A synthetic DNA motor that transports nanoparticles along carbon nanotubes

Tae-Gon Cha[1], Jing Pan[1], Haorong Chen[1], Janette Salgado[1], Xiang Li[2], Chengde Mao[2] and Jong Hyun Choi[1]*

Intracellular protein motors have evolved to perform speci“c tasks critical to the function of cells such as intracellular traf-“cking and cell division[1,2]. Kinesin and dynein motors, for example, transport cargoes in living cells by walking along microtubules powered by adenosine triphosphate hydrolysis[3,4]. These motors can make discrete 8 nm centre-of-mass steps and can travel over 1 mm by changing their conformations during the course of adenosine triphosphate binding, hydrolysis and product release[5,6]. Inspired by such biological machines, synthetic analogues have been developed

32.32901.k-0.36565(and 291.)218.4e68.4(mak)1141.4(d32905p4118.8[ST BT) 7 -412(mo)35.7(v)30.6(ements)] TJ ET BT 1.1339 TL 9.2999 0 0 9.29

every few hours) to allow it to travel suf“ciently long distances,

To understand how environmental factors affect motor operation, we measured the distance travelled by the molecular motor while varying the conditions, including concentration, type of metal cation, buffer temperature and pH. In Fig. 3a, the molecular motor movement is examined as a function of Mg ion concentration in TAE buffer at 22°C and pH 8.0. Given the processive walking, the

A simple kinetic model was developed within the framework of single-molecule kinetics to quantitatively understand the single turnover reaction from states (i) to (v) in Fig. 1b. A set of concentration-based rate equations describing the series of DNA conformation change reactions were converted into probability-based rate equations[29], which were numerically solved to predict the rates for each reaction step as well as the single turnover event (see Supplementary Section •Kinetic model•). Figure 4 shows the experimental and theoretical translocation kinetics of the motor as functions of cationic type and concentration. Two divalent cations

12. Wickham, S. F. J. et al. Direct observation of stepwise movement of a synthetic molecular transporter. Nature Nanotech. **6,** 166…169 (2011).
13. Gu, H. Z., Chao, J., Xiao, S. J. & Seeman, N. C. A proximity-based programmable DNA nanoscale assembly line. Nature **465,** 202…205 (2010).
14. Santoro, S. W. & Joyce, G. F. A general purpose RNA-cleaving DNA enzyme. Proc. Natl Acad. Sci. USA **94,** 4262…4266 (1997).
15. Santoro, S. W. & Joyce, G. F. Mechanism and utility of an RNA-cleaving DNA enzyme. Biochemistry **37,** 13330…13342 (1998).
16. Tian, Y., He, Y., Chen, Y., Yin, P. & Mao, C. D. Molecular devices„a DNAzyme that walks processively and autonomously along a one-dimensional track. Angew. Chem. Int. Ed. **44,** 4355…4358 (2005).
17. Zhang, D. Y. & Seelig, G. Dynamic DNA nanotechnology using strand-displacement reactions. Nature Chem. **3,** 103…113 (2011).
18. Block, S. M. Kinesin motor mechanics: binding, stepping, tracking, gating, and limping. Biophys. J. **92,** 2986…2995 (2007).