{final}}$. Reaction Time (minutes) was the time difference between T$_{\text{final}}$ and T$_{\text{initial}}$. V was the sample volume (mL) added to the tube. GOx activity was reported as n mole min$^{-1}$ mL$^{-1}$ = milliunit mL$^{-1}$, where one unit of GOx was defined as the amount of enzyme that generates 1.0 mmole of H$_2$O$_2$ per minute at 37 °C. After calculating the enzyme activity, the amount of enzyme immobilized onto PANI/VGCF (or AuNPs/VGCF) composite was obtained by subtracting the amount of GOx in the upper solution from the total amount of GOx.
III. Figures

**Figure S1.** A schematic of the EBC cell consisting of anode, cathode and Nafion 117 membrane.
Figure S2. Isotherm linear plot of HCl doped PANI/VGCF composite and VGCF.
Fig. S3. TGA of PANI/VGCF composite (cyan) and PANI/CNT composite (blue).
Fig. S4. SEM of PANI/VGCF composite doped with SDS with different magnifications (large: 2000×, inset: 50000×).
Figure S5. Absorbance vs time (A-T) plot for calculation of enzyme activity of PANI/VGCF composite enzyme matrix.
Figure S6. The UV absorbance of residual solution of AuNPs/VGCF with increasing time.
Figure S7. Absorbance vs time (A-T) plot for calculation of enzyme activity of AuNPs/VGCF composite enzyme matrix.