'Nanotorch' highlights ultrafast biochemical reactions

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Life depends on remarkable arrays of biochemical reactions. Understanding the workings of biomolecules involves real-time monitoring of these reactions. Happening in only tiny fractions of a millisecond, this is very difficult even with highly sensitive optical instruments. Therefore, Ph.D. researcher Yuyang Wang uses a 'plasmonic nanotorch," a single metal nanoparticle that illuminates single fluorescent molecules, making it possible now to detect those ultrafast biochemical reactions. Wang defends his Ph.D. on 19 June.

Biochemical reactions, especially those involving enzymes, are what makes life possible. The study of these reactions forms the basis of modern biophysical sciences, and a wealth of information has been revealed on the length- and timescales involved. Until recently, biomolecules and their interactions were studied at the ensemble level, where many molecules are studied on timescales much longer than in a biochemical reaction.

Tackle the biological puzzles

Single-molecule fluorescence microscopy (SMFM) is an essential tool in gaining biological insight into complex molecular systems where high temporal and spatial resolutions are required. Using SMFM, one can tackle the biological puzzles that are traditionally impossible to solve. This is because single-molecule sensitivity gives access to time-to-time and molecule-to-molecule differences associated with complicated

biological processes, which are hidden in ensemble-level observations.

However, the temporal resolution of SMFM is limited by the brightness of single molecules due to their intrinsic fluorescence saturation at high laser power. New approaches to enhance the brightness are urgently needed to expand the applications of SMFM to faster regimes. Yuyang Wang explored therefore the use of single gold nanoparticles to increase the maximum brightness of single molecules.

Nanoscale antennas

Noble metal nanoparticles, gold or silver particles sized smaller than 100 nanometers, behave like nanoscale antennas. Fluorescence molecules that are in the vicinity of these particles are significantly affected and appear much brighter as if being lighted up by a "plasmonic nanotorch." Wang paid special attention to the saturation behavior of single molecules near plasmonic particles, since saturation limits brightness. He found that single plasmonic nanoparticles modify the saturation behavior and boost the maximum brightness of single molecules by up to hundreds of times. He also developed a systematic approach both in theory and in practice to work with these nanoparticles.

For the first time single plasmonic nanotorches are now initially applied to the detection of fluorogenic enzyme reactions, a significant step of pushing fluorescence enhancement to the field of single-molecule enzymology. Wang's research advances the understanding of plasmon-enhanced fluorescence and paves the way for studying fast biomolecular processes.

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