# Electron transfer in 12-mer double-stranded DNA by muon spectroscopy and scanning tunneling microscopy

H. Rozak,[*1,*2] S. Sulaiman,[*2] W. N. Zaharim,[*2] N. E. Ismail,[*2] S. N. Abu Bakar,[*2] M. R. Samian,[*4] I. Miyazaki,[*3] K. Ichimura,[*3] and I. Watanabe[*1,*2,*3]

Electron transport through DNA plays a pivotal role in biological systems. Processes that use electron transfer include scanning the damaged sites in DNA and DNA repair.[1,2] To understand these biological phenomena, it is necessary to investigate the electron transfer process in normal and damaged DNA at the microscopic level. The main questions of this study are: what is the difference in the characteristics of electron transfer between normal and damaged DNA, and how much the difference in the quantitative value for electron diffusion along the normal and damaged DNA helix.

In order to answer those questions, muon spin relaxation ($\mu$SR) measurements were performed at the Argus spectrometer RIKEN RAL. This $\mu$SR technique has been suggested as a good probe to study the motion of electron transfer in DNA because the muon spin relaxation could characterize or model the diffusion of electrons along the DNA helix via hyperfine interaction without producing any radiation effect on the sample.[3]

In this study, 12-mer double-stranded synthetic DNA GC (12 mer-dsDNA GC) was used to portray the conditions for normal DNA. The measurements were performed at room temperature and the external longitudinal magnetic fields were applied up to 3400 G. The 80 mg powder sample of 12 mer-dsDNA GC was wrapped in a thin silver foil with the diameter of 1.5 cm.

Fig. 1. STM image of 12 mer-dsDNA GC molecules aligned in one-dimensional chain structure.

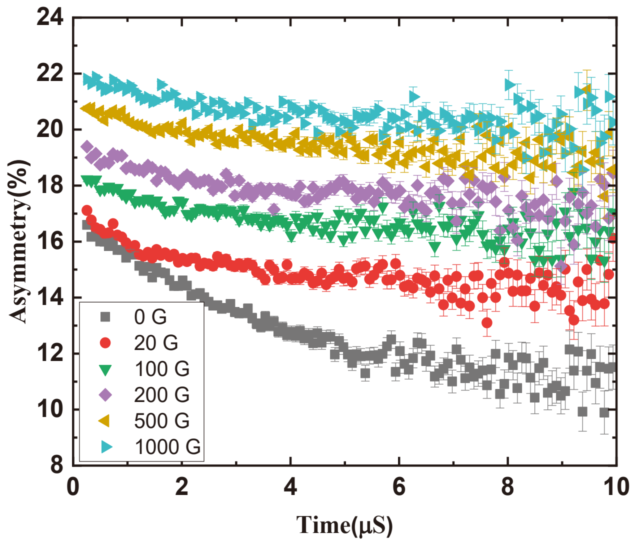


Fig. 2. Raw data of muon spin relaxation for 12-mer double-stranded synthetic DNA GC dependence over time.

In addition, scanning tunneling microscopy (STM) measurements were conducted to probe the molecular structure of 12 mer-dsDNA GC. From the STM measurements, the images of 12 mer-dsDNA GC molecules were successfully observed as shown in Fig. 1. The image in Fig. 1, was taken in constant current mode at room temperature and it corresponds to the surface map of electron tunneling from HOMO tip to the LUMO of the sample.[4]

Figure 2 shows the raw data of muon spin relaxation spectra dependence over time. The asymmetry is increased as the applied magnetic field increases. The muon spin relaxation becomes suppressed at the highest external magnetic fields. This result indicates that the spin relaxation of a muon is interacting with an electron that is rapidly diffusing along the molecule. At higher applied field, the muon-electron hyperfine coupling starts to be quenched. Accordingly, the muon spin relaxation is decreased, as illustrated in Fig. 2.

References
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*1 RIKEN Nishina Center
*2 School of Distance Education, Universiti Sains Malaysia
*3 Department of Engineering, Hokkaido University
*4 School of Biological Sciences, Universiti Sains Malaysia