# Acceleration of DNA strand exchange reaction by cationic comb-type copolymers

**Naohiko Shimada**[1]
nshimada@bio.titech.ac.jp

**Wei Song**[2]
songwei@ms.ifoc.kyushu-u.ac.jp

**Atsushi Maruyama**[1]
amaruyama@bio.titech.ac.jp

[1] School and Graduate School of Bioscience and Biotechnology, Tokyo Institute of Technology, 4259 Nagatsuta-cho, Midori-ku, Yokohama-shi, Kanagawa Pref. 226-8501, Japan
[2] Departments in Graduate School of Engineering, Kyushu University,744, Motooka, Nishi-ku, Fukuoka, 819-0395, Japan

**Keywords**: molecular robotics, cationic polymers, DNA strand exchange reaction

DNA strand exchange reaction (SER) between double-stranded DNA(dsDNA) and its complementary single-stranded DNA(ssDNA) is a key reaction in biotechnological applications(1) There are many reports describing DNA nanomachines triggered by the SER. Highly programed SER has been exploited to build DNA logic gate (2). In these application, the dsDNAs generally have sticky end as known as toehold in order to control rate of the SER because of very slow rate of SER between dsDNA having blunt end and ssDNA. In nature, recombination proteins promote the SER even in DNA having blunt end. However, the applications of the proteins to DNA biotechnology based on the SER are limited by the instability and resource ineffectiveness of the proteins. An artificial agent showing the activity of the proteins has been desired for the application of the DNA biotechnology including molecular robotics.

We have previously demonstrated that cationic comb type copolymers consisting of polycation backbone and abundant hydrophilic graft chain influence kinetics and thermodynamics of nucleic acid hybrid under physiologically relevant condition. For example, poly(L-lysine)-*graft*-dextran (PLL-*g*-Dex) copolymer significantly accelerates DNA hybridization over 200-folds(3). Moreover, the copolymer markedly accelerated the SER by 4-5 orders of magnitude (4), while stabilizing dsDNA DNA (5). However, the stabilization of dsDNA is considered to be principally unfavorable for acceleration of the SER, because partial dissociation of dsDNA is required for an initial step of SER. In this study, we focused on urea which is a well-known destabilizing agent for dsDNA, we prepared cationic comb type copolymers partially modified with urea (ureido) groups, poly(allylamine-*co*-allylurea)-*graft*-dextran. The copolymers showed higher acceleration effect of SER than unmodified copolymer.

[1]Zhang, D.Y. and Seelig, G. (2011) Dynamic DNA nanotechnology using strand-displacement reactions. *Nat Chem*, **3**, 103-113.
[2]Qian, L. and Winfree, E. (2011) Scaling Up Digital Circuit Computation with DNA Strand Displacement Cascades. *Science*, **332**, 1196-1201.
[3]Wu, L., Shimada, N., Kano, A. and Maruyama, A. (2008) Poly(l-lysine)-graft-dextran copolymer accelerates DNA hybridization by two orders. *Soft Matter.*, **4**, 744-747.
[4]Kim, W.J., Akaike, T. and Maruyama, A. (2002) DNA Strand Exchange Stimulated by Spontaneous Complex Formation with Cationic Comb-Type Copolymer. *Journal of the American Chemical Society*, **124**, 12676-12677.
[5]Maruyama, A., Katoh, M., Ishihara, T. and Akaike, T. (1997) Comb-Type Polycations Effectively Stabilize DNA Triplex. *Bioconjugate Chemistry*, **8**, 3-6.