Nano-scale temperature measurements using anisotropy-based nanothermometers for cancer theranostics

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Temperature is a crucial parameter in biology, medicine, and physics. Because of that, in the last years, several methods have been developed and presented to measure nanoscale temperature. Optical methods excel because they are non-invasive, spatially accurate and can measure real-time local changes in temperature. Among these, fluorescence anisotropy-based methods are particularly advantageous because they are less affected by changes in the probe concentration and irradiation conditions. Here we present intracellular temperature measurements in cancer cells and live organism using the green fluorescent protein (1,2) and a method to add thermosensitivity to any protein thereby transforming them into nanothermoters (3). The method consists of covalently attaching a dye to the protein, which increases the rotational time of the dye-protein system compared to the free dye, and confers thermosensitivity to the resulting bioconjugates. With this method, we transformed bovine serum albumin, glucose oxidase and catalase into nanothermoters. This also allowed us to analyze the anisotropy signal changes occurring during the catalytic cycle of catalase, as well as their correlation with the reaction exothermicity. In addition, it will also be presented the theoretical model that predicts the optimal sensitivity for anisotropy-based thermometers based on protein size and dye fluorescence lifetime (4). Using this model, most of the proteins and dyes can be converted to nanothermometers. The utilization of these nanothermometers by a broad spectrum of disciplines within the scientific community will bring new knowledge and understanding that today remains unavailable with current techniques.

References

(1) Mapping intracellular temperature using green fluorescent protein SA Thompson et al, Nano letters 12 (4), 2012
(2) Imaging of plasmonic heating in a living organism SA Thompson et al, ACS nano 7 (10), 2013
(3) Plug and Play Anisotropy-Based Nanothermometers SA Thompson, et al ACS Photonics 5 (7), 2018
(4) Universal guidelines for the conversion of proteins and dyes into functional nanothermometers G Spicer et al, Journal of biophotonics 2019