Attomolar label-free dopamine detection with aptamer functionalized graphene field-effect transistors

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Dopamine is a neurotransmitter with critical roles in the human brain and body, and its dysfunction underlies brain disorders such as Parkinson's Disease and schizophrenia. However, current sensors to detect dopamine in the brain lack relevant selectivity or sensitivity hindering the development of reliable diagnostics and the potentiation of earlier and more efficient treatment. Our previous work reported electrolyte-gate graphene transistors for DNA detection down to the attomolar level [1] using DNA functionalization and protein detection on a picomolar range [3] using antibody functionalization. In this work, we adapted this technology to detect dopamine by using a dopamine-specific aptamer for high selectivity and specificity [2]. The aptamer was immobilized onto a graphene field-effect transistor's channel by a previously reported functionalization process with a pyrene derivate linker [3]. The sensor signal is the charge neutrality point, V_{Dirac}, in the transistor transfer curve.
Dopamine detection experiments were performed using phosphate buffered-saline solution (PBS 1x) and artificial cerebrospinal fluid (aCSF) as the electrolyte gate solution. Dopamine was diluted in these solutions from 0.1 pM to 1 aM. Figure 1 (left) shows the linear transistor response to dopamine, diluted in PBS 1x, from attomolar level to 0.01 picomolar concentration followed by saturation at 0.1 picomolar, with 10mV/dec sensitivity. Figure 1 (right) shows selective dopamine detection compared with transistor's response to L-Dopa, L-Tyrosine, Homovanillic acid and, L-Ascorbic acid.
These results show that the combination of graphene field-effect transistors with a dopamine-specific aptamer allows highly selective and sensitive dopamine detection. The measured detection limit is the lowest ever reported for dopamine. These promising results allow us to consider further experiments in an *in vivo* setting.

REFERENCES

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[3] Fernandes *et al.*, Appl. Surf. Science, 480 (2019) 709-716.

FIGURES

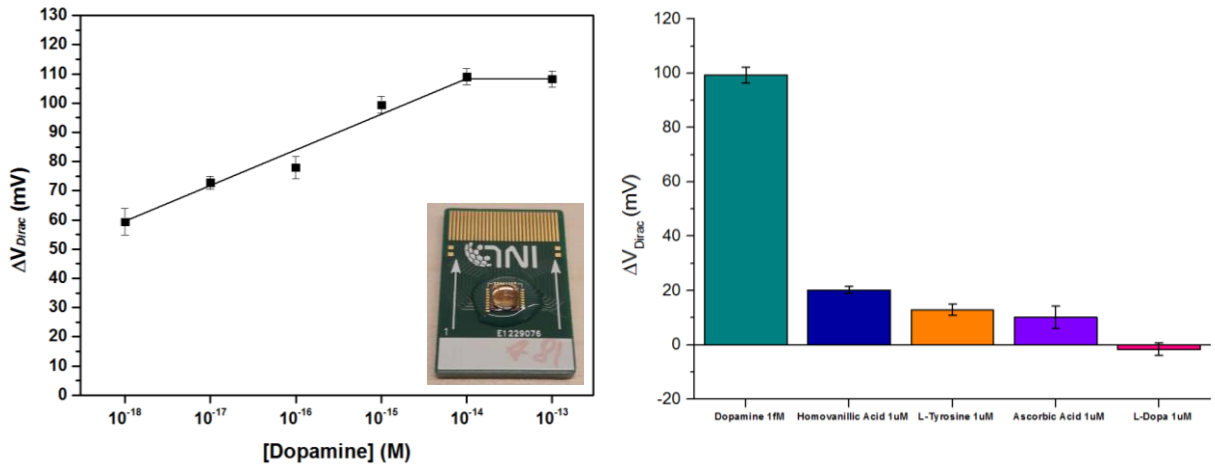

Figure 1: Calibration curve obtained measuring the Dirac point of 20 graphene EGFETs by applying a V_{DS} of 1mV and sweeping V_{GS} from 0V to 1V (left); a graphene EGFET chip is shown in the inset, and the sensors' response compared to non-specific targets, being all diluted in PBS 1x (right).