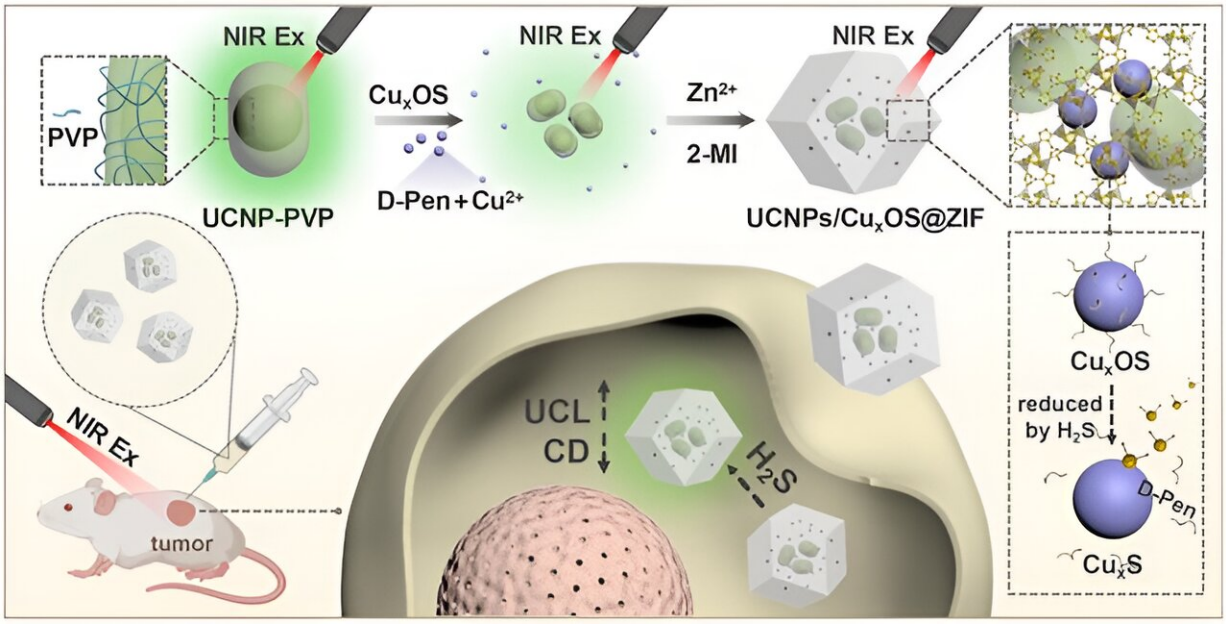
Chiral nanocomposite for highly selective dual-mode sensing and bioimaging of hydrogen sulfide

August 6 2024



The designed UCNPs is encapsulated in ZIF-8 along with Cu_xOS nanoparticles. Due to the quenching of UCL by Cu_xOS, the UCL signal of UCNPs/Cu_xOS@ZIF nanocomposite probe under 980 nm excitation is weak. At this time, the probe showed a significant CD signal due to Cu_xOS. When H_2S exists in the detection environment, the destruction of Cu_xOS by H_2S weakens the CD signal of the probe, while the UCL signal of UCNPs is restored. Based on this principle, UCL/CD dual-mode sensing against H_2S is realized in vitro. At the same time, as one of the typical biomarkers of cancer, the high expression of H_2S in the tumor also enhances the UCL signal of the probe inside the tumor, achieving bioimaging in vivo. Credit: Yang Lu, Xu Zhao, Dongmei Yan,

Yingqian Mi, Peng Sun, Xu Yan, Geyu Lu, and Xiaomin Liu.

With the continuous development of nanotechnology, more artificial chiral nanomaterials have been constructed. As one of the most representative optical properties of these chiral nanomaterials, circular dichroism (CD) is a powerful sensing technology. Compared with other analytical methods, CD signal has higher sensitivity, but it cannot achieve in-situ imaging in vivo.

Scientists have managed to prepare chiral nanocomposites with more diverse biological functional properties to compensate for this shortcoming. However, some chiral nanocomposites assembled by electrostatic adsorption or other methods are easily dissociated and destroyed in complex physiological environments, resulting in performance deviations.

In addition, it is difficult for some nanocomposites to distinguish interferences with properties similar to the analyte, resulting in poor detection selectivity. Therefore, it is still a challenging task to develop chiral composite nanomaterials with stable structure and excellent properties to meet the needs of biomedical diagnosis and detection.

In a paper published in *Light: Science & Applications*, a team of scientists, led by Professor Geyu Lu from State Key Laboratory of Integrated Optoelectronics, College of Electronic Science and Engineering, Jilin University, China and co-workers have developed a UCNPs/Cu_xOS@ZIF nanocomposite probe used for in vitro UCL/CD dual-mode sensing for H_2S and in vivo imaging.

In this probe, upconversion nanoparticles (UCNPs) and chiral Cu_xOS nanoparticles are encapsulated in zeolitic imidazolate framework-8

(ZIF-8).

The reduction of Cu_xOS by H_2S leads to changes in Cu_xOS absorption and CD signal, which enables the change in UCL and CD signals of the probe. UCL/CD dual-mode sensing for H_2S was realized in vitro.

At the same time, UCNPs enable in situ imaging of living tumor-bearing mice. The construction of UCNPs/Cu_xOS@ZIF dual-mode nanoprobes makes chiral sensing a more advantageous tool in biological detection, and provides a new idea for the application of multi-functional chiral nanomaterials in biomedicine.

UCNPs/Cu_xOS@ZIF as a designed chiral nanocomposite, can effectively eliminate the influence of interference in the detection environment, and achieve highly selective sensing for H_2S. The scientists summarized the probe's "selection" process for H_2S:

"The realization of this 'selection' actually comes from ZIF-8, which we designed as an encapsulation shell for the entire nanocomposite, not only to stabilize the composite, but more importantly, to use its unique pore structure to enable it to function as a gas molecular sieve."

"In short, H_2S molecules easily enter the inside of ZIF-8, while other molecules are isolated from the outside, thus resolving some common molecular influences on probe sensing to a certain extent."

"Without the encapsulation of ZIF-8, reductive substances such as L-Cys, L-Lys, and GSH can also alter the UCL and CD signals of the probe, and this effect is extremely unfavorable for the evaluation of the sensing performance of the probe," they added.

"The assembly idea used in this nanocompositeprobe can be applied to the assembly of other kinds of composite. As long as the design is

reasonable, more diversified multi-functional chiral composites can be prepared, creating more possibilities for the application of chirality in the field of biosensing, bioimaging and biotherapy, " the scientists forecast.

More information: Yang Lu et al, Upconversion-based chiral nanoprobe for highly selective dual-mode sensing and bioimaging of hydrogen sulfide in vitro and in vivo, *Light: Science & Applications* (2024). DOI: 10.1038/s41377-024-01539-6

Provided by Chinese Academy of Sciences