TOPICAL REVIEW

Organic superconductors with an incommensurate anion structure

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Tadashi Kawamoto[1] and Kazuo Takimiya[2]

[1] Department of Organic and Polymeric Materials, Graduate School of Science and Engineering, Tokyo Institute of Technology, O-okayama, Meguro-ku, Tokyo 152-8552, Japan

[2] Department of Applied Chemistry, Graduate School of Engineering, Hiroshima University, Kagamiyama, Higashi-Hiroshima, Hiroshima 739-8527, Japan

E-mail: kawamoto@o.cc.titech.ac.jp and ktakimi@hiroshima-u.ac.jp

Abstract. Superconducting incommensurate organic composite crystals based on the methylenedithio-tetraselenafulvalene (MDT-TSF) series donors, where the energy band filling deviates from the usual 3/4-filled, are reviewed. The incommensurate anion potential reconstructs the Fermi surface for both (MDT-TSF)$(AuI_2)_{0.436}$ and (MDT-ST)$(I_3)_{0.417}$ neither by the fundamental anion periodicity $\boldsymbol{q}$ nor by $2\boldsymbol{q}$, but by $3\boldsymbol{q}$, where MDT-ST is 5*H*-2-(1,3-dithiol-2-ylidene)-1,3-diselena-4,6-dithiapentalene, and $\boldsymbol{q}$ is the reciprocal lattice vector of the anion lattice. The *selection rule* of the reconstructing vectors is associated with the magnitude of the incommensurate potential. The considerably large interlayer transfer integral and three-dimensional superconducting properties are due to the direct donor–donor interactions coming from the characteristic corrugated conducting sheet structure. The materials with high superconducting transition temperature, T_c, have large ratios of the observed cyclotron masses to the bare ones, which indicates that the strength of the many-body effect is the major determinant of T_c. (MDT-TS)$(AuI_2)_{0.441}$ shows a metal–insulator transition at T_{MI}=50 K, where MDT-TS is 5*H*-2-(1,3-diselenol-2-ylidene)-1,3,4,6-tetrathiapentalene, and the insulating phase is an antiferromagnet with a high Néel temperature (T_N=50 K) and a high spin–flop field (B_{sf}=6.9 T). There is a possibility that this material is an *incommensurate Mott insulator*. Hydrostatic pressure suppresses the insulating state and induces superconductivity at T_c=3.2 K above 1.05 GPa, where T_c rises to the maximum, T_c^{max}=4.9 K at 1.27 GPa. This compound shows a usual temperature–pressure phase diagram, in which the superconducting phase borders on the antiferromagnetic insulating phase, despite the unusual band filling.

Keywords: organic superconductor, incommensurate composite crystal, Fermi surface, metal-insulator transition

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