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Plasma-Functionalized CNT using Atmospheric Pressure Plasma Jet for the Development of CNT-based Amperometric Biosensor

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1. Introduction

Carbon nanotubes (CNTs) have many great interests for sensitive detection of biomolecules because of their high surface area, good electrical properties and high biomolecules recognition capability [1]. Successful realization of biosensors based on CNTs requires proper control of their functionalization and surface immobilization. Compared to the conventional chemical functionalization treatments, plasma treatments have the advantages, such as low temperature and little damaging effects [2]. Among the plasma treatments, atmospheric pressure plasma treatment has attracted many researchers. In this work, an atmospheric pressure plasma jet (APPJ) technique is developed to functionalize amino moieties on CNT microarray selectively. The design of the biosensor based on CNT, such as amperometric type biosensor was also studied. Biomolecules immobilization onto plasma-functionalized CNT was conducted by using biotin-avidin system and E. coli to assess the feasibility of CNT as a biosensor.

2. Experimental

The fabrication of CNT microarray type biosensor was performed by electron beam lithography for patterning microarray type biosensor and thermal plasma chemical vapor deposition method for growing the CNT. The fabrication method of CNT microarray has been reported in detail elsewhere [3]. An APPJ was utilized to functionalize amino groups onto CNT. Plasma discharge was produced in the glass tube under the high voltage square-wave pulses. To immobilize biomolecules selectively, we employed biotin-avidin system and antibody-antigen reaction of E. coli.

3. Results and Discussion

The mechanism of the surface functionalization and biomolecules immobilization of CNT is shown in Fig.1. The surface functionalization was carried out by applied two-stage plasma treatment: (1) pre-treatment by using He discharge gas with -500 V dc biasing and (2) post-treatment by using a mixture of helium and ammonia without bias. The Dangling bonds were created by ion bobmardment during pre-treatment process to ease amino group introduction onto CNT in the post-treatment [4]. The biomolecules immobilization was simulated by biotin-avidin and E. coli immobilization. The confirmation of the avidin-biotin and E. coli immobilization was evaluated by chemical derivatization with the fluorescent dye which can be visualized by fluorescent microscope.

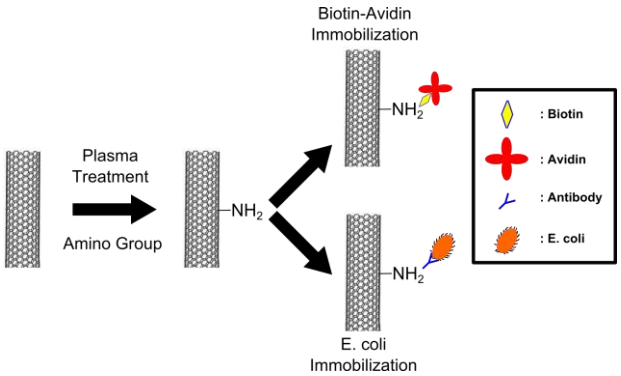

Fig.1. Mechanism of the biomolecules immobilization onto plasma-functionalized CNT.

4. Conclusion

We demonstrated functionalization of the CNT microarray by using an APPJ technique and studied the immobilization of biomolecules onto CNT. To immobilize biomolecules selectively, we employed biotin-avidin system and antibody-antigen reaction of E. coli. The successful functionalization using APPJ and simulating biomolecules immobilization onto CNT are valuable for development of amperometric biosensor.

References

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