We have demonstrated the uncoupling of the electron pair in a Kekulé polyacetylene aromatic hydrocarbon (PAH) to the extent of which being governed by the energy balance between the formal loss of the double bond and the aromatic sextet formation. Our study further shows that the singlet biradical character in PAHs can be exploited in an unexpectedly small-size molecule. This finding would encourage a bottom-up approach for establishing spintronics and nonlinear optics, both based on molecular-size nanographene compounds.

Three benzene rings can be fused in three different ways to yield linear anthracene, angular phenanthrene, and triangular phenalenyl. The former two structures are drawn as closed shell structures, while the latter one is only drawn as open-shell structure. These three kinds of benzene derivatives are designed by clipping from graphene known as a planar sheet-like gigantic graphene electronic system. Triangular clipping from graphene similar to the phenalenyl structure leads to an entire family of “open shell graphene fragments” which are of substantial interest, from the standpoints of fundamental science as well as their potential applications in materials chemistry. We discuss current trends and challenges in this field.

The topological insulator is a novel quantum state of matter that is supposed to show insulating behavior in the bulk and spin-filtered metallic conduction on the surface. In practice, however, most of the known topological-insulator materials are poorly insulating in the bulk, hindering the transport studies of the topological surface state. We have synthesized a new topological insulator, BiTeSe, which approaches insulating behavior in the bulk for the first time in this class of materials. Moreover, we observed clear Shubnikov-de Haas oscillations coming from the topological surface state, paving the way for exploiting the unique surface conduction properties of topological insulators.

Low-molecular weight compounds that disrupt protein-protein interactions (PPIs) have tremendous potential applications for investigating PPI networks, however, designing such compounds still remains difficult due to the flat protein interfaces. We reported a new strategy for designing bivalent enzyme inhibitors that anchor to that of FTase. This is the first example demonstrating that common structural features on protein surfaces can be vulnerable for PPI inhibitors as well as dual inhibitors of structurally related enzymes.

Synthetic Organic Spin Chemistry for Structurally Well-defined Open-shell Graphene Fragments

Moriy, S.; Suzuki, S.; Sato, K.; Takui, T. (Graduate School of Science)

Nature Chemistry, 3, 197-204 (2011)

Large Bulk Resistivity and Surface Quantum Oscillations in the Topological Insulator BiTeSe

Ren, Z.; Taskin, A. A.; Sasaki, S.; Segawa, K.; Ando, Y. (Institute of Scientific and Industrial Research)

Physical Review B, 82, 241306(R) (2010)

Bivalent Inhibitors for Disrupting Protein Surface-Substrate Interactions and for Dual Inhibition of Protein Prenyltransferases


Low-molecular weight compounds that disrupt protein-protein interactions (PPIs) have tremendous potential applications for investigating PPI networks, however, designing such compounds still remains difficult due to the flat protein interfaces. We reported a new strategy for designing bivalent enzyme inhibitors that anchor to the active site and deliver a minimally sized module to the targeted surface involved in PPI with a substrate. Inhibitors of FTase, derived by linking a gallicate derivative to a CVIM tetrapeptide, show remarkably improved inhibitory activity against FTase compared to the CVIM. Furthermore, the compounds also inhibit GGTase I, which is composed of the identical α-subunit of that of FTase. This is the first example demonstrating that common structural features on protein surfaces can be vulnerable for PPI inhibitors as well as dual inhibitors of structurally related enzymes.

The Prominent 5d-orbital Contribution to the Conduction Electrons in Gold


Journal of the Physical Society of Japan, 80, 013603 (2011)

Far-Infrared Interferometric Telescope Experiment (FITE): Three-Axis Stabilized Attitude Control System


Transactions of the Japan Society for Aeronautical and Space Sciences, 53, 193 (2010)

Miniaturized High-Resolution Time-of-flight Mass Spectrometer MULITUM-II with an Infinite Flight Path

Shimizu, S. 1; Nagao, H. 2; Aoki, J. 1; Takahashi, K.; Miki, S.; Toyoda, M. 1, 2 1) (Center for Advanced Science and Innovation) 2) Renovation Center of Instruments for Science Education and Technology (Graduate School of Science)


We have developed a far-infrared balloon-borne interferometric telescope (FITe). The goal of this project is to achieve a very high spatial resolution (1 second of arc) for electromagnetic waves at around 3 THz frequency. This telescope must be flown up to at least 30,000 m of altitude because the atmosphere of the earth is almost opaque for the far-infrared radiation. In order to meet this requirement, we adopted a three-axis attitude control system for a balloon-borne telescope (as a satellite on orbit in space), and achieved high control accuracy enough to resolve fine structures of important astronomical objects, such as protoplanetary disks where planets are born.

Minimization of the mass resolution was 30,000, and CO2 and CH4 were detected by using a single Mott insulating material where both α-type and β-type doping are realized. We have synthesized a unique cuprate material Yc-La2CuO4 and found intriguing results at very low doping levels, where a marked difference in properties of electron- and hole-doped materials is manifest.

High-temperature superconductivity occurs when a sufficient number of charge carriers are doped into a parent cuprate Mott insulator. In order to clarify the mechanism, it was desirable to study what happens when a small number of electrons are either added or removed from the Mott-insulating state. Yet, until recently, we could only examine a single Mott insulating material where both α-type and β-type doping are realized. We have synthesized a unique cuprate material Yc-La2CuO4 and found intriguing results at very low doping levels, where a marked difference in properties of electron- and hole-doped materials is manifest.

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