Impact of the Fabrication Method of Graphene on the Electrochemical Performance in Sensing Applications

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Carbon-based electrodes are widely used in electrochemical sensors and have almost outperformed the traditional noble metal based electrodes. Especially graphene has become a promising electrode material due to its low cost, high chemical stability, the wide potential window, or the rich surface chemistry [1]. Various preparation methods for graphene have been developed yielding carbon materials of different physical and chemical properties. Structure, composition and morphology of the carbon nanomaterial strongly influence the electrochemical characteristics and therefore the sensor performance. Graphene, prepared by chemical exfoliation can be easily processed, yet bear a long purification procedure and contain a lot of structural defects. Mechanically exfoliation of graphite with a subsequent liquid cascade centrifugation step lead to carbon allotropes mostly free from defects with a precise flake size and number of layers. [2] Nevertheless, the colloidal stable graphene dispersion requires a complex transfer process. Graphene prepared by the three most prominent protocols (chemical vapour deposition (CVD), mechanical exfoliation (meG) and chemical exfoliation (rGO)) were benchmarked regarding their application as electrode material in electrochemical sensors. The influence of flake size distribution and number of defects was evaluated. Apart from fabrication and processing, detailed electrochemical characterization by cyclic voltammetry and electrochemical impedance spectroscopy using $K_3Fe(CN)_6$ as redox active species was performed. The graphene materials were compared to a commercially available screen-printed carbon electrode (SPC). A three times smaller peak separation for rGO compared to non-defective CVD and SPC was found. The charge transfer resistance of rGO and meG is three times higher compared to CVD. It became apparent, that highly defective graphene allotropes are favoured for electrochemical sensing applications, as they meet the requirements of a fast heterogeneous electron transfer and a low charge transfer resistance best.

References

[1] W. Zhang et al., Chem. Soc. Rev., 45 (2016), 715-752

[2] C. Backes et al., ACS Nano, 10 (2016) 1589-1601

Figures

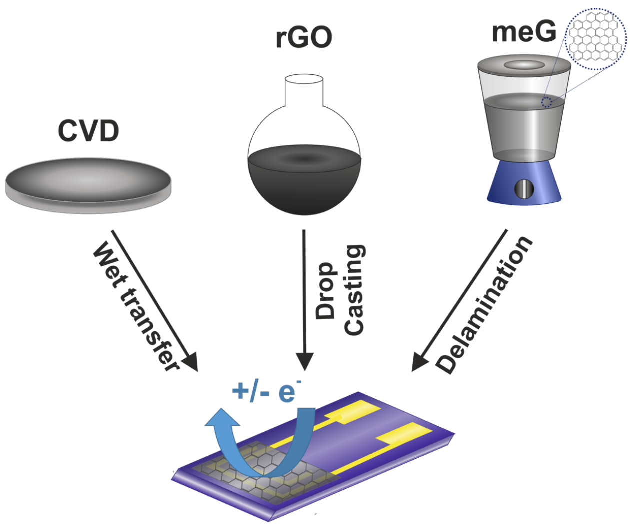

Figure 1: Scheme of the processing method of various graphene types for modifying interdigitated gold electrodes.