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Editorial

Organic Conductors

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Since the pioneering work concerning organic semiconductors in the middle of the 1900s, organic conductor research has experienced a series of milestones, from metallic to superconducting charge-transfer complexes (1980s–1990s). The history of these materials is reviewed in this Special Issue by considering a body of references [1].

The publication "Organic Conductors" covers various solids containing both organic and inorganic species with a variety of shapes and dimensions. The physical properties of these materials include electrical, magnetic, structural, optical, dielectric, and mechanical. The most prominent feature of organic conductors and related materials is the wide variety of degrees of freedom, which enables peculiar electronic states, physical properties, and phase transitions that are otherwise unobserved. As a result, even an insulating organic crystalline material can be a center of interest in this field if it provides an important piece of information concerning the mechanism of superconductivity, for example, or sheds light on other subjects of broad interest from the abovementioned point of view.

In 2022, researchers in this ever-expanding and developing field are looking for further interesting and exciting targets that are yet to be explored. On such a memorial occasion, this Special Issue, entitled "Organic Conductors", has collated 25 papers (plus editorials) from 11 countries. Readers will enjoy the latest developments in new materials, ideas, and methodologies, which will propel the field in a new direction and age.

The Special Issue consists of the following papers and reviews:

1. The synthesis of new molecules and organic conductors:
    - Kubo et al. reported a series of nickel–dithiolene complexes fused with bulky cycloalkane substituents to study their steric-based effects on molecular arrangements [2].
    - Kadoya et al. reported the structural and physical properties of a new organic Mott insulator with a θ-type molecular arrangement [3].
    - Mroweh et al. reported new chiral conducting salts based on ethylenedithio-tetrathiafulvalene (EDT-TTF) derivatives, presenting their crystal structures, extended Hückel band structures, and electrical properties [4].
    - Sakaguchi et al. reported a new single-component molecular conductor, $[Au(etdt)_2]\cdot THF$ (etdt = ethylenedithiotetrathiafulvalenedithiolate), that is, the synthesis, structure, and physical properties of a neutral gold-dithiolene-complex [5].
    - Akutsu et al. reported three types of new organic conductors containing $HOC_2H_4SO_3^-$ anions and discussed their electrical properties in terms of the Madelung energies [6].
    - Sato et al. reported new stable neutral radical species, $M^{III}(Pc)Cl_2\cdot THF$ (M = Co or Fe, Pc = phthalocyanine, THF = tetrahydrofuran), as three-dimensional, single-component molecular conductors [7].
    - Koyama et al. reported the synthesis and structural, spectroscopic, and electrical properties of a new molecular conductor with a weak hydrogen-bonding network [8].

2. Structural, optical, magnetic, electrical, and other related properties:
    - Rohwer et al. reported the effects of deuteration on the transport properties of quasi-one-dimensional Fabre salts, $(TMTTF)_2X$ (TMTTF = tetramethyltetrathiafulvalene, X = Br, PF_6, and ClO_4), and discovered various conduction properties such as Mott insulators, variable range hopping, and activated band transport with a temperature-dependent bandgap [9].
    - Kitou et al. reported an experimental method for use in estimating valence electron densities, that is, frontier orbitals, in the solid state based on X-ray diffraction data [10].
    - Yoshino et al. reported the crystal structures and electrical resistivities of a series of TMTSF (TMTSF = tetramethyltetraselenafulvalene) salts with unusual stoichiometries and determined the valence state of TMTSF in each type of salt using quantum chemistry calculations [11].
3. Physical property measurements with new techniques and/or under extreme conditions:
    - Yamamoto et al. reported a new system for measuring the pyroelectricity of small ferroelectric single crystals [12].
    - Hino et al. reported the current- and voltage-dependence of the heat capacity of a single crystal of a charge glass compound, θ-$(BEDT\text{-}TTF)_2CsZn(SCN)_4$ (BEDT-TTF = bis(ethylenedithio)-tetrathiafulvalene) [13].
4. Spectroscopic studies concerning molecular functional crystals:
    - Hiraki et al. reported ^{77}Se-NMR studies on λ-type BETS superconductors, λ-$(BETS)_2Fe_{1-x}Ga_xCl_4$ (BETS = bis(ethyleneditho)tetraselenafulvalene), to examine the π-spin polarization affected by the localized 3*d* spins on Fe atoms [14].
5. Theoretical studies on organic conductors:
    - Tsumuraya et al. reported first-principle density functional theory calculations of the charge-ordered phase of α-$(BEDT\text{-}TTF)_2I_3$, which is closely related to Dirac electron systems [15].
    - Roy et al. reported accurate zero-temperature density matrix renormalization group calculations for κ-$(BEDT\text{-}TTF)_2X$, the most studied family of organic superconductors, and concluded that magnetic fluctuations in the effective half-filled band approach do not drive superconductivity in these and related materials [16].
    - Ménard et al. reported a one-dimensional alternating extended Hubbard model at quarter-filling based on a renormalization group method to examine structural instabilities in Fabre and Bechgaard salts and related organic conductors [17].
    - Suzumura et al. calculated electrical transport in nodal line semimetals of single-component molecular conductors to examine the effects of acoustic phonon scattering on electrical conductivity [18].
    - Naito et al. reported a method of calculating intermolecular interactions in disordered molecular charge-transfer complexes of STF (STF = bis(ethylenedithio)-diselenadithiafulvalene) by proposing a new interpretation or usage of wavefunctions [19].
    - Kesharpu et al. calculated the evolution of the shape and volume fraction of superconducting domains in relation to temperature and anion disorder in a highly anisotropic organic superconductor, $(TMTSF)_2ClO_4$ [20].
6. Molecular π-d, Dirac, and strongly correlated electron systems:
    - Cui et al. reported the high-pressure crystal structure and magnetoresistance of a single-component molecular conductor $[Pt(dddt)_2]$ (dddt = 5,6-dihydro-1,4-dithiin-2,3-dithiolate), a theoretically expected three-dimensional Dirac electron system, under high pressure [21].
    - Yasuzuka reviewed the interplay between the vortex dynamics and superconducting gap structures in layered organic superconductors containing strongly correlated electron systems. Particular attention was paid to the symmetry of

the superconducting gaps, which is a key feature in understanding the pairing mechanism [22].

7. Organic magnets, dielectrics, semiconductors, superconductors, and photoconductors:
   - Manabe et al. reported reversible structural and magnetic transformations in inorganic ladder compounds; these transformations are dependent on the gas-phase chemical species absorbed in single crystals [23].
8. Molecular electronics, optoelectronics, spintronics, devices, and related topics:
   - Kawasugi et al. reported doping effects using field-effect transistors consisting of electric double layers of charge-ordered insulators, α-(BEDT-TTF)$_2$I$_3$, and α-(BETS)$_2$I$_3$ [24].
   - Gou et al. reported experimental and modelling studies of a series of high-performance inorganic semiconductor devices based on doped GaAs and related materials [25].

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