Charge Transport Behavior of Hybrid Assembly Structures between Gold Nanoparticles and Porphyrin Derivatives

Yuki Noda[1], Shin-ichiro Noro[1, 2], Tomoyuki Akutagawa[1, 2], Takayoshi Nakamura[1, 2]
[1] *Graduate School of Environmental Science, Hokkaido University, N10W5 Kita-ku, Sapporo, 060-0810, Japan*
[2] *Research Institute for Electronic Science, Hokkaido University, N20W10, Kita-ku, Sapporo, 001-0020, Japan*
E-mail: y-noda@es.hokudai.ac.jp

Gold nanoparticle assemblies have attracted much attention because they are expected as building blocks for a new electronic device. A number of studies have been carried out to connect gold nanoparticles using organic molecules, and the electron transport properties of the resulting network structure were evaluated. For example, saturated alkane - gold nanoparticle assemblies showed metal-insulator transitions depending on inter-nanoparticle separation. On the other hand, charge transport mechanisms of nanoparticle assemblies incorporating conjugated moleclules have not been fully understood although they would have remarkable feature arising from the contribution to molecular orbital to the electron conduction. Studies on this subject are expected to open up new applications in the field of molecular electronics.

In this work, we fabricated hybrid assembly structures between gold nanoparticles and porphyrin derivatives, in which macrocyclic rings were expected to attach parallel on gold surface. The electronic transport properties in the temperature range from room temperature to 4 K were investigated using gold electrode with an electrode gap of 30 μm.

Around room temperature, the conductivity of the hybrid assembly structure showed Arrhenius-type behavior. On the other hand, the activation energies at low temperatures were decreased. Non-linear current–voltage characteristics, which corresponded to the collective quantum transport [1] ($I \sim (V/V_{th} - 1)^{\xi}$), was observed below 20 K.

*This work was supported by the Research Fellow of the Japan Society for the Promotion of Science.
[1] Middleton, A. A.; Wingreen, N. S. *Phys. Rev. Lett*. 71 (1993) 3198.