Development of Molecule-based Functional Material

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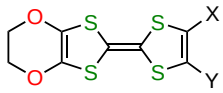
He was born in 1977. He graduated from Department of Industrial Chemistry, Faculty of Engineering, Kyoto University in 2000 and received his Doctor of Engineering from Kyoto University in 2005 for a thesis entitled "Studies on Electronic Properties of Organic Multi-Spin Systems". He was a postdoctoral fellow in Research Center for Low Temperature and Materials Sciences (Apr., 2005 - Jun., 2008), and Institute for Integrated Cell-Material Sciences (Jul., 2008 - Mar., 2009), Kyoto University. From Apr., 2009, he has been an Assistant Professor in Research Center for Low Temperature and Materials Sciences, and then an assistant professor in the Division of Chemistry, Graduate School of Science, Kyoto University.

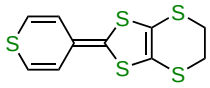
(1) Anion size and isotope effects in $(EDO\text{-}TTF)_2XF_6$: $(EDO\text{-}TTF)_2PF_6$ undergoes the peculiar metal-insulator transition and the ultra-fast and highly efficient photo-induced insulator-to-metal phase transition. The deuterated salts, $(EDO\text{-}TTF\text{-}d_2)_2XF_6$ (X = P, As), showed the higher transition temperatures (T_{MI}'s) by 2~3 K than the undeuterated salts. The T_{MI} and the width of thermal hysteresis (ΔT_{MI}) of $(EDO\text{-}TTF)_2XF_6$ (X = P, As, Sb) systematically changed depending on the anion, i.e., the T_{MI} decreased and the ΔT_{MI} increased with increasing the anion size (PF_6 < AsF_6 < SbF_6).



EDO-TTF: X = Y = H
EDO-TTF-d_2: X = Y = D
MeEDO-TTF: X = CH_3, Y = H

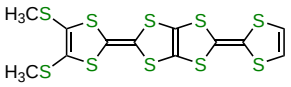
(2) Room temperature phase transition in $(MeEDO\text{-}TTF)_2PF_6$: The black plate modification of $(MeEDO\text{-}TTF)_2PF_6$ exhibited the semiconductor-to-semiconductor first-order phase transition at around room temperature. One donor molecule was crystallographically unique in both the high- and low-temperature (HT and LT) phases, the HT phase of which is isostructural to the metallic $(MeEDO\text{-}TTF)_2X$ (X = BF_4, ClO_4). The vibrational spectroscopy, which is a higher time-resolution measurement than X-ray diffraction, proved that the nearly localized charge disproportionation takes place in the HT phase and the distinct charge disproportionation evolved in the LT phase.

(3) Structures and physical property of radical cation salts of TP-EDTT: $(TP\text{-}EDTT)_2SbF_6$, $(TP\text{-}EDTT)_3(PF_6)_2$, $(TP\text{-}EDTT)GaCl_4$, and $(TP\text{-}EDTT)ReO_4$ were prepared. Based on the bond lengths, it was suggested that three kinds of differently charged molecules coexisted in the PF_6 salt. In the semiconducting SbF_6 salt, no sign of charge disproportionation was found in the range from 300 to 6 K to assign this salt as a dimer Mott insulator.



TP-EDTT

(4) Charge disproportionation in θ-$(BTM\text{-}TTP)_2SbF_6$: θ-$(BTM\text{-}TTP)_2SbF_6$ shows semiconducting behavior, while the band calculation affords the closed Fermi surface characteristic of 2D metal. In order to clarify the origin of the carrier localization, Raman spectroscopy was applied to reveal that the charge disproportionation occurs from room temperature and the fluctuation of charge is suppressed with decreasing temperature.



BTM-TTP

Publications

1. Isotope effect on metal–insulator transition of $(EDO\text{-}TTF)_2XF_6$ (X = P, As) with multi-instability of metallic state, Y. Nakano, K. Balodis, H. Yamochi, G. Saito, M. Uruichi, K. Yakushi, *Solid State Sci.*, **10**(12), 1780-1785 (2008)
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3. Anion size and isotope effects in $(EDO\text{-}TTF)_2XF_6$, Y. Nakano, H. Yamochi, G. Saito, M. Uruichi, K. Yakushi, *J. Phys.: Conf. Ser.*, **148**, 012007/1-4 (2009)
4. Charge ordering state of mixed-valence $(TP\text{-}EDTT)_3(PF_6)_2$, Y. Nakano, M. Takahashi, M. Sakata, H. Yamochi, G. Saito, K. Tanaka, *Synth. Met.*, **159**(21-22), 2381-2383 (2009)
5. Synthesis, crystal structure, and physical property of radical cation salt of 2-(thiopyran-4-ylidene)-4,5-ethylenedithio-1,3-dithiole (TP-EDTT): $(TP\text{-}EDTT)_2SbF_6$, Y. Nakano, T. Nishi, M. Uruichi, K. Yakushi, H. Yamochi, *Physica B*, **405**(11S), S49-S54 (2010)
6. Charge disproportionation in a semiconducting θ-type salt of BTM-TTP, Y. Nakano, Y. Misaki, M. Uruichi, K. Yakushi, H. Yamochi, *Physica B*, **405**(11S), S198-S201 (2010)