

Local magnetic field at negative muon in simple organic materials

S. Takeshita^{1,2#}, T. Kiyotani³, M. Hiraishi⁴, M. Yoshida⁵, D. Tomono⁶,
J. Sugiyama⁷, I. Umegaki^{1,2}, A. Koda^{1,2}, Y. Kobayashi⁵, and K. Shimomura^{1,2}

¹*Institute of Materials Structure Science, KEK, Tokai, Ibaraki 319-1106, Japan*

²*J-PARC Center, Tokai, Ibaraki 319-1106, Japan*

³*Department of Pharmacy, Showa Pharmaceutical Univ., Machida, Tokyo 194-8543, Japan*

⁴*Graduate School of Science and Engineering, Ibaraki Univ., Mito, Ibaraki 310-8512, Japan*

⁵*Grad. School of Info. and Eng., The Univ. of Electro-Communications, Chofu, Tokyo 182-8585, Japan*

⁶*Research Center for Nuclear Physics, Osaka University, Ibaraki, 567-0047, Japan*

⁷*Neutron Sci. and Tech. Center, CROSS, Tokai, Ibaraki 319-1106, Japan*

a corresponding author: E-mail soshi@post.kek.jp

Since the MUSE D-line at the J-PARC MLF is a decay muon beamline, it provides a high-intensity spin-polarized muon beam with both polarities: i.e., positive and negative. Positive muons implanted into polymers are known to form paramagnetic muons (muoniated radicals), while negative muons are captured by atomic nuclei to form muonic atoms. Thus, the sites for the positive muons in a sample are sometimes ambiguous, while those for the negative muons are clearly determined. This is one of the merits of a negative muon spin relaxation (μ^- SR) technique over a positive muon spin relaxation (μ^+ SR) technique, particularly for polymer science, as there are usually many possible μ^+ sites. However, to observe molecular dynamics in polymers with μ^- SR, it is essential to know the local magnetic field between μ^- and nuclear spins of the nuclei on which μ^- is captured. In this study, we have performed μ^- SR measurements on several simple organic materials to know the local magnetic field and to investigate the chemical states in the vicinity of the captured μ^- .

The ZF- μ^- SR spectrum of a polymer often exhibits an oscillation at low temperatures due to the formation of two (or three) spin-1/2 system. The oscillation frequency is well explained by the local magnetic field between the spin-1/2 μ^- captured by ^{12}C and one or two spin-1/2 H nuclei bound to the carbon. The bonding distance between the muonic carbon and hydrogen is estimated from the oscillation frequency: in the case of methane, the distance is estimated to be 1.1897(69) Å (two body coupling model) or 1.387(23) Å (three body coupling model). We will discuss the structures around the captured μ^- based on these local magnetic fields.