DNA detection by photoelectric spectral response at dye-sensitized mesoporous electrode

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Introduction

Detection of DNA hybridization by gene sensors has been recently extensively studied by electrochemical methods for low-cost and convenient alternative to conventional laser-excited fluorescence detection methods. Previous electrochemical methods are mostly based on measurement of redox reactions of species at the electrode-electrolyte interface where immobilized DNA affects the redox activity. We have developed a new method to detect the occurrence of hybridization in the form of action spectrum of photo-induced current (dye-sensitized current) by which the bonding of a complementary DNA can be identified.

Experimental results and discussion

The electrode for DNA detection was composed of a transparent conductive glass (F-doped SnO_2 glass) coated with a thin mesoporous TiO_2 layer (2 μm thick) of large surface area (roughness factor >2000). A single strand DNA, 25mer (cgcaagcttatttcaatgggactgc, supplied from Appl. BioSystems) with its 5' terminal labeled with VIC (green absorbing dye), as a probe DNA, was dissolved at various concentrations in Tris-EDTA HCl solution. The electrode was dipped in the DNA solution at 4℃ overnight to allow chemical adsorption of DNA on the mesoporous surface *via* phosphate group. After washing, DNA-adsorbed electrode was made into junction with iodide-containing electrolyte solution and counter-electrode to construct a sandwich-type cell. The cell was subjected to IPCE (incident photon to current conversion efficiency) action spectrum measurement under amplification of photoelectric signals. Figure 1 displays action spectra of sensitized photocurrents obtained with VIC-labeled DNA adsorbed on electrode for various concentrations of DNA. Action spectra peaked at 540 nm, following the maximum optical absorption of VIC. It was found that VIC-DNA can be detected in a minimum concentration range of 0.3-0.8 μM. A VIC-labeled double-strand DNA was also examined and showed a lowest concentration of detection to be around 0.8-1.0 μM.

For practical application of our method to DNA hybridization detection, target single-strand DNA is primarily adsorbed on the mesoporous surface. Dye (VIC)-labeled DNA, as a probe DNA, is hybridized to the target DNA adsorbed on the surface to generate sensitized photocurrent, the action spectrum of which matching the dye's characteristic absorption indicates detection of hybridization. This process is illustrated in Fig. 2. To enhance the sensitivity of detection, various kinds of sensitizing dyes for labeling of DNA are under investigation.

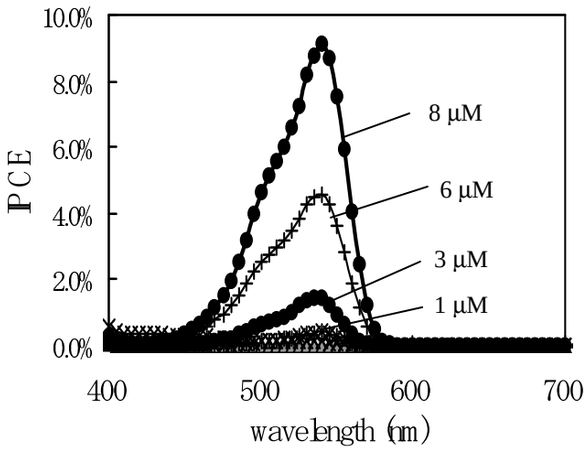

Figure 1 Action spectra of photocurrents, as the sign of DNA detection, measured for various concentrations of VIC-labeled DNA

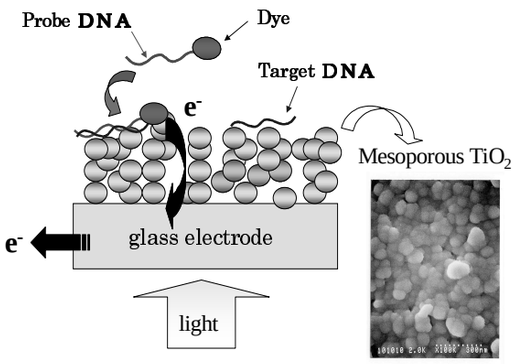

Figure 2 Schematic illustration for detection of a hybridized double-strand DNA on the mesoporous electrode.