Fabrication of Au-nanoparticle-embedded lipid bilayers on solid substrates

Yokohama National University [1], Tokyo University of Technology [2], Tohoku University [3]

Naotoshi Sakaguchi [1], Yasuo Kimura [2], Ayumi Hirano-Iwata [3], °Toshio Ogino [1],

E-mail: ogino-toshio-rx@ynu.ac.jp

Supported lipid membranes are expected to be new platforms for novel two-dimensional devices operated in aqueous environment because they exhibit unique performance both as electrically insulating films and as substrates for biomolecules and metal-nanoparticle arrays [1,2]. Graphene is a single layer of carbon atoms with high conductivity and expected to be high-performance two-dimensional electrodes in nanodevices. Figure 1 shows one of the ideal structures for nanodevices that consists of molecular sheets as a fluidic substrate, graphene sheets as electrodes, and two-dimensional metal-nanoparticle sheets.

Au-nanoparticles (Au-NPs) were incorporated into lipid vesicles by hydrophobization of the Au-NP surfaces. Au-NP-embedded lipid bilayers supported on solid surfaces were fabricated by the vesicle-vesicle fusion, in which the Au-NP-embedded vesicles are adsorbed to the substrate, ruptured and fused, or by the vesicle-membrane fusion, in which the Au-NP-embedded vesicles are fused into preformed Au-NP-free supported lipid bilayers. The Au-NP incorporation was observed by atomic force microscopy (AFM) and transmission electron microscopy. Figure 2 shows an AFM image of lipid bilayer islands formed by the vesicle-vesicle fusion, where the Au-NPs are incorporated into the islands observed in the lower area. The Au-NPs form two-dimensional particle sheets with a uniform particle density in lipid bilayers. Au-NP-embedded lipid bilayers can be fabricated also by the vesicle-membrane fusion illustrated in Figure 3. We found that vesicle approach control by addition of charged lipids and destabilization of the lipid bilayers by addition of lipids with a small polar head group are key techniques in this method.

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[3] Yamazaki, et al., J. Phys. Chem. C 117 (2013) 18913.

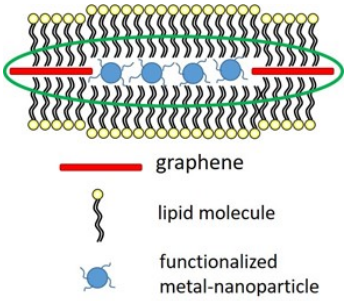

Fig. 1. Concept of a two dimensional fluidic device consisting of atom-, molecule- and nanoparticle-sheets.

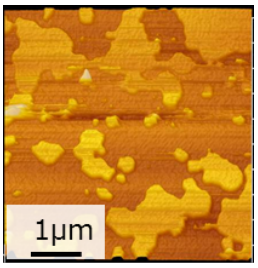

Fig. 2. AFM image of lipid bilayer with (lower area) and without (upper area) Au-nanoparticles on a SiO_2/Si substrate.

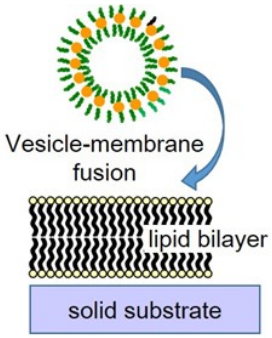

Fig. 3. Illustration of the vesicle-membrane fusion.