DEVELOPMENT OF FUNCTIONAL XOR DNA-BASED LOGIC GATE IN ENZYME-FREE BIOLOGICAL CIRCUIT

PEERAPAT INTALUCK 4801130 SCBT/D

Ph.D. (BIOTECHNOLOGY)

THESIS ADVISORY COMMITTEE: PRASIT PALITTAPONGARNPIM, MD., WATANALAI PANBANGRED, Dr.Eng, BOONSIT YIMWADSANA, Ph.D., RADEEKORN AKKARAWONGSAPAT, Ph.D.

ABSTRACT

DNA computing is an emerging field in nanotechnology with the purpose of using DNA molecules to execute the computing processes as in conventional computer. Development of DNA computing shows the capability of DNA molecules for solving some kinds of mathematical problems; however, the universality for other kinds of problems is lacking. This thesis reports the development of signal synchronization system or "separator system" by utilizing the hairpin structure of DNA molecule in order to control the state of the input strand signal to be ON or OFF in enzyme-free condition. Two aspects of the separator system were analyzed: data leakage and activation level via separator strand. By optimizing lengths of various parts in the separator system (i.e. stem region, loop region, separator strand, and related downstream logic gate structure for cascading circuit application), we show that the length of 14 bases of the stem region is optimal for signal activation and data leakage prevention. The results also show an increase of activation level when a 4-extra-base-extended separator strand was applied to the hairpin structure with more than 14 bases the in loop region.

We also develop an XOR DNA-based logic gate, which is able to execute computing process correctly with cascading circuit design in an enzyme-free condition. According to our design, the optimization experiments suggest an extra seven bases as clamps for $X_{in}Y_{in}$ complex in order to prevent cross-activation reaction with the XOR logic gate up to 92.9%. Furthermore, full-adder DNA-based logic gate development for enzyme-free system is reported in this thesis. We introduce two methods for the full-adder system: 3-way-junction structure and non-assembly system. The results show the possibility of the non-assembly system to execute 1-bit full-adder operation and also suggest the possibility of multiple-bit circuit construction with the non-assembly system.

KEY WORDS: DNA COMPUTING / ENZYME-FREE CASCADING CIRCUIT / DNA SYNCHRONIZATION / XOR DNA-BASED LOGIC GATE / DNA-BASED FULL ADDER

105 pages