On-Chip Graphene Field-Effect Biosensors for the Detection of Glial Fibrillary Acidic Protein in Patient Plasma

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Glial fibrillary acidic protein (GFAP) has been suggested to be used as blood biomarker for early detection and monitoring the progress for many neurological diseases, such as traumatic brain injury, as its concentration can reflect the stage of the TBI [1]. Enzyme-linked immunosorbent assay (ELISA) is the classical method for GFPA detection. However, it has limit of detection (LOD) in nM range which is not adequate for many clinical concentrations. State-of-art method such as single molecular array (Simoa) technology has been developed to detect ultra-low concentration. However, this method is complex, expensive and requires complicated processing steps. Here, we demonstrate an on-chip graphene field-effect transistor (GFET) biosensing method for sensitive and ultrafast detection of GFAP in patient plasma [2]. Patients with moderate–severe traumatic brain injuries were recruited to provide plasma samples. The binding of target GFAP with the specific antibodies that are conjugated on a monolayer GFET device (Figure 1) triggers the shift of its Dirac point, and this signal change is correlated with the GFAP concentration in the patient plasma (Figure 2A). Limit of detection (LOD) values of 20 fg/mL in buffer solution and 231 fg/mL in patient plasma (Figure 2B) have been achieved using this approach. In parallel, we compare our results to the state-of-the-art Simoa technology and the classic ELISA for reference (Figure 2C&D). The GFET biosensor shows competitive LOD to Simoa (1.18 pg/mL) with faster sample-to-result time (<15 min). In comparison to ELISA, GFET offers advantages of total detection time, detection sensitivity, cost, and simplicity. This GFET biosensing platform holds great promise for the point-of-care diagnosis and monitoring of traumatic brain injury.

References

[1] Hambisetty, M.; Lovestone, S., Biomarkers Med, 4(2010) 65– 79.
[2] L. Xu et al., ACS Sens., 7 (2022) 253–262.

Figures

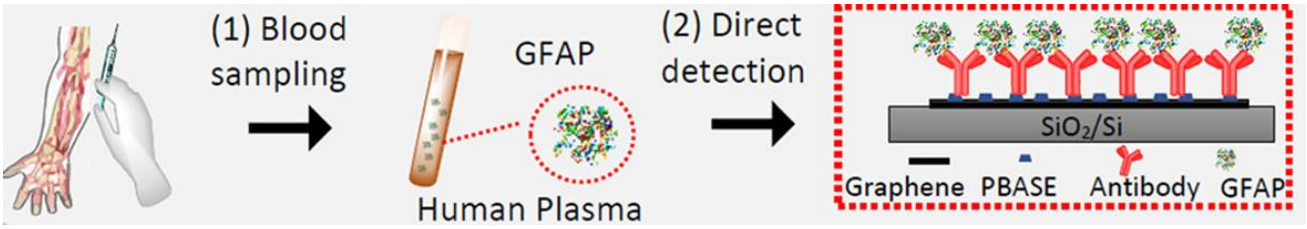

Figure 1: Schematic of the methods for GFAP detection using On-chip GFET biosensing platform.

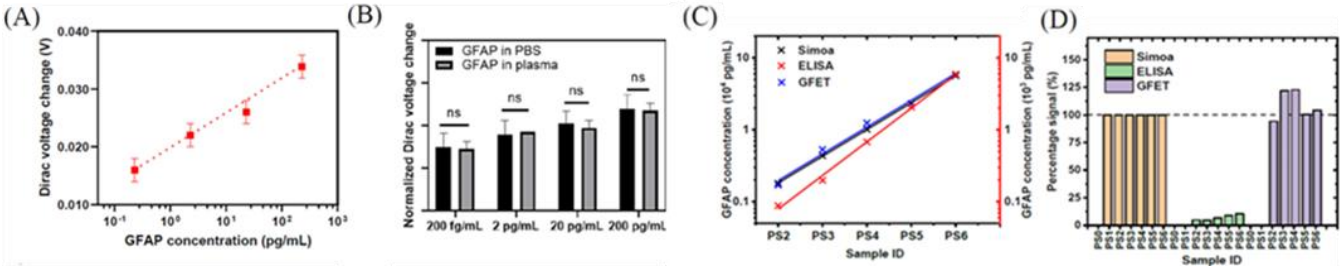

Figure 2: Detection of GFAP in patient plasma using the GFET biosensor. (A) Calibration curve of the GFET biosensor for the GFAP detection in plasma. (B) Signal intensity comparison between the tests in PBS and in the plasma for the same concentration order of magnitude illustrating excellent selectivity of the GFAP biosensor. (C) Correlation of GFAP concentration measured by Simoa, ELISA, and GFET. (D) Signal percentage of GFAP concentration measured by GFET and ELISA in comparison to Simoa as a reference.