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Hyperfine Field and Local Structures in Muonic Organic Compounds

The D-line at the MUSE facility of the J-PARC MLF delivers high-intensity, spin-polarized muon beams of both positive and negative. Positive muons implanted into organic materials tend to form paramagnetic muoniated radicals at various sites, sometimes making it difficult to identify precise local environments. In contrast, negative muons are captured by atomic nuclei, resulting in well-defined muonic atoms. This clear site specificity offers a unique advantage for probing local structures in complex materials such as polymers.
To explore this potential, we conducted negative muon spin rotation (μ^-SR) measurements on several simple organic compounds. The goal was to observe local magnetic fields arising from hyperfine interactions between bound μ^- and nearby nuclear spins. In zero-field μ^-SR spectra at low temperatures, we observed clear oscillations, indicating hyperfine coupling in two- or three-spin-½ systems. These interactions provided quantitative information on atomic distances; for example, in ethylene, the C–H bond length in the muonic state was estimated as 1.202(9) Å. These findings suggest that μ^-SR can be a valuable probe for investigating molecular dynamics in organic compounds or polymers.

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