

Novel sensors enable precise measurement of dopamine

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Sebastian Kruss (right) and Björn Hill are part of the team that was able to directly measure the neurotransmitter dopamine. Credit: RUB 25 May 2022

Dopamine is an important signaling molecule for nerve cells. Its concentration could not be precisely determined with both high spatial or

temporal resolution until now. A new method has now made this possible: A research team from Bochum, Göttingen and Duisburg used modified carbon nanotubes that glow brighter in the presence of the messenger substance dopamine.

These sensors visualize the release of dopamine from [nerve cells](#) with unprecedented resolution. The researchers headed by Professor Sebastian Kruss from the Physical Chemistry Department at Ruhr-Universität Bochum (RUB) and Dr. James Daniel as well as Professor Nils Brose from the Max Planck Institute for Multidisciplinary Sciences in Göttingen report on this in the journal *PNAS* from 25 May 2022.

Fluorescence changes in the presence of dopamine

The [neurotransmitter dopamine](#) controls the brain's reward center, among other things. If this [signal transmission](#) no longer functions, it can lead to disorders such as Parkinson's disease. Moreover, the [chemical signals](#) are altered by drugs such as cocaine and play a role in substance abuse disorders. "However, until now there was no method that could simultaneously visualize the dopamine signals with high spatial and [temporal resolution](#)," explains Sebastian Kruss, head of the Functional Interfaces and Biosystems Group at RUB and a member of the Ruhr Explores Solvation Cluster of Excellence (RESOLV) and the International Graduate School of Neuroscience (IGSN).

This is where the novel sensors come into play. They are based on ultra-thin carbon tubes, about 10,000 times thinner than a [human hair](#). When irradiated with visible light, they glow in the near-infrared range with wavelengths of 1,000 nanometers and more. "This range of light is not visible to the human eye, but it can penetrate deeper into tissue and thus provide better and sharper images than [visible light](#)," says Kruss. In addition, there are far fewer background signals in this range that can distort the result.

"We have systematically modified this property by binding various short nucleic acid sequences to the carbon nanotubes in such a way that they change their fluorescence when they come into contact with defined molecules," explains Sebastian Kruss. This is how his research group has succeeded in turning carbon nanotubes into tiny nanosensors that specifically bind to dopamine and fluoresce more or less strongly depending on the dopamine concentration. "We immediately realized that such sensors would be interesting for neurobiology," says Kruss.

Coating healthy nerve cells with a sensor layer

In order to do this, the sensors have to be moved into the vicinity of functioning neuronal networks. Dr. Sofia Elizarova and James Daniel from the Max Planck Institute for Multidisciplinary Sciences in Göttingen developed cell culture conditions for this, in which the nerve cells remain healthy and can be coated with an extremely thin layer of sensors. This allowed the researchers to visualize individual dopamine release events along neuronal structures for the first time and gain insights into the mechanisms of dopamine release.

Kruss, Elizarova and Daniel are confident that the new sensors have [enormous potential](#): "They provide new insights into the plasticity and regulation of dopamine signals," says Sofia Elizarova. "In the long term, they could also facilitate progress in the treatment of diseases such as Parkinson's." In addition, further sensors are currently being developed with which other signaling molecules can be made visible for example to identify pathogens.

More information: Sofia Elizarova et al, A fluorescent nanosensor paint detects dopamine release at axonal varicosities with high spatiotemporal resolution, *Proceedings of the National Academy of Sciences* (2022). [DOI: 10.1073/pnas.2202842119](https://doi.org/10.1073/pnas.2202842119)

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