A nearly isotropic triangular lattice system EtMe$_3$P[Pd(dmit)$_2$]$_2$ (space group $P2_1/m$), which is a spin-gapped Mott insulator at ambient pressure, exhibits a superconductivity under pressures [1-3]. This superconductivity is unusual because it is adjacent not to an antiferromagnetic Mott phase but to the spin-gapped Mott phase. It also should be noted that this superconductivity is realized on a nearly isotropic triangular lattice. The triangular-lattice nature can destabilize a $d$-wave state, which is often realized in strongly correlated metals near the Mott transition, and formally favors the Cooper paring with three-fold symmetry, such as $d + i d$ or $f$ wave parings. Thus, the properties of the superconductivity in EtMe$_3$P[Pd(dmit)$_2$]$_2$ are intriguing and needed to be elucidated.

First, in order to conclude the dimensionality of the superconductivity, we performed ac susceptibility measurements under a pressure of ~5 kbar for three single crystals (#1-#3), with dc magnetic field applied perpendicular to ac field to measure the ac susceptibility. The direction of the dc magnetic field (0.10 T for the crystal #1, and 0.025 T and 0.10 T for the crystal #2 and #3) was rotated around the conducting layers. In general, two-dimensional superconductivities show the lock-in state with vortices trapped in the insulating layers, when magnetic field is applied nearly parallel to the conducting layers. When this lock-in state is realized, the diamagnetic signal ($\chi$) should show a sudden decrease [4]. However, the diamagnetic signal observed in EtMe$_3$P[Pd(dmit)$_2$]$_2$ under pressures show no decrease (Fig. 1), which suggests that the lock-in state is never realized in EtMe$_3$P[Pd(dmit)$_2$]$_2$. Therefore, we conclude that the superconductivity is regarded not as a two-dimensional superconductivity but as an anisotropic three-dimensional superconductivity.

Second, in order to conclude the symmetry of the superconductivity, we performed single-crystal $^{13}$C-NMR measurements for three single crystals (#1-#3) of EtMe$_3$P[Pd(dmit)$_2$]$_2$ under ambient pressure and an applied pressure of ~5 kbar. Magnetic fields (1.7 T for the crystal #1 and #2, and 2.5 T for the crystal #3) were applied precisely parallel to the conducting layers. We confirmed that the spin-echo spectra in the high-temperature metallic phase at 5 kbar shows a finite Knight shift from the shift origin, which is precisely determined by observing the spectra in the spin-gapped state at ambient pressure. The bulk superconducting transition for each crystal was observed at $T_{c} = 3.4$ K under the magnetic fields by measuring the ac susceptibility and the NMR spin-lattice relaxation rate $1/T_1$. It is remarkable that the Knight shift does not decrease below the superconducting transition temperature and has a finite value almost the same as that in the metallic phase, even at $1.4 K < 0.5T_c$ (Fig. 2). This result possibly suggests finite spin susceptibility of the Cooper pairs and thus triplet superconductivity.

References