【助成 38 -27】

リポソームとナノフォトニック共振器のインタフェース

研究者　東京理科大学　理学部　准教授　Sadgrove　Mark　Paul

〔研究の概要〕

Liposomes are biological nano-particles made from lipid bilayers. Liposomes have the same structure as cells, but they do not have a cell nucleus. For this reason, liposomes make an excellent test platform to develop manipulation techniques for living cells, and other bio-particles such as exosomes. In this research project, the applicant's goal was to create a nanophotonic platform to **i)** Transport and trap liposomes on a nanowaveguide (optical nanofiber) and **ii)** couple the liposomes to a nanowaveguide cavity. These novel techniques could provide new opportunities for diagnosis of diseases, or the realization of biological systems in quantum regimes.

〔研究経過および成果〕

Background: Liposomes are biological nano-particles made from lipid bilayers as shown in Fig 1. Liposomes have the same structure as cells, but they do not have a cell nucleus. For this reason, liposomes make an excellent test platform to develop manipulation techniques for living cells, and other bio-particles such as exosomes. Use of nanowaveguides will allow the development of integrated optical circuits for trapping, transport and analysis of nanoparticles. This method could allow new miniaturized technology for analysis of bio-nanoparticles. However, for bio-nanoparticles such as liposomes, two large problems exist: **i)** particles adhere to the nanowaveguide surface and **ii)** particles are very difficult to trap because of very low refractive index.

In this research project, we proposed the creation of a nanophotonic platform to **i)** Transport and trap liposomes on a nanowaveguide (optical nanofiber) (see Figure 1) and **ii)** couple the liposomes to a nanowaveguide cavity. Below, we will detail our achievements related to this project.

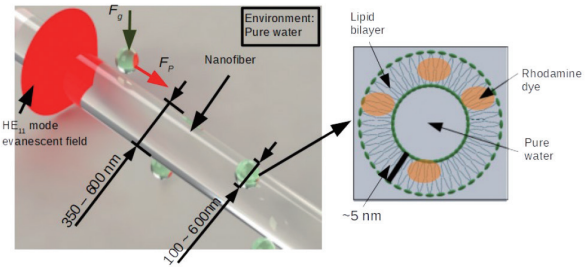

Figure 1：*Concept of trapping and transporting of liposomes using an optical nanofiber.*

Research results

In December 2021, we reported the first use of an nanowaveguide (an optical nanofiber) to transport Liposomes. These liposomes had a sub-micron diameter (size distribution shown in Fig. 2(a)), making them the same size as liposomes used for typical applications in medical drug development, etc. Our method of manipulation is very simple, as shown in Fig. 2(b). An optical nanofiber (diameter 300 ~ 550 nm)

made from a commercial optical fiber is placed in a droplet of water containing liposomes. The liposomes are optically trapped in the evanescent field of the nanofiber by injecting a 785 nm laser into the fiber. A 540 nm laser is also introduced to make the dye-tagged liposomes photoluminescence (PL) so that they can be imaged. Optical trapping and transport are viewed as shown in Fig. 2(c) where a liposome moves along the fiber in the same direction as the optical mode. These images are focused using an objective lens (OL) and recorded on a standard CMOS digital camera. Our results showed that thinner nanofibers performed more efficiently to trap and transport liposomes, with 360 nm diameter fibers showing higher transport speeds and longer trap times compared to a 550 nm diameter fiber. We also analyzed the experiment theoretically, and our results suggested that most of the observed behavior could be explained by optical forces as opposed to heating effects. These results were reported in Optics Letters in 2021 [1] and at conferences in the same year [2-4]. Our future plans involve the use of bottle resonators which we realized in 2021 [5]. We plan to trap liposomes near to the resonator using a taper trap [6].

〔発表論文〕

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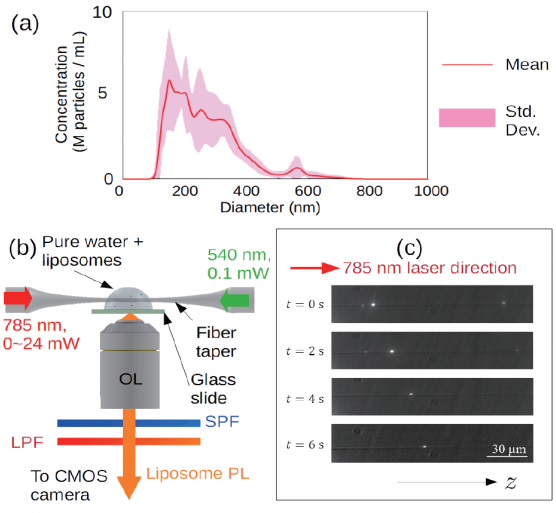

Figure 2 (a) *Liposome size distribution.* (b) *Experimental setup.* (c) *Frames of movie showing liposome trapping and transport.*