Single-particle tracking, kinetic simulation, and rational engineering of high performance artificial molecular motors

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ABSTRACT

Engineering artificial molecular motors which show high performance comparable to motor proteins is an important challenge for their applications. DNA is not only a fundamental molecule of living organisms but also a versatile building block used to engineer a variety of artificial molecular motors. DNA-gold nanoparticle (DNA-AuNP) motor is one of the fastest nanoscale artificial motors ever reported. DNA-AuNP motor operates as a burnt-bridge Brownian ratchet driven by RNA hydrolysis catalyzed by RNase H, and shows super-diffusion on RNA-modified 2D surface. However, its speed was 2~3 nm/s, still much lower than those of motor proteins. We recently resolved elementary processes of motion (pauses and steps) of the DNA-AuNP motor using high-speed/high-precision single-particle tracking. Furthermore, we developed a geometry-based kinetic simulation and revealed elementary chemical reaction processes that cause pauses, steps, and bottlenecks in motion. Then, we rationally engineered DNA-AuNP motor which shows high speed (30 nm/s) and long run-length (3 μm) simultaneously, performance comparable to a motor protein processive chitinase. Here we discuss the results above and our efforts to achieve perfect unidirectionality in motion with a DNA-gold nanorod motor and an RNA-modified 1D DNA nanotube rail, and to estimate force and efficiency of these artificial molecular motors.

REFERENCES

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KEYWORDS

Molecular motors, Brownian ratchet, Optical microscopy, DNA nanotechnology

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