THERMODYNAMIC STUDIES ON THE SUPERCONDUCTIVITY AND THE SPIN LIQUID STATE IN ORGANIC CHARGE TRANSFER COMPOUNDS

Y. Nakazawa, S. Yamashita, R. Yoshimoto, S. Imajo, H. Akutsu

[1] *Department of Chemistry, Graduate School of Science, Osaka University*
Machikaneyama 1-1, Toyonaka, Osaka 560-0043, Japan

e-mail: nakazawa@chem.sci.osaka-u.ac.jp

We discuss low-temperature thermodynamic properties studied by the single crytal calorimetry techanique for two-dimensional (2D) organic charge transfer compounds which show various quantum mechanical features dominated by charge and spin degrees of freedom.

At first, we show results of heat capacity measurements of κ-$(BEDT\text{-}TTF)_2Cu_2(CN)_3$, $EtMe_3Sb[Pd(dmit)_2]_2$ and κ-$H_3(Cat\text{-}EDT\text{-}TTF)_2$, which are known as 2D dimer-Mott systems with triangle structure. Thermodynamic features characteristic of gapless liquid-like states produced by π-electron spins were obaserved as common aspects in these three compounds. We also discuss magnetic field effects for these low energy excitations from the analyses of heat capacity data under magnetic fields up to 10 T. Through detail studies of $X[Pd(dmit)_2]_2$ of which cation layers are chemically controlled by making solid-solution of different size of cations, we derived information on the systematic variation of electronic ground states. [1-3] We observed that the spin-liquid state exists as a distinct phase and kind of quantum phase transitions to AF and CO phases by changing chemical pressures. The relation with spin properties coupled with other degrees of freedoms is discussed in order to clairfy the electronic structrures in such organic compounds. The curious magnetic properties of dimer-Mott system of $X[Ni(dmit)_2]_2$ with non-symmetric counter cations X are also reported in relation to spin-liquid properties.

If the triangularity of spin-liquid system changes to square lattice, the system become antiferromagnetic insulators. In these materials, the application of pressure leads the system to conductive and superconductive phases. The thermodynamic measurements of the superconductors of these organic compounds show quadratic temperature dependences at low temperatures. The analyses of electronic heat capacity against magnetic fields both in magnitude and direction demonstrate that the superconductivity has d-wave with line-node characters.[4] Thermodynamic features for other organic superconductors with different structures are also discussed.

[1] S. Yamashita, T. Yamamoto, Y. Nakazawa, M. Tamura, and R. Kato, *Nat. Commun.* **2**, 275-279 (2011).
[2] S. Yamashita, Y. Nakazawa, M. Oguni, Y. Oshima, H. Nojiri, Y. Shimizu, K. Miyagawa, and K. Kanoda, *Nat. Phys.* **4**, 459-463 (2008).
[3] Y. Nakazawa and S. Yamashita, *Chem. Lett.* **42**, 1446-1454 (2013).
[4] S. Imajo, S. Yamashita, S. Fukuoka, H. Akutsu, and Y. Nakazawa, *J. Therm. Anal. Calorim. in press* (2016).