Multifunction Integrated Macromolecules for Molecular-Scale Electronics

Research Center for Molecular Scale Nanoscience
Division of Molecular Nanoscience

TANAKA, Shoji Assistant Professor

Single molecular science and technology are the new frontier for physical and synthetic organic chemistry. Especially quantum device engineering is a promising field. Recently the power consumption of information processing systems becomes critical issues, and the growing demand for ultra-low-power device has led to a greater interest in a single electron tunneling (SET) device. A SET device manipulates an electron by means of one-by-one electron transfer, resulting in ultimately low power consumption. However, for room temperature operation, the size of SET device must be as small as a few nm to overcome the thermal fluctuation problems. The process size of a few nm is out of the range of conventional micro-technology, and therefore new nano fabrication approaches for SET device have been explored worldwide.

In this project, to establish an innovative fabrication process for SET device systems, we have been developing step-wise synthetic protocols for integrating molecule-based quantum device elements (quantum dots, wells, and tunnel junctions) within a single planar macromolecule. Our strategy is based on "modular architecture" using a library of basic functional building blocks, and so far we have developed various types and sizes of 1-dimensional (1D) building blocks (**1-3**). Now we shift to the next stage, that is, the development of multi-terminal building blocks for the step-wise fabrication of planar 2-dimensional (2D) macromolecular systems.

1. Development of Multi-Terminal Molecular Building Blocks for Precisely Defined Functional 2D-Macromolecules

To synthesize a precisely defined 2D-macromolecule we first prepared three types of multi-terminal modules (**4-20**). Figure 1 shows the molecular structures. The module Type-1 is a conductive junction block, in which the π-system of the main chain and that of the side chain are fully conjugated. The type-2 is a multi-terminal tunnel/capacitive junction block: The main chain and the side chain are electronically coupled by tunnel or capacitive junction. The type-3 is an insulating spacer block: The side chain is used to prevent electrical short circuits between the conductive parts and to maintain a desired structure of the 2D system. Now we are challenging to fabricate planar 2D macromolecules operating as an individual SET device from these trial modules.

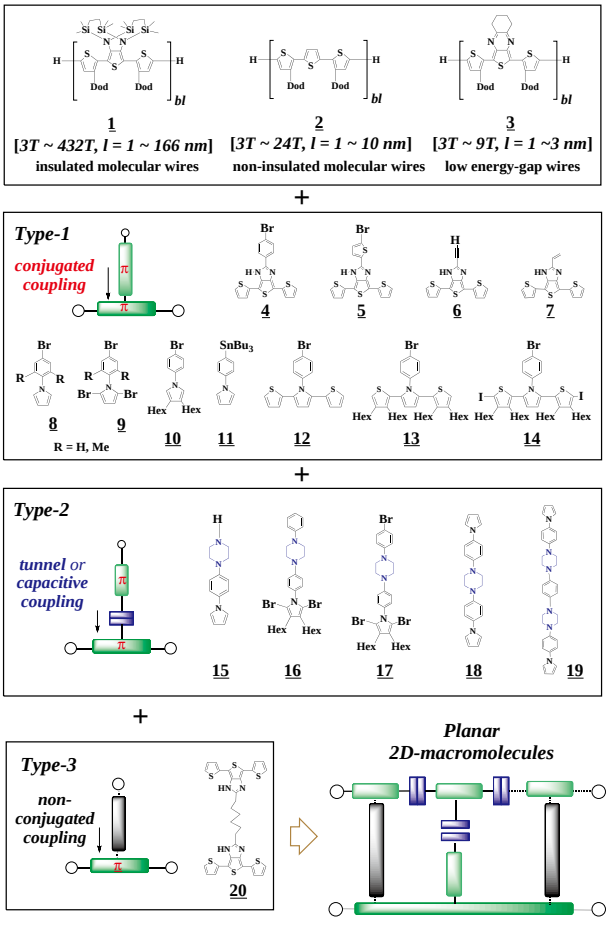

Figure 1. Structures of wire and multi-terminal modules.