Photo-regulated DNA memory gate system using DNA photo-cross-linker

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Nucleic acid, as a highly programmable biological material, has been widely used in biochemical engineering. Most of the nano-scale information processing devices using DNA, such as DNA computers, logic gates and biochemical circuits, achieve their function by using enzyme or DNA strand displacement reaction. In this study, a photo-regulated memory gate transition system using DNA photo-cross-linker 3-Cyanovinylcarbazole nucleoside (^{CNV}K) was presented.

The memory gate is composed of a hairpin DNA and two orthonormal linear DNA strands (input strands). Input strands are complementary to different parts of the memory gate, hairpin gate results in different structure with different input order. When the input strand 1 was added in the gate first, it opens the hairpin structure by binding to its, and the input strand 2 added later binds to the loop area. But with the reverse order, input strand 2 added first binds to the hairpin loop, forming a more stable structure that inhibits input 1 to bind with the hairpin. The input order can be obtained by visualizing the final structure of the DNA hairpin gate.

The gate transition is functioned by toehold-mediated strand displacement reaction, which operates at the very slow rate. Here we introduced the ultrafast photo-cross-linker ^{CNV}K into input strands to accelerate the process. ^{CNV}K can cross-link to pyrimidine bases in complementary strand within 1 s under 366 nm photo irradiation. And DNA strand having ^{CNV}K exhibits high capability of invading double-duplex DNAs. Moreover, the strand displacement ratio can be regulated by controlling the photoirradiation energy or changing the insert position of ^{CNV}K.

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