Muon dynamics in superprotonic conductors

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In order to clarify the mechanism of high proton conductivity (σ_{H^+}) for superprotonic conductors, $MHXO_4$, where M=Cs and Rb, X=S and Se, μ^+SR experiments have been performed in the temperature range between 250 and 450 K using single crystal samples. Here, $MHXO_4$ exhibits extraordinary high σ_{H^+} at T above its structural phase transition (T_c=414 K for $CsHSO_4$ (CHS)) from a low-T orthorhombic phase (Phase II) to a high-T tetragonal phase (Phase I) [1].

Figure 1 (a) shows the dependences of the muon hopping rate (ν_μ) and field distribution width (Δ_{KT}) on inverse T, where ν_μ and Δ_{KT} are obtained by fitting ZF and weak LF spectra using a dynamic Kubo-Toyabe (KT) function. The activation energies of muon hopping in phase I and II are estimated as 0.01 eV and 0.1 eV, respectively. This is qualitatively in good agreement with values from σ_{H^+} measurements. Figure 1 (b) shows the weak TF asymmetry (A_{TF}) for CHS and $CsHSeO_4$ (CHSe) as a function of T. Since the $A_{TF}(T)$ curve doesn't reach its maximum at ambient T, muonium (Mu) state is found to exist in both samples. This behavior is consistent with the past μ^+SR experiments for CHS using a polycrystalline sample [2]. The Mu fraction for CHS is still a finite value even in Phase I, while the Mu state didappears in Phase I of CHSe. Considering the fact that the σ_{H^+} in Phase I of CHS is about ten times larger than that of CHSe, the Mu formation implies the presence of the atomic hydrogen state and a possible crucial role for the high σ_{H^+} in phase I of CHS.

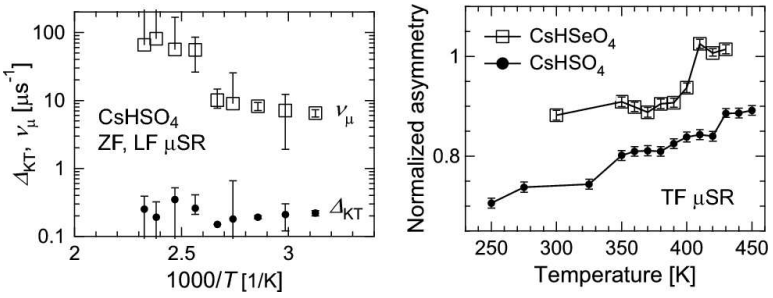

Fig. 1: (a) T inverse dependence of the KT parameters obtained from ZF- and LF-μSR spectra for CHS. (b) T dependence of A_{TF} for CHS and CHSe.

[1] A. I. Baranov et al., JETP Lett. 36 (1982) 459.
[2] A. V. Belushkin et al., OIJaI E14-89-128 (Dubna: OIJaI, 1989)