# Nanotubes as optical stopwatch for the detection of neurotransmitters

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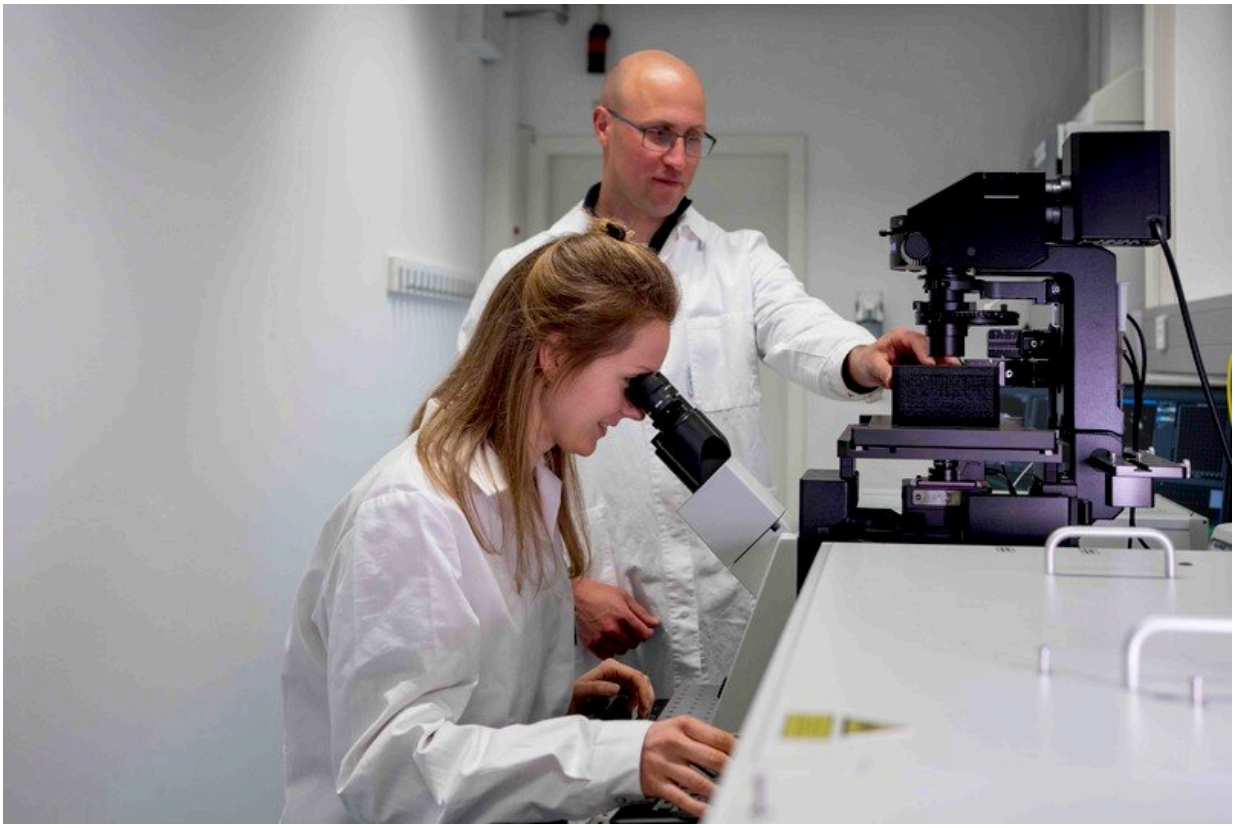

The researchers visualize neurotransmitters with the help of carbon nanotubes. Credit: RUB, Kramer

Carbon nanotubes not only shine brighter in the presence of dopamine, but also for longer. The time period of the shining serves as a new

parameter to detect biological messenger substances.

An interdisciplinary research team from Bochum and Duisburg has found a new way to detect the important neurotransmitter dopamine in the brain. The researchers used carbon nanotubes for this purpose. In earlier studies, the team led by Professor Sebastian Kruss had already shown that the tubes glow brighter in the presence of dopamine. Now the interdisciplinary group showed that the duration of the glow also changes.

"This is the first time that such an important messenger substance as dopamine has been detected in this way," says Sebastian Kruss. "We are confident that this will open up a new platform that will also enable better detection of other human messenger substances such as serotonin." The work was a collaboration between Kruss' two research groups in physical chemistry at Ruhr University Bochum, Germany, and the Fraunhofer Institute for Microelectronic Circuits and Systems (IMS).

The results are described by a team around Linda Sistemich and Sebastian Kruss from Ruhr University Bochum together with colleagues from the IMS and the University of Duisburg-Essen in the journal *Angewandte Chemie International Edition*, published online on March 9, 2023.

## With dopamine, the nanotubes shine brighter and longer

The sensors used are tubes made of carbon that are 100,000 times thinner than a human hair. If they are irradiated with visible light, they can even emit light in the near-infrared range, at a wavelength of 1,000 nanometers, which is not visible to humans.

Previous studies led by Sebastian Kruss had shown that certain carbon nanotubes modified with biopolymers glow brighter when they come into contact with certain biomolecules such as dopamine. In the new study, the researchers observed how long it takes for the nanotubes to emit this light in the near-infrared. To do this, the researchers observed the emitted light as individual light particles.

Using a stopwatch, they recorded the time it took for the light particles to travel from the moment the nanotube was irradiated to the moment the light particles were released by the nanotube. "We need special stopwatches to measure such a time span, because the emission of light is 100 million times faster than the blink of a human eye," Linda Sistemich clarifies.

This so-called lifetime of light is characteristic for different substances and represents a more robust signal compared to brightness. While the brightness depends on how many layers of cells the light has to pass through before it can be measured, this does not affect the lifetime of the light. Because each individual light particle carries the information about the lifetime, each measured particle is an increase in information, regardless of how many particles are measured.

"This is particularly advantageous if, like us, you not only measure in simple aqueous solutions, but also in complicated environments such as in cell culture or in the organism itself," explains Sebastian Kruss, who heads the Functional Interfaces and Biosystems group at Ruhr University and is a member of the Cluster of Excellence Ruhr Explores Solvation (RESOLV) and the International Graduate School of Neuroscience. In this work, dopamine release from single cells was recorded. However, the method is also applicable to networks of cells or organisms.

The detected dopamine is an important messenger substance in the human brain through which the cells communicate with each other.

Dopamine not only controls the reward center, but is also the driving force for movement, coordination, concentration and mental performance. When too little dopamine is released, movement disorders and declining memory can occur—symptoms that are present, for example, in Parkinson's disease.

**More information:** Linda Sistemich et al, Near-Infrared Lifetime Imaging of Biomolecules with Carbon Nanotubes, *Angewandte Chemie International Edition* (2023). DOI: 10.1002/anie.202300682

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