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All-Ink Dopamine Sensors with Ultralow Detection Limit Enabled by One-Step Annealing of Graphene Ink

Existing analytical tools for detection of dopamine (an important neurotransmitter involved in motor function, neurological diseases, and blood pressure regulation) are expensive, bulky, or require highly-skilled personnel, making them challenging to scale to point-of-care (POC) settings.(1) Among various biosensing technologies, electrochemical devices are the leading technology in POC diagnostics owing to their simple operation, real-time readout, low cost, high sensitivity, and portability.(2-3) Being atomically thin and having high specific surface area, 2D materials are ideal for developing highly sensitive electrochemical sensors. Beyond enabling high sensitivity, analyte-specific biosensors can be developed by modifying physical, (opto)electronic, and electrochemical properties of the 2D layer via various physical and chemical modification approaches. In particular, graphene is an attractive sensing layer for dopamine detection due to their π-π interaction and favorable electrostatic interactions at physiological pH. However, the lowest reported detection limit solely based on graphene is limited to 1 nM. In this talk, I will present our recent work on developing an all-ink sensor on polyimide for electrochemical quantification of dopamine down to 5 pM, even in serum.(4) The record-low limit of detection is achieved through a one-step, low-temperature post-deposition annealing process to favorably tune the surface chemistry and surface interactions between the graphene ink layer and the dopamine molecule. Using X-ray photoelectron spectroscopy (XPS), Raman spectroscopy, Scanning Electrochemical Microscopy (SECM), and electrochemical analysis with specific control molecules, we studied the role of functional groups, defects, and anisotropy (edge vs. basal plane) on the sensor response.

References

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