Ultrasensitive Dopamine Detection with Graphene Aptasensor Multitransistor Arrays

Pedro Alpuim[1,3]
Mafalda Abrantes[1,2,3], Diana Rodrigues[2], Telma Domingues[1,3], Patrícia Monteiro[2], Jérôme Borme[1], Luís Jacinto[2]

[1]*International Iberian Nanotechnology Laboratory, 4715-330, Braga, Portugal*
[2]*Life and Health Sciences Research Institute (ICVS), School of Medicine, University of Minho, 4710-057, Braga, Portugal*
[3]*Physics Centre of Minho and Porto Universities (CF-UM-UP), University of Minho, 4710-057, Braga, Portugal*
pedro.alpuim.us@inl.int

Dopamine is a neurotransmitter with critical roles in the human brain and body, and abnormal alterations of its levels underlie brain disorders such as Parkinson's Disease, Alzheimer's Disease, and substance addiction. Herein, we present a novel high-throughput biosensor based on graphene multitransistor arrays (gMTAs) functionalized with a selective aptamer for robust ultrasensitive dopamine detection. The miniaturized biosensor based on multiple electrolyte-gate graphene transistors in an array format was fabricated by high-yield reproducible and scalable methodologies optimized at the wafer level. Our previous works reported DNA detection down to the attomolar level [1] using DNA functionalization and protein detection on a picomolar range [2] using antibody functionalization. With these gMTA aptasensors, we present a record limit-of-detection of 1 aM (10^{-18} M) for dopamine in both undiluted phosphate-buffered saline (PBS) and dopamine-depleted brain homogenate samples spiked with dopamine. The gMTAs display wide sensing ranges in all physiological buffers, up to 100 µM (10^{-8} M), with a 22 mV/decade peak sensitivity in artificial cerebral spinal fluid (aCSF). Furthermore, we show that the gMTAs can detect minimal changes in dopamine concentrations in small working volume biological CSF samples obtained from a mouse model of Parkinson's Disease.

References

[1] Campos et al, ACS Sens, 4 (2019) 286-293.
[2] Fernandes et al., Appl. Surf. Science, 480 (2019) 709-716.

Figures

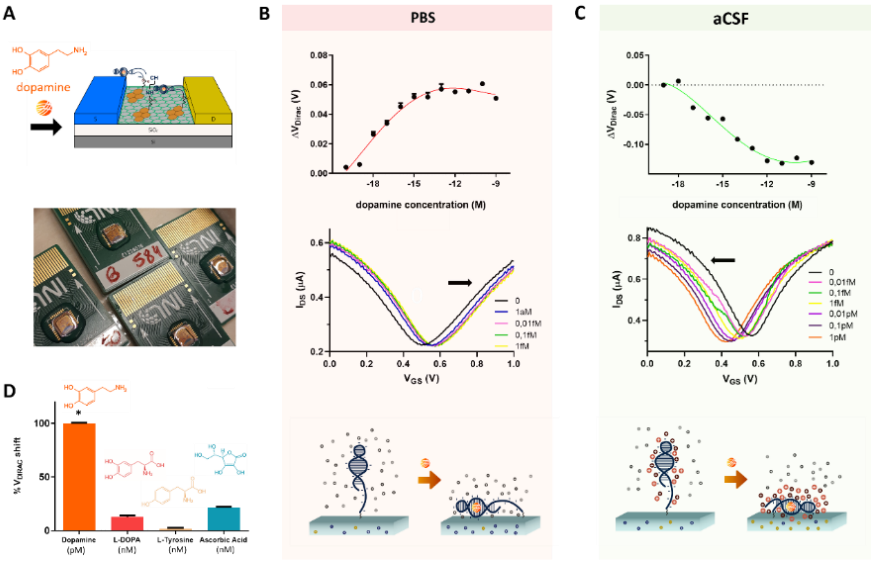

Figure 1: Dopamine detection *in vitro* with gMTAs. (A) Schematic illustration of aptamer structure reorientation close to an EG-gFET. Calibration curves in (B) PBS and (C) aCSF. (D) Comparative responses of gMTAs to 1 pM dopamine, 1 nM L-DOPA, 1nM L-tyrosine and 1 nM ascorbic acid in 1 × PBS.