New Optical Tweezers Put on the Pressure to Change Color

2022-03-02

Osaka City University creates new trapping technique using "optical tweezers" modified with nanotextured black silicon and a perylene-modified polymer solution and demonstrates a fully reversible remote control of color.

Scientists demonstrate an optical trapping technique using nanotextured black silicon that can efficiently trap polymer chains. By adjusting the laser intensity, these "optical tweezers" can control the florescence color emitted through a local concentration of a perylene-modified polymer solution. From a low intensity blue to high intensity orange, this reversible and fully remote technology can almost reach the entire RGB spectrum.

One big stumbling block in the field of photonics is that of color control. Until now, to control color, i.e. the wavelength of light emission, researchers would have to alter the chemical structure of the emitter or the concentration of the solvent – all of which require direct contact, greatly limiting their application.

"Such conditions make it impossible to change color quickly, use it as a light source in microscopic spaces like a cell, or in closed systems where exchange is not an option," says Yasuyuki Tsuboi and professor of the Department of Chemistry, Osaka City University. With "optical tweezers", a technology he developed in previous research, Prof. Tsuboi led a team of researchers to show it possible to control the luminescence color remotely, using only the effect of light pressure.

Their findings were recently published online in the German international journal Angewandte Chemie Intl.

For years, Professor Tsuboi and his colleagues have been conducting research on a technology that can capture and manipulate nano- and micrometer-sized materials with a laser. In exploring this “optical tweezers” technology, they found that when a silicon crystal with a special needle-shaped nanostructure, called black silicon, was submerged in a sample solution, the optical field enhancement effect of the nanostructure trapped a perylene-modified polymer, causing a local concentration of the solution to increase and form an aggregate of polymers.

“When the concentration of the perylene increases, it forms a dimeric excited complex called an excimer,” explains lead author Ryota Takao. These excimers emit fluorescence that changes color depending on the degree of concentration.

This is what the research team investigated in prior trapping experiments that did not employ a trapping laser. Here they found that as the laser beam intensity increased, light pressure did as well, which caused the concentration of the polymer aggregate on the black silicon to become denser – and vice versa.

“We observed the color of the fluorescence emitted by the polymer aggregate change in response to this,” explains Prof, Tsuboi, “with low intensities producing blue, and then changing to green, yellow, green yellow, to orange as the intensity increases.” As the laser intensity is what is being controlled, the color change is fully reversible and able to be done remotely.

While the research is still in its infancy, it relies on excited complexes and excitation energy transfer, which means potential applications in ultraviolet and near-infrared regions, in addition to the visible realm. The research team is currently promoting further research in the direction of encapsulating the perylene-modified polymer solution to be used as a light source in micromachine components and intracellular bioimaging.

Read the original article on Osaka City University.