Electron Transport Studies in Biological Molecules with respect to Ageing Science

H. Rozak,[*1] W. Zaharim,[*2] F. Astuti,[*1,*3] R. Asih,[*1,*4] R. Samian,[*2] S. Samsudin,[*2] S. N. Abu Bakar,[*2] N. Ismail,[*2] I. Watanabe,[*1,*3,*4] M. I. Mohamed-Ibrahim,[*2] and S. Sulaiman[*2]

The electron transport process in deoxyribonucleic acid (DNA) is a very important biological phenomenon but the process itself is not fully understood at the microscopic level. DNA is the molecule that stores genetic information in a living cell and the structure of DNA consists of four bases. These four bases are guanine (G), adenine (A), cytosine (C) and thymine (T).[1)] Damages in DNA can lead to various types of diseases such as cancers and neurological disorders. There is a direct relationship between the damages in DNA and ageing. We hypothesize that damages in the DNA would alter the behavior of electron transfer since DNA is well known as a good electron conductor. If there are some defects in DNA, the electron transfer in it will be disturbed, thus changing the electron motion. However, the degree and type of alterations are yet unknown at the microscopic level. In order to understand this phenomenon, systematic studies on the alteration of electron transfer in DNA are needed and μSR is known to be useful in this respect as has been demonstrated in the past on one-dimensional organic molecules.[2–4)]

In this project, we used simple model molecules of DNA where the sequence is less than 12 bases, which would make it easier to interpret the results.

Experiments on the μ^+ relaxation in guanine and adenine have been conducted using an intense pulsed beam μ^+ at the RIKENRAL Muon Facility. All measurements were conducted on the powder sample and the weight of each sample was 50 mg. We measured the muon-spin relaxation rate under various longitudinal magnetic fields in the range between 0 T and 0.3 T and the temperatures that we used to carry out our experiment were at 100 K and 300 K. The observed relaxation functions, $G(t)$, were fitted to the Risch-Kher function.

Based on the curve in Fig. 1, at temperatures 100 K, the μ^+ relaxation function was found to depend on the external field, where the initial asymmetry was increased as the external magnetic field increased. Unfortunately, the muon spin precession did not show clearly in this curve due to the limitation of the pulse muon source at RAL. Therefore, it is better to repeat the experiment involving guanine at PSI by using a continuous beam to confirm the existence of the diamagnetic muon components which are strongly bound to the molecules. For the curve in Fig. 2, the relation parameter (Γ) was found to take an inverse-field dependence in guanine above 50 G, thus suggesting existence of a quasi-1D rapid diffusion of electron in DNA strands It is clear that the electron-transfer process at the microscopic level was directly detected in the present experiments as shown in Fig. 2.

*1 RIKEN Nishina Center
*2 School of Distance Education, Universiti Sains Malaysia
*3 Department of Physics, Hokaido University
*4 Department of Physics, Osaka University

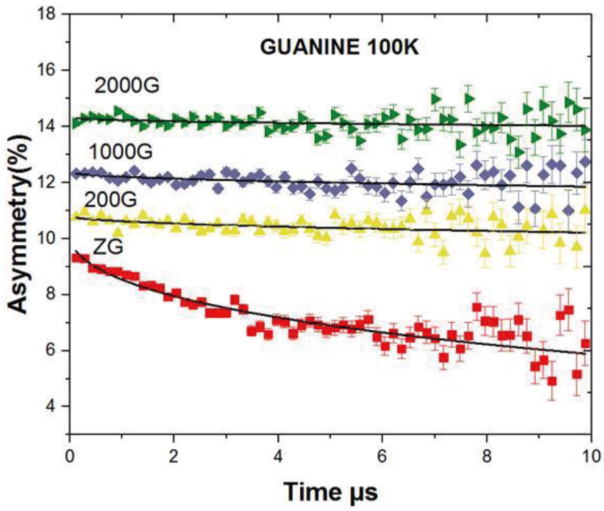

Fig. 1. μSR Time spectra in Guanine at 100 K under external longitudinal fields of 0, 200, 1000 and 2000 G.

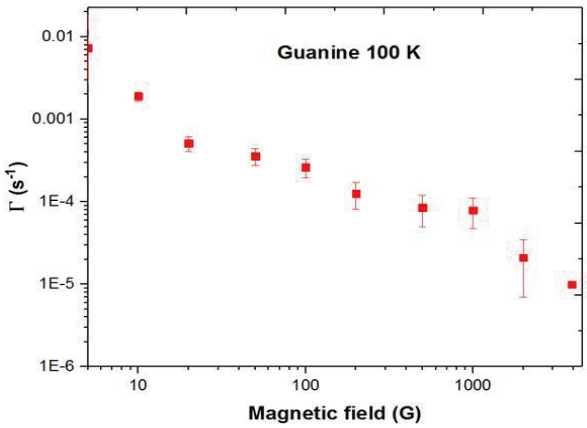

Fig. 2. Relaxation parameter versus an external longitudinal magnetic field for μ^+ in guanine at a temperatures of 100 K.

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