Review on Paper-"Detection of Breast Cancer 1 (BRCA1) Gene Using an Electrochemical DNA Biosensor Based on Immobilized ZnO Nanowires"

Student Anushkaa Ambuj
Roll No. B21ES006

This article explores the development of an electrochemical DNA biosensor that employs zinc oxide (ZnO) nanowires for the detection of the BRCA1 gene, a critical biomarker for breast cancer.

Working Principle

The working principle of the electrochemical DNA biosensor utilizing immobilized ZnO nanowires (ZnONWs) for the detection of the BRCA1 gene can be explained in a detailed, step-wise manner as follows:

1. Preparation of the Electrode:

- A gold electrode is selected as the substrate due to its excellent conductivity and biocompatibility.
- ZnO nanowires are chemically synthesized and immobilized onto the surface of the gold electrode using a hydrothermal technique. This creates a nanostructured surface that enhances the electrode's properties.

2. Utilization of ZnO Nanowires:

- Field Emission Scanning Electron Microscopy (FESEM) is used to confirm the uniformity, density, and perpendicular orientation to the substrate of ZnO nanowires.
- The nanowires provide a high surface area compared to flat electrodes, which is crucial for the immobilization of DNA probes.
- ZnO is known for its biocompatibility and chemical stability.
- Multiplexing Capability: The use of nanowires can potentially allow for the development of multiplexed biosensors, enabling the simultaneous detection of multiple genetic markers associated with breast cancer.

3. Immobilization of DNA Probes:

- Single-stranded oligonucleotide DNA (ssDNA) probes specific to the BRCA1 gene are chemisorbed onto the surface of the ZnONWs/Au electrode.
- The immobilization process ensures that the DNA probes remain stable and accessible for hybridization with target DNA.

4. Hybridization Process:

- When a complementary target DNA sequence (specific to the BRCA1 gene) is introduced to the biosensor, it hybridizes with the immobilized DNA probes.
- This hybridization event is a critical recognition step, as it forms a stable double-stranded DNA complex.

5. Electrochemical Detection:

- The hybridization event is monitored using Differential Pulse Voltammetry (DPV), an electrochemical technique that measures the current response at specific potentials.
- Upon hybridization, an oxidation signal is generated, typically observed at around $+0.8$ V. This signal corresponds to the presence of the target DNA.

6. Signal Amplification:

- The unique properties of the ZnO nanowires facilitate fast electron transfer and enhance the electrochemical signal, leading to improved sensitivity of the biosensor.
- The high surface area of the nanowires allows for a greater number of hybridization events, further amplifying the signal.

7. Optimization of Conditions:

- The pH of the buffer solution is optimized (pH 7 in this case) to ensure maximum efficiency of the hybridization and detection processes.
- The concentration of the target DNA is varied to establish a linear response range, which is crucial for quantitative analysis.

Analyte

The primary analyte is the BRCA1 gene sequence present in the breast cell/tissue sample.

Linkers/Capture Probes Used

Specific oligonucleotide DNA probes are utilized as capture probes, designed to hybridize with the target BRCA1 sequence.

- Probe DNA: 5' AAT GGA TTT ATC TGC TCT TCG 3'
- Target DNA: 5' CGA AGA GCA GAT AAA TCC ATT 3'
- Three-base mismatch: 5' CGA AGA GGA GAA AAA TCG ATT 3';
  5' CAA AGA GCA GAT AGA TCC GTT 3'

Immobilising Method

Immobilized onto zinc oxide nanowires (ZnONWs) chemically synthesized onto gold electrode via hydrothermal technique.

Sensitivity

The biosensor demonstrates a high sensitivity, allowing for the effective identification of low concentrations of the target DNA. It can detect the target sequence in the range of concentration between 10.0 and 100.0 μM with a detection limit of 3.32 μM

Citations

Top 3 citations from 25 mentioned in the paper are:

[1] Li, T., Fan, Q., Liu, T., Zhu, X., Zhao, J. and Li, G. (2010) Detection of Breast Cancer Cells Specially and Accurately by an Electrochemical Method. Biosensors and Bioelectronics, 25, 2686-2689. http://dx.doi.org/10.1016/j.bios.2010.05.004

[2] Dolatabadi, J.E.N., Mashinchian, O., Ayoubi, B., Jamali, A.A., Mobed, A., Losic, D., et al. (2011) Optical and Electrochemical DNA Nanobiosensors. TrAC Trends in Analytical Chemistry, 30, 459-472. http://dx.doi.org/10.1016/j.trac.2010.11.010

[3] Antoniou, A., Pharoah, P.D.P., Narod, S., Risch, H.A., Eyfjord, J.E., Hopper, J.L., et al., (2003) Average Risks of Breast and Ovarian Cancer Associated with BRCA1 or BRCA2 Mutations Detected in Case Series Unselected for Family History: A Combined Analysis of 22 Studies. The American Journal of Human Genetics, 72, 1117-1130. http://dx.doi.org/10.1086/375033