Abstract

A novel programmable biosensor system using solid phase probe synthesis (SPPS) for on-site and on-demand detection was developed. This programmable biosensor system is capable of changing the target molecule on-site and on-demand by changing the sequence of probe molecule on the chip. Probe sequence, on the chip can be changed by synthesizing the different sequence. On-chip synthesis of probe molecule is expected to avoid the problem of conventional biosensor system like flexible changing of target molecule, the immobilization method for probe attachment and stability of attached probe molecule. Hence a programmable biosensor system using SPPS on microchip was proposed.

In the first step, to demonstrate the concept of programmable biosensor system, a new design of PDMS chip for on-chip probe synthesis with optical detection using fluorescent labeling method was developed. Oligopeptides, utilized as probes for the biosensor, were synthesized by the on-chip SPPS on a single bead trapped at the center of a micro channel. After the completion of probe synthesis, a sample solution containing target was exposed to the beads. The binding and the selectivity of on-chip synthesized probe was confirmed with different target biomolecule.

In the next step, a label free electrochemical programmable biosensor for heavy metal ion detection was developed. A new design of electrochemical chip having three electrodes system, made of gold was developed. Metal ion selective peptide probe sequence was synthesized on the chemically modified gold working electrode surface using PDMS microfluidic chip for the first time. After probe synthesis, working electrode was preconcentrated by copper ion solution, and copper ion was detected in micromolar range using differential pulse voltammetry (DPV) analysis. Other heavy metal ions can also be detected by synthesizing the metal ion specific probe on gold surface. Further, a label free electrochemical programmable biosensor for DNA hybridization detection was developed. Oligonucleotide as a probe sequence was used for DNA hybridization. The oligonucleotide sequence was synthesized on chemically modified gold working electrode, using PDMS chip via novel deprotecting reagent. New deprotecting reagent enables the synthesis of oligonucleotide on PDMS chip. Using as grown oligonucleotide probe, label free detection of DNA hybridization for on-site and on-demand sequence was achieved by electrochemical impedance spectroscopy (EIS) technique.

Hence, step by step progress confirmed the development of programmable biosensor using on-chip solid phase probe synthesis for on-site and on-demand detection of biomolecules, heavy metal ion, DNA hybridization and other malfunctions. This programmable biosensor system flexibly changes the target molecule by synthesizing the target selective probe sequence on the chip.

Keywords: Programmable biosensor, On-chip solid-phase probe synthesis, Biosensor, Single bead, Electrochemical detection, Heavy metal detection, DNA hybridization