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Investigation of the optimal arrangement of state sequences for efficient operation of a DNA state machine

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Whiplash PCR (WPCR) is a unique reaction system, which implements successive state transitions according to a computational program encoded by each DNA molecule, in the form of pairs of state sequences and intervening stopper sequences [1]. By iterating hairpin structure formation and DNA polymerase extension, WPCR allows the program-parallel computation to perform various types of information processing, including solution to a graph problem [2]. However, WPCR requires very high temperature conditions due to its characteristic reaction design utilizing the sub-stable hairpin formation. We formerly revealed that the competitive formation of the sub-stable hairpin structure as the target structure leads to the requirement of high temperature conditions [3, 4]. In this work, we investigated the effect of changing the arrangement and length of state sequences on the efficiency of the target hairpin structure formation. The present results would help to improve the design of WPCR, by reducing the problematic thermophilic property of the DNA state machine with the aid of statistical thermodynamic model simulation. In addition, we report a preliminary investigation of the proposed design via a biochemical experiment.

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