Portable graphene transistor sensing system for wine DNA detection

Agnes Purwidyantri
Telma Domingues, Andrey Ipatov, Catarina Abreu, Marco Martins, Jérôme Borme, Pedro Alpuim, Marta Prado
International Iberian Nanotechnology Laboratory (INL), Av. Mestre José Veiga, Braga 4715-330, Portugal
agnes.purwidyantri@inl.int

Miniaturized sensing system has been a spotlight in various detection schemes for a wide application owing to its portability, low-cost and rapid response. Especially in pandemic scenes, most of the attention from both government, researchers, and societies are focused on the rapid medical diagnosis. Little is addressed to the slow rippling effects of the outbreak on the food sector, such as in the limited food supply chain [1]. Besides the threat of food supply shortage, the risk of food fraud is potentially increased due to disrupted food material distribution. Therefore, less laborious and rapid food analysis protocol is urgently required to speed up not only the typically time-consuming “farm-to-fork” analytical process” [2] but also to control the good business practice for the food safety and security. In this study, a single layer graphene-based field-effect transistor (FET) chip integrated into a compact readout system is used to identify a unique DNA sequence from the wine of Douro protected Designation of Origin (PDO), one of the most important products in Portugal. Graphene has been highly noted for its paramount characteristics for ultrasensitive biomolecular detection due to its two dimensional (2D) with only 1-atom thick carbon structure [3]. The biorecognition process on the graphene FET channel in this work was performed through surface functionalization with a pyrene-based linker via π- π stacking interaction [4]. The process was followed by single-stranded DNA immobilization onto the interface and ethanolamine blocking of the unreactive sites of the linker. The introduction of the complementary single-stranded DNA allowed the hybridization to occur, leading to the shifting of the Dirac point (V_{Dirac}) of the graphene [5]. The chip with multi-arrayed sensors was integrated with a mini-output reader packed in a “business-card” size, practically linked and controlled from a computer. Before the detection of DNA, surface functionalization stages were tested with the integrated sensor and validated with Raman analysis. In the DNA hybridization study, the proposed system was able to perform a distinction of full complementary DNA and single nucleotide polymorphism (SNP) type DNA with a single mismatch, as shown by about 14% sensitivity difference tested from a considerably wide dynamic range. The overall results denote the potency of the proposed device for the wine authenticity checking in a rapid and portable fashion as well as multiplex detection by the multi-arrayed sensor configuration.

REFERENCES

[1] C. M. Galanakis, *Foods*, vol. 9, p. 523, 2020.
[2] J. Liu *et al.*, *PLoS One*, vol. 14, no. 5, pp. 1–18, 2019.
[3] A. Roberts *et al.*, *Sci. Rep.*, vol. 10, no. 1, pp. 1–12, 2020.
[4] R. Campos *et al.*, *ACS Sensors*, vol. 4, no. 2, pp. 286–293, 2019.
[5] M. T. Hwang *et al.*, *Nat. Commun.*, no. 11, p. 1543, 2020.

FIGURES

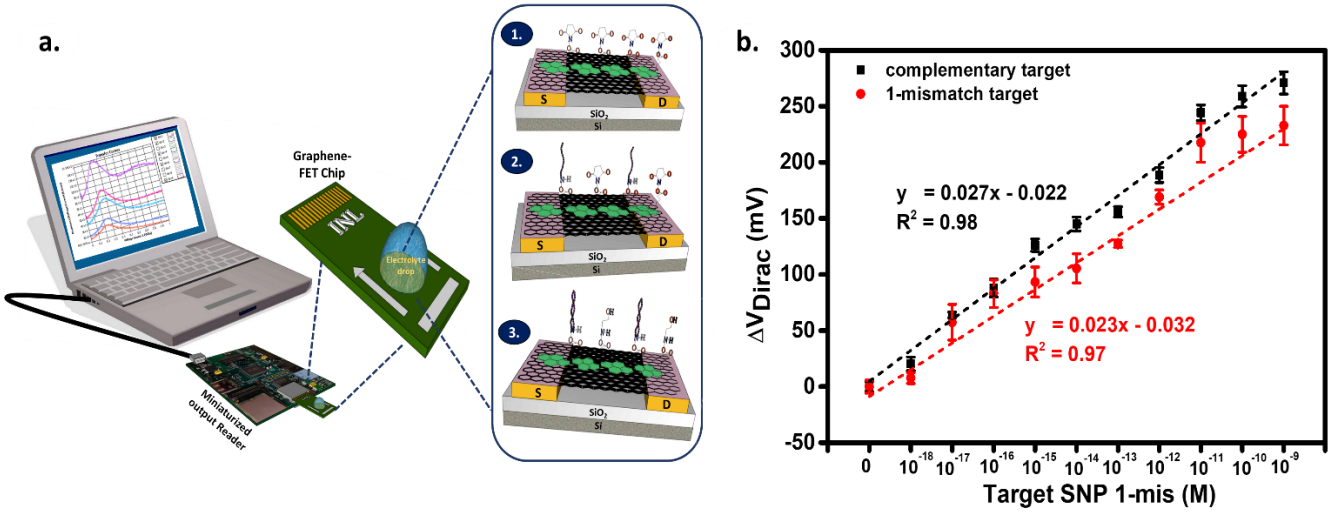

Figure 1: a. The proposed setup of the portable graphene FET sensor and surface functionalization for DNA hybridization study, b. The calibration plots from the measurement of wine DNA hybridization using complementary and single-mismatch DNA target.