Noncovalent Biofunctionalization of Graphene Field Effect Transistors: A Theoretical and Experimental Approach

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Abstract

In recent years, graphene-based platforms have focused on research for highly sensitive, fast, and label-free biosensing. Among the devices for biomolecular detection, one of the most promising Field-Effect Transistor (FET)-Based Biosensors is the electrolyte-gate FET (EGFET), which takes advantage of graphene's conductive properties for detecting molecular interactions and allows the device to operate at very low voltages, an advantage in preserving biomolecules' high-order structure [1, 2]. This study is a theoretical and experimental approach to the functionalization of an EGFET, using the 1-Pyrenebutyric Acid Succinimidyl Ester (PBSE) as a linker. The PBSE immobilization enables the bioreceptor-functionalization of graphene. In this study, an aptamer was selected from the literature for interaction with the oncoprotein Human Epidermal Growth Factor Receptor type 2 (HER2), aiming to develop a biosensing device for early HER2 breast cancer diagnosis. The functionalization steps followed the same procedures as those of other authors [3, 5], starting with an initial cleaning, followed by passivation of the gold contacts, functionalization with PBSE, biofunctionalization with the aptamer, and blocking of the unreacted sites. At the end of each step, the charge modulation was experimentally verified and is in agreement with the results found in the literature [3, 6], indicating the success of the device's construction and biofunctionalization. The experimental analyses were carried out by measuring the shift in the minimum conductance point of the EGFET transfer curve. In addition, the SIESTA software [6] was used to conduct a simulation based on density functional theory (DFT) to analyse the graphene-linker interaction. The experimental and theoretical results indicate that PBSE immobilization occurs through π-π type interactions, identifying a p-doping of graphene [4]. All of the steps for EGFET functionalization show charge modulation similar to the literature for EGFET aptasensors [3].

References

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