Possible Biological Radiation Effect in Protein and DNA produced and detected by Muon Spin Probes

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The positive muon, like proton, when it is injected into biological substances as an energetic beam, produces a radiation effect. The most significant feature of the muon is a capability to observe the molecular level radiation after-effect produced by the muon itself. So far, a direct molecular-level observation of the radiation effect in the time range of μs is limited, because existing radiation sources such as proton etc. do not have an "eye" to see radiation effect. The use of the muon as a double act of radiation producer and monitor is entirely new approach and will contribute to the progress of molecular level understanding of the biological radiation effect and the radiation therapy. One example of such phenomena is the nature of electron pick-up just before thermalization during slowing-down in the soft-matter followed by a localization to form a radical state and/or a dynamics of the brought-in electron such as a rapid diffusion, chemical reaction.

The following phenomenon which were observed and tried to be explained only by the electron transfer picture can now be reconsidered under the light of the biological effect of the radiation introduced and detected by the muon itself.

Wet heme-protein and protein water solution In most of solid heme-proteins like cytochrome c, myoglobin, a rapid on-chain diffusion and a slow inter-chain diffusion of the brought-in electron were observed [1]. Thus, muon radiation seems to cause a limited molecular-level effect in solid. There are some indications of radiation effects in dense water solution: a) in both wet cytochrome c (90 % concentration) [2] and wet cytochrome c oxydase (50 %) [1], on-chain diffusion of the brought-in electron is suppressed at 300 K, while it takes a rapid diffusion at low temperatures; b) in hemoglobin aqueous solution (17 %), an unique rapid depolarization was observed in both oxy- and deoxy-Hb [3].

Wet DNA The observed difference in muon spin relaxation parameter (λ) in DNA between dry A-form and wet B-form was tried to be understood by either the difference in brought-in electron transport due to different base pair arrangement [4] or the effect of helicity-dependent interaction [5]. Strange temperature dependence of λg?gindicating a slower diffusion at higher temperatures (upto 350 K) was left unexplained.

All of these observations can be consistently interpreted by possible radiation effect; muon radiation may produce radicals in water which take a chemical reaction with muon-introduced electrons at higher temperatures. More direct evidences can be obtained by applying electric fields.

New molecular-level understanding of muon radiation effect is expected to contribute to the progress of biomedical studies e.g. proton radiation therapy for cancer.

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