Carbon nanotubes study finds local solvation is decisive for fluorescence of biosensors

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Carbon nanotubes develop their fluorescence through interactions with the surrounding aqueous solution. Credit: RUB, Juliana Gretz

At Ruhr University, the groups of Professor Martina Havenith and Professor Sebastian Kruss collaborated for a new study, which took
place as part of the Cluster of Excellence "Ruhr Explores Solvation," or RESOLV for short. Ph.D. students Sanjana Nalige and Phillip Galonska also made significant contributions to the research, now published in *Nature Communications*.

Single-walled carbon nanotubes are powerful building blocks for biosensors, as previous studies have revealed. Their surface can be chemically tailored with biopolymers or DNA fragments to interact specifically with a certain target molecule.

When such molecules bind, the nanotubes change their emission in the near-infrared range, which penetrates deep into tissue. This way, for example, the presence of certain neurotransmitters, i.e., messenger substances in the brain, can be detected. Although such sensors are already in use, their exact functional principle has been unclear.

Because most relevant biological processes take place in water, the researchers analyzed the carbon nanotubes in an aqueous solution. Using terahertz spectroscopy, they were able to detect how energy flows between the carbon nanotubes and water.

The decisive factor is the hydration shell of the biosensors, i.e., the water molecules surrounding the nanotubes. When a carbon nanotube is excited, the internal energy can couple to the vibrations of the hydration shell.

Energy flows between the water and the nanotubes: Sensors that become brighter in the presence of the analyte transfer less energy into the water. In contrast, sensors that become dimmer transfer more energy into the water.

"Terahertz spectroscopy allows us to measure directly what we had previously only suspected," says Sebastian Kruss. "These insights
provide a general and rational design principle to develop optimal biosensors with the best performance for novel applications in research and medicine."

Martina Havenith, spokesperson of the Cluster of Excellence RESOLV, adds, "In this interdisciplinary study, we did not put the spotlight on the carbon nanotube itself. Instead, we put the spotlight on the solvent, water, and discovered a previously unknown direct correlation with the changes in the water around the carbon nanotube and the function as a biosensor. This is exactly what RESOLV stands for."

**More information:** Sanjana S. Nalige et al, Fluorescence changes in carbon nanotube sensors correlate with THz absorption of hydration, *Nature Communications* (2024). DOI: [10.1038/s41467-024-50968-9](https://doi.org/10.1038/s41467-024-50968-9)

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