“Intracellular temperature imaging using polymeric thermometer and quantitative microscopy”

Kohki Okabe, Ph.D.
Assistant Professor, Graduate School of Pharmaceutical Sciences, University of Tokyo; JST, PRESTO

[abstract]
Temperature is a fundamental physical quantity that governs every biological reaction within living cells, and intracellular temperature reflects cellular thermodynamics and function. In medical studies, the cellular pathogenesis of diseases (e.g., cancer) is characterized by extraordinary heat production. Therefore, intracellular temperature imaging of living cells should promote better understanding of cellular events and the establishment of novel diagnoses and therapies. Here we report our thermometric methods for the monitoring and imaging of intracellular temperature based on a fluorescent polymeric thermometer and quantitative fluorescence imaging techniques. The fluorescent polymeric thermometer has several advantages in intracellular temperature measurement such as biocompatibility (i.e., size, sensitivity, and solubility) and functional independence (i.e., negligible interactions with cellular components), enabling intracellular temperature measurement in single living cells. The spatial and temperature resolutions of our thermometry were at the diffraction limited level (200 nm) and 0.2 °C, respectively. We first performed tracking of the averaged temperature of a single whole cell and showed that the averaged temperature of single COS7 cells significantly varied in association with biological processes such as apoptosis. Next, we developed a novel method to visualize intracellular temperature distribution, indicating non-homogeneous temperature distribution in steady-state living cells. Furthermore, we have investigated intracellular thermogenesis: both temperature monitoring and imaging showed that uncoupling of mitochondria allowed the local temperature increase, suggesting that mitochondria undertakes thermogenesis in living cells. Heating the cells with an external infra-red laser was also conducted and the visualization of intracellular temperature increase was detected with our thermometry. Therefore, our intracellular temperature imaging will contribute to uncover an important connection between intracellular temperature and cell functions.