# Research Introduction

**profile**
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Graduated from Department of Structural Molecular Science, the Graduate University for Advanced Studies in 1994. Worked as the postdoctoral researcher at the University of Alabama in 1994 and the University of South Carolina in 1995. He became the assistant of the Faculty of Science, OCU in 1997, the lecturer of the Graduate School of Science, OCU in 1999, and the assistant professor of the Graduate School in 2005, and took up his present post in 2015.

## Creation of new π-electron conjugate compounds and the investigation of their functions

### Development of precise macromolecules and the investigation of their functions

Macromolecules that can express the high-level functions required in vital activities are playing active roles in living organisms. For instance, protein complexes of size 10 nm or larger play a significant role in plants' photosynthesis. Protein is made up of a number of accurately arranged atoms to express its functions. It is possible to synthesize macromolecules of the same size as natural ones; however, synthesized macromolecules are incomparable to their natural counterparts in structural accuracy.Meanwhile, state-of-the-art fine processing technologies have enabled the construction of 10 nm-scale microstructures on the surface of semiconductors. Our research team is engaged in the development of technology that can produce 10 nm-scale molecules at will. We aim to create finely designed macromolecules, provide them with similar functions to those of natural ones, and to produce macromolecules that can be used as a single molecule device through being connected with a metal terminal.

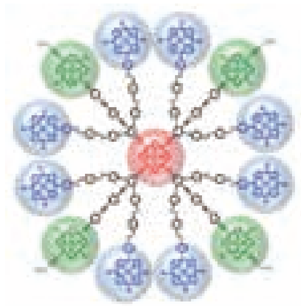

Fig. 1 : A solar light-harvesting antenna

I focus on molecules that belong to the dendrimer group. Dendrimer is a precise macromolecule that has a structure of repetitive branches radiating from the center toward the peripheral area. We designed and established a method of constructing dendrimer molecules that have a characteristic structure of flexible branch chains and rigid straight conjugated chains. At present, we are trying to realize high-level functions by using their flexibility and rigidity. So far, we have succeeded in creating antenna molecules that can efficiently collect solar energy and molecules that can convert light energy to electric energy. [1,2] The rigid structures of these molecules can be used to accurately arrange dye molecules in a three-dimensional space that are required for expressing functions. For example, the antenna molecule shown in Fig. 1 contains three kinds of porphyrin pigments finely arranged. As a result, energy moves from the peripheral parts toward the center with high efficiency. In addition, the rigid structure of conjugated chains functions as a pathway for the efficient transfer of electrons and energy. We aim to develop macromolecules that can express high-level functions comparable to those of natural macromolecules, by accurately arranging a wide range of functional parts in the dendrimer structure.

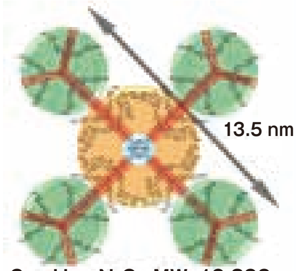


Fig. 2: A cross-shaped dendrimer assembly

We have developed many functional macromolecules using the dendrimer structure. Meanwhile, the protein mentioned earlier is made up of multiple macro sub-units that express high-level functions. Similarly, I assume that it is possible to express high-level functions that cannot be accomplished through a single molecule, by integrating multiple artificial macromolecules and forming an assembly. For this, we need technology that can integrate and arrange macromolecules freely. Therefore, I tried producing a huge dendritic compound by combining the surface ends of dendrimer's rigid structures. [3] Using this method, it is possible to produce an assembly of macromolecules in the same way as assembling a molecule model by using a dendrimer structure that contains an appropriate number and arrangement of conjugated chains. Bonding the macromolecules was more difficult than expected; however we patiently examined a number of reacting conditions and separating conditions, and succeeded in producing a huge dendrimer assembly with a diagonal length of more than 10 nm. (Fig. 2) We further improved our molecule bonding technology, and succeeded in synthesizing dendrimer octamers with a total length of approximately 50 nm. [4] As shown in Fig. 3, the structure of this molecule extends out at high temperatures and folds in at low temperatures. The rigid conjugated chains present characteristic changes in absorption spectra in accordance with the octamer's high-order structural changes. Therefore, the changes in absorption spectra are used to monitor the octamer's high-order structure. We are now trying to express innovative functions using the characteristic high-order structural changes of dendrimer assemblies.

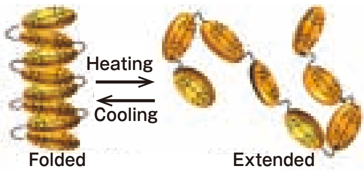


Fig. 3: Dendrimer assembly's high-order structural change

References
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3. M. Kozaki et al. *J. Org. Chem.* 2012, *77,* 9447.
4. S. Nishioka et al. *Org. Lett.* 2015, *17,* 2720.