【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Chemistry)

Title of Project : Development of Electronic Multifunction Based on Organic Triangular Spin Lattice

Gunzi Saito
(Meijo University, Research Institute, Professor)

Research Area : Chemistry
Keyword : Electric/Magnetic function, Crystal structure, Organic electronic materials/devices

【Purpose and Background of the Research】

Quantum spin liquid, that was first proved experimentally by our group for organic triangular spin lattice κ-$(ET)_2Cu_2(CN)_3$, remains wave nature of electron spins down to extremely low temperatures and competes with several electronic phases (Mott insulating, metal, and superconducting phases). For the triangular spin lattice system, the magnitude (t) and its anisotropy (t'/t; Fig. 1) of transfer integrals can be controlled by selecting component molecules and designing the assemblies, and therefore, systematic material exploration including the adjacent electronic phases is an urgent issue. In this project, we will systematically develop the triangular spin lattice system, control the t and t'/t values with applying pressure utilizing the characteristics of organic matters (soft lattice and electronic state), and inject the carriers by electric field and light irradiation, with the aim of exploration of new quantum spin lattice system and electronic multifunctions.

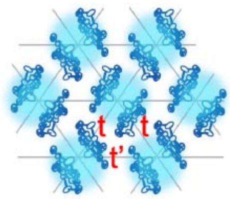

Figure 1 ET packing in κ-$(ET)_2X$ (Light blue circle: $(ET)_2^{\bullet +}$ dimer).

【Research Methods】

On the basis of accumulated knowledge, we will develop new triangular spin lattice system composed of molecular units with S = 1/2 spin (e.g., cationic radical dimer for TTF system, and anionic radical monomer for C_{60} system) by designing and selecting component molecules (ref. 1). In addition, we will establish (1) the chemical control method of localization and symmetry of electronic system, (2) the control method of geometrical spin anisotropy and bandwidth by applying uni-axial stress and hydrostatic pressure, (3) the T-P phase diagram around the quantum spin liquid phase, (4) the novel pressure-induced superconducting phase and external field induced metal-insulator transition associated with the spin frustration, (5) the ionic liquids for improving FET device performance, and (6) the non-equilibrium dynamics of excitation state for electron and lattice systems on a wide energy and time (fs ~ ms) scales.

【Expected Research Achievements and Scientific Significance】

Exploration of new quantum spin liquid system and their comprehensive understanding would allow the elucidation of quantum spin liquid behavior. Although seven quantum spin liquid materials (one being organic matter and the other being inorganic matters) have been found after our discovery, the phase neighboring the superconducting one is still limited for κ-$(ET)_2Cu_2(CN)_3$. Therefore, our project is a leading and ingenious one that faces the nature of quantum spin liquid, with the aim of the derivation of the relationship between quantum spin liquid and superconductivity. We also promote construction of new principle devices, and lay an innovative and advanced foundation of material science, by chemical and physical control (i.e., temperature, pressure, electric field, light, magnetic field, etc).

【Publications Relevant to the Project】

1. G. Saito and Y. Yoshida "Development of Conductive Organic Molecular Assemblies: Organic Metals, Superconductors and Exotic Functional Materials" *Bull. Chem. Soc. Jpn.*, **80**, 1-137 (2007).
2. D. V. Konarev, S. S. Khasanov, A. Otsuka, M. Maesato, G. Saito, and R. N. Lyubovskaya, "A Two-Dimensional Organic Metal Based on Fullerene" *Angew. Chem. Int. Ed.*, **49**, 4829-4832 (2010).
3. Y. Shimizu, H. Kasahara, T. Furuta, K. Miyagawa, K. Kanoda, M. Maesato, and G. Saito "Pressure-Induced Superconductivity and Mott Transition in Spin-Liquid κ-$(ET)_2Cu_2(CN)_3$ Probed by ^{13}C NMR" *Phys. Rev.*, **B81**, 224508/1-5 (2010).

【Term of Project】 FY2011-2015

【Budget Allocation】 188,400 Thousand Yen

【Homepage Address and Other Contact Information】

In preparation