Carbon Nanotube BIOSENSOR

CHEM 395
Bioanalytical Chemistry

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Carbon Nanotube BIOSENSOR

- Carbon Nanotubes... a brief introduction
- Types of CNTs
- Applications of CNTs
- Biosensors
- SWCNT biosensors
- Summary
- References
What are carbon nanotubes?

Carbon nanotubes are carbon cylinders made up of one or more rolled up graphene sheets, closed off at either end by half spheres in the shape of a soccer ball.
Salient features of CNTs

• 100 times stronger than Steel and 1/6\textsuperscript{th} the weight of steel. (Tensile strength value, 63 GPa, exceeds that of any reported value for any type of material. Applications for very light-weight, high-strength cables and composites, where the carbon nanotubes are the load-carrying element.)

• Electrical conductivity as high as copper, thermal conductivity as high as diamond.

• Average diameter of 1.2 – 1.4 nm (10000 times smaller than a human hair).
Types of Carbon nanotubes

Depending on the way the graphene sheet is rolled up
Synthesis of Carbon Nanotubes

- Arc Discharge
- Laser Ablation
- Chemical Vapor Deposition

Purification of Carbon Nanotubes

- Acid treatment
- SEC
- Annealing
Applications of Carbon Nanotubes

- Nanotubes can be opened and filled with materials such as biological molecules, raising the possibility of applications in biotechnology, like TDD.
Faster, Better, Cheaper
Space Transportation with Nanotubes

- Electronically operated Flight Surface (smart materials)
- Micro (Nano) Electrochemical Systems (MEMS or NEMS)
- Lithium batteries and fuel cells
- TPS elements
- Composite Aeroshell
- Digital Nanoelectronics (computers)
- H2 Storage
- Integrated Aerospike Engines
Application of CNTs in the FET devices
A biosensor is a bioanalytical device consisting of 2 components a bioreceptor and a transducer. The bioreceptor is a biomolecule that recognizes the target analyte whereas the transducer converts the recognition event into a measurable signal.
**BIOSENSOR**

- Selecting the suitable bioreceptor.
- Type of immobilization.
- Appropriate transducer element.

- Electrical contacting of redox enzymes with electrodes.
Functionalization of SWCNT

- SWCNTs are oxidised, which develop carboxylic ends.

- The carboxylic ends so formed are used for further functionalization with various biomolecules.

- Using carbodiimide coupling chemistry amine groups of biomolecules (like DNA, Proteins, Enzymes..) can be coupled to the carboxylic moieties of the CNTs.
Functionalization of SWCNT
SWCNT Glucose Biosensor

[Diagram of glucose biosensor with labeled components: glucose, gluconic acid, GOx, Fc, Fc⁺, electron transfer, and electrode.]
Comparative Faradic Responses

Faradic response of a GC macroelectrode before and after modification with SWCNTs.
SWCNT enzyme coated at the sidewalls

SWCNT enzyme coated at the endcaps
Summary

✓ Carbon nanotubes are rolled up graphene sheets.

✓ Biosensors are bioanalytical devices consisting of a bioreceptor and a transducer.

✓ CNT plays dual role in a biosensor both as immobilization matrices and as electron mediator.

✓ The high conductivity and high surface-area of CNTs make them a better material for bionanoelectroanalytical devices.
References


- "Peroxidase activity of enzymes bound to the ends of single-wall carbon nanotube forest electrodes" Xin Yu, Debjit Chattopadhyay, Izabela Galeska, Fotis Papadimitrakopoulos, and James F. Rusling.
