Study of the functionalization of graphene surfaces for biosensing applications

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Abstract

Graphene is a unique material where each carbon atom is part of the surface. Since its discovery we have witnessed staggering achievements in both fundamental and applied research on this 2D material, yet it still lacks the pervasiveness that its unique properties anticipated. The extreme sensitivity of graphene to charges and electric fields in its vicinity suggests the use of graphene for molecular detection. However, graphene high sensitivity and chemical stability comes at the cost of a poor analyte selectivity. Therefore, biosensing with graphene requires surface functionalization for specific analyte detection. To this end, a detailed study of the processes taking place on the surface is needed. The results of such a study can then be transferred to different graphene-based sensing platforms, which can be based on, e.g. electrolyte-gated field-effect transistors (EGFETs) [1] and electrochemical electrodes.

Nucleic acids allow the development of biosensors with high specificity and affinity and its electrochemical characterization is commonly performed taking advantage of the well-known and well-studied thiol-gold interaction [2,3]. In the present work, CVD graphene is used as an alternative substrate for biosensor development. The tethering of the nucleic acid is done via 1-Pyrenebutyric acid N-hydroxysuccinimide ester (PBSE) which irreversibly adsorbs to the substrate via π-staking forces [4]. This system requires studies to evaluate the fundamentals of electron transfer (ET) reactions proceeding in the electrode-tethered DNA for the design and development of advanced biosensor technologies.

In the case of thiol-Au it is known that both the surface density of nucleic acid [2] and the length of the alkanethiol [5] slow the rate of ET, which has influence on the applicability of the system as a biosensor. Here, we study two distinct situations; i) the influence of the surface coverage on the rate of ET of species adsorbed to the duplex and, ii) the rate of ET of methylene blue intercalated in the duplex and its sensitivity to single nucleotide polymorphism. This characterization will provide us information regarding the optimal parameters for future biosensor development.

References

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