Comparison of Different Graphene Materials in Amperometric Sensors

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Abstract

Carbon nanomaterials, especially graphene has become in focus for amperometric chemical and biosensors. Advantages in contrast to classical amperometric sensors, consisting of conductive polymers and transition-metal-complexes as mediators, can be found in the excellent conductivity and the large surface-to-volume-area of the 2-D carbon nanomaterial. Lower detection limits, broader detection range as well as higher selectivity have been reported [1,2]. On the other hand, the electrochemical properties of the graphene depend a lot on the preparation method of this highly advanced material. The defect density has a considerable effect on the electronic properties of graphene, with a higher concentration of defects resulting in lower electrical conductivity [3]. Whereas graphene flakes obtained by the Scotch-tape method are nearly defect-free, graphene fabricated by chemical vapor deposition (CVD) contains structural defects, and chemically reduced graphene oxide consists of a highly disturbed sp^2 carbon lattice containing many functional groups. These three most popular preparation methods require varying amounts of effort, and result in materials differing in size, quality and uniformity of coverage. For an application as sensor material practical considerations such as differences in the ease of synthesis, transfer, and electrical contacting for the various types of graphene must be taken into account for future widespread industrial applications and mass production.

Here we have systematically evaluated and compared three differently prepared graphene materials using optical microscopy to study their varying morphology, Raman microscopy to obtain chemical and structural information, and electrochemical methods to characterize the electron transfer properties and the sensor behavior. We studied the ability to detect hydrogen peroxide of all three graphene types in comparison to classical graphite electrode (Fig. 1). The immobilization of enzymes to the graphene is discussed. In essence it turned out that for practical biosensor applications graphene obtained from CVD modified with an antidote lattice performed by plasma etching seems to be favorable.

References

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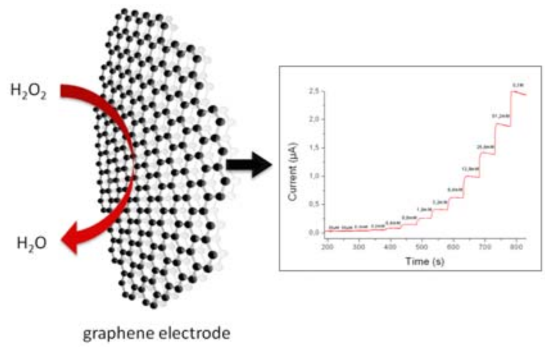
Figures

Figure 1:



Principle of an amperometric sensor based on graphene materials.