Analysis of biofunction by means of μSR

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Research Objects

Functions of biomacromolecules have been investigated by various biochemical and biophysical techniques. X-ray free electron lasers and cryo-electron microscopes cause our attentions as new powerful tools for structural biology. Muon spin rotation/relaxation/resonance (μSR) spectroscopy is one of the powerful tools in the fields of solid-state physics and radical chemistry, but its application in life science has been restricted. The muon (μ) is an elementary particle with a positive or a negative electric charge ($\pm e$) and a spin of 1/2. When a positively charged muon (μ^+) is implanted into materials, it captures an electron during the deceleration process and a muonium (Mu) which is a hydrogen-like exotic atom is formed. It attacks an unsaturated bond of compounds and a radical, conventionally called as a muonium radical, is formed. The spin states of a muon or a muonium reflect the local magnetic field around the stopping site and is monitored through the direction of a positron which is emitted when the muon or the muonium decays with a mean lifetime of 2.2 μs. Although μSR is an attractive tool for life sciences, its application has been prevented by the complexity of biomacromolecules. The establishment of μSR as the new method in the field of life science is the final object of this research.

Research Methods

1. Information of muon/muonium stopping sites in proteins are inevitable for understanding of μSR spectra of proteins. By means of experimental analysis and theoretical calculations of basic components of biomacromolecules, muon or muonium stopping sites and their characteristics will be unveiled.

2. Synchronized measurements under outer fields such as light and electric field will be powerful tool for monitoring of electron and proton transfer processes. Collaborating with biophysicists and specialists of muon experiments, we will establish appropriate conditions for the μSR experiments to monitor the outer field induced biophenomena.

3. At the present stage, amounts of samples for muon experiments are in the order of several hundred mg and too much for most of the targets in life science. Using the high intensity of the muon facility at MLF, we are going to reduce sample amounts. In addition, sample preparation methods for a ultra slow muon facility, which would be the very attractive tool in life science, will be examined.

Expected Effects

The μSR measurements offer information on dynamics of magnetic environment around muon or muonium stopping sites. It will show us the different aspects of biological functions from those monitored by crystallography and absorption/emission spectroscopy including NMR.