

研究论文

DNA拓扑异构酶II的多态转换模型

丁辉, 林昊, 冯娟

电子科技大学生命科学与技术学院, 神经信息教育部重点实验室, 成都 610054

摘要:

DNA拓扑异构酶II是一种分子马达, 它利用ATP水解产生的化学能, 切断一条双链DNA片段(G segment), 并让另一条双链DNA片段(T segment)从缺口处通过。对DNA拓扑异构酶II的工作循环研究将有助于阐明其工作机制。本文根据已有实验资料, 利用主方程方法构建了DNA拓扑异构酶II状态转变的随机跃迁模型, 求得系统各态的稳态解。进而推导出稳态下无机磷(Pi)浓度随时间的变化, 得到DNA拓扑异构酶II的最小工作周期约为0.78秒, 该结果同实验获得的DNA拓扑异构酶II工作周期为0.5~1秒一致。该模型定量地分析了DNA拓扑异构酶II的动力学行为。

关键词: DNA拓扑异构酶II 主方程 稳态 无机磷

A Multi-States Model for DNA Topoisomerase II Cycle

DING Hui, LIN Hao, FENG Juan

Key Laboratory for NeuroInformation of Ministry of Education, School of Life Science and Technology, University of Electronic Science and Technology of China, Chengdu 610054, China

Abstract:

DNA topoisomerase II is a molecular motor that couples ATP hydrolysis to the transport of one DNA segment (T segment) through a transient break in another segment (G segment). The study of DNA topoisomerase II cycle is useful in elucidating the mechanism of DNA topoisomerase II work. Based on experiments, a master equation approach is used to model multi-states change of DNA topoisomerase II cycle. The non-equilibrium steady state solution describes the probability distribution of each state as a function of concentration of ATP. Moreover, the concentration of inorganic phosphate Pi as a function of time t and ATP concentration under steady state is obtained. By calculating the released velocity of Pi, we deduce that the minimized cycle of DNA topoisomerase II is 0.78 second. This result is consistent with the cycle of DNA topoisomerase II derived from experiments, which are in the range of 0.5~1 second. The conclusions demonstrate that the proposed model can qualitatively explain experiment results rather being satisfactory.

Keywords: DNA topoisomerase II Master equation Steady state Inorganic phosphate

收稿日期 2010-03-07 修回日期 2010-05-11 网络版发布日期

DOI:

基金项目:

国家自然科学基金项目(11047180, 20973034), 电子科技大学启动基金

通讯作者: 丁辉, 电话: (028)83208232, E-mail: hding@uestc.edu.cn

作者简介:

作者Email: hding@uestc.edu.cn

参考文献:

1. Collins TR, Hammes GG, Hsieh TS. Analysis of the eukaryotic topoisomerase II DNA gate: A single-molecule FRET and structural perspective. *Nucleic Acids Res*, 2009, 37(3): 712~720
2. Bates AD, Maxwell A. Energy coupling in type II topoisomerases: why do they hydrolyze ATP? *Biochemistry*, 2007, 46(27): 7929~7941
3. Miller KG, Liu LF, Englund PT. A homogeneous type II DNA topoisomerase from HeLa cell nuclei. *J Biol Chem*, 1981, 256(17): 9334~9339

扩展功能

本文信息

- ▶ Supporting info
- ▶ PDF(538KB)
- ▶ [HTML全文]
- ▶ 参考文献[PDF]
- ▶ 参考文献

服务与反馈

- ▶ 把本文推荐给朋友
- ▶ 加入我的书架
- ▶ 加入引用管理器
- ▶ 引用本文
- ▶ Email Alert
- ▶ 文章反馈
- ▶ 浏览反馈信息

本文关键词相关文章

- ▶ DNA拓扑异构酶II
- ▶ 主方程
- ▶ 稳态
- ▶ 无机磷

本文作者相关文章

- ▶ 丁辉
- ▶ 林昊
- ▶ 冯娟

PubMed

- ▶ Article by Ding, H.
- ▶ Article by Lin, H.
- ▶ Article by Feng, J.

4. Osheroff N, Shelton ER, Brutlag DL. DNA Relaxation of supercoiled DNA. *J Biol Chem*, 1983, 258(15): 9536~9543
5. Lindsley JE, Wang JC. On the coupling between ATP usage and DNA transport by yeast DNA topoisomerase II. *J Biol Chem*, 1993, 268(11): 8096~8104
6. Baird CL, Harkins TT, Morris SK, Lindsley JE. Topoisomerase II drives DNA transport by hydrolyzing one ATP. *Proc Natl Acad Sci USA*, 1999, 96(24): 13685~13690
7. Morris SK, Baird CL, Lindsley JE. Steady-state and rapid kinetic analysis of topoisomerase II trapped as the closed-clamp intermediate by ICRF-193. *J Biol Chem*, 2000, 275(4): 2613~2618
8. Campbell S, Maxwell A. The ATP-operated clamp of human DNA topoisomerase II alpha: hyperstimulation of ATPase by "piggy-back" binding. *J Mol Biol*, 2002, 320(2): 171~188
9. Harkins TT, Lindsley JE. Pre-steady-state analysis of ATP hydrolysis by *Saccharomyces cerevisiae* DNA topoisomerase II. 1. A DNA-dependent burst in ATP hydrolysis. *Biochemistry*, 1998, 37(20): 7292~7298
10. Harkins TT, Lewis TJ, Lindsley JE. Pre-steady-state analysis of ATP hydrolysis by *Saccharomyces cerevisiae* DNA topoisomerase II. 2. Kinetic mechanism for the sequential hydrolysis of two ATP. *Biochemistry*, 1998, 37(20): 7299~7312
11. Guo WS, Luo LF, Li QZ. A chemical kinetic theory on muscle contraction and spontaneous oscillation. *Chem Phys Lett*, 2002, 363(5-6): 471~478
12. 韩英荣, 赵同军, 展永, 吴建海. 分子马达定向运动的两态模型. *生物物理学报*, 2004, 2(3): 239~244
- Han Y, Zhao T, Zhan Y, Wu J. Two-state model for directed motion of Brownian motor. *Acta Biophys Sin*, 2004, 2(3): 239~244
13. Fan D, Zheng W, Hou R, Li F, Wang Z. Modeling motility of the kinesin dimer from molecular properties of individual monomers. *Biochemistry*, 2008, 47(16): 4733~4742
14. Xie P, Dou SX, Wang PY. Model for kinetics of myosin-V molecular motors. *Biophys Chem*, 2006, 120(3): 225~236
15. Xie P. Dynamics of strand passage catalyzed by topoisomerase II. *Eur Biophys J*, 2010, DOI 10.1007/s00249-010-0578-y
16. Adachi N, Miyaike M, Kato S, Kanamaru R, Koyama H, Kikuchi A. Cellular distribution of mammalian DNA topoisomerase II is determined by its catalytically dispensable C-terminal domain. *Nucleic Acids Res*, 1997, 25(15): 3135~3142
17. Mueller-Planitz F, Herschlag D. Coupling between ATP binding and DNA cleavage by DNA topoisomerase II: A unifying kinetic and structural mechanism. *J Biol Chem*, 2008, 283(25): 17463~17476
18. Baird CL, Gordon MS, Andrenyak DM, Marecek JF, Lindsley JE. The ATPase reaction cycle of yeast DNA topoisomerase II. Slow rates of ATP resynthesis and P(i) release. *J Biol Chem*, 2001, 276(30): 27893~27898
19. 展永, 吴魏霞, 赵同军, 关荣华, 梅俊平. 分子马达不等间距四态跃迁模型. *生物化学与生物物理进展*, 2003, 30(3): 416~421
- Zhan Y, Wu WX, Zhao TJ, Guan RH, Mei JP. A stochastically unequal interval four-state hopping model of molecular motor. *Prog Biochem Biophys*, 2003, 30(3): 416~421
20. 冯娟, 卓益忠. 应用主方程方法研究分子马达的定向运动. *生物物理学报*, 2002, 18(4): 418~428
- Feng J, Zhuo Y. Master equation approach to molecular motor's directed motion. *Acta Biophys Sin*, 2002, 18(4): 418~428
21. Smiley RD, Collins TR, Hammes GG, Hsieh TS. Single-molecule measurements of the opening and closing of the DNA gate by eukaryotic topoisomerase II. *Proc Natl Acad Sci USA*, 2007, 104(12): 4840~4845

本刊中的类似文章

1. 苗志奇, 未作君, 元英进. 紫杉醇合成中甲基茉莉酮酸作用位点与配伍特性研究[J]. *生物物理学报*, 2000, 16(2): 204-212
2. 张建平, 谢洁, 赵井泉, 彭程航, 郑锡光, 赵福利, 张景民, 汪河洲. 多管藻中R-藻蓝蛋白能量传递途径及动力学[J]. *生物物理学报*, 2001, 17(4): 767-772
3. 王向群, 赵同军, 宋杨, 展永. 钾离子通道两态跳跃的通透机制[J]. *生物物理学报*, 2005, 21(4): 289-294
4. 王书敏, 于鹏, 段相林, 常彦忠. 膜铁转运蛋白1, 铁调素的靶分子? [J]. *生物物理学报*, 2006, 22(1): 12-18
5. 吴正华, 尧德中. 用稳态视觉诱发电位研究注意的选择机制[J]. *生物物理学报*, 2006, 22(6): 455-460
6. 鲁保云, 岳红. 系统方法分析NF-kB信号转导网络产生持续振荡的条件[J]. *生物物理学报*, 2010, 26(5): 406-420

文章评论

反 馈 人	<input type="text"/>	邮 箱 地 址	<input type="text"/>
-------------	----------------------	------------------	----------------------

反
馈
标
题

验证码

2875

Copyright by 生物物理学报