

## Nitro-explosives detection realized by coresheath pillar architecture

October 12 2022, by Liu Jia



Design of the CSP architecture and the specific interaction. (a) Design of visiblelight-activated CSP (TiO<sub>2</sub>, NH<sub>2</sub>-MIL-125) chemiresistive material for nitroexplosive detection at RT. (b) Schematic of the structure of NH<sub>2</sub>-MIL-125 and the specific interaction of its organic ligand with nitro-explosives (golden ball:



the cavity of NH<sub>2</sub>-MIL-125). Credit: *National Science Review* (2022). DOI: 10.1093/nsr/nwac143

To create an artificial structure that surpasses the sensitivity, selectivity, and speed of the olfaction system of animals is a challenge.

In a study published in *National Science Review*, researchers at Fujian Institute of Research on the Structure of Matter of the Chinese Academy of Sciences, Beijing Institute of Technology and Kyoto University presented a new paradigm of a core-sheath pillar (CSP) architecture with a perfect synergistic interface that effectively integrates the advantages of metal organic frameworks (MOFs) and <u>metal oxides</u> (MOs) to tackle the above-mentioned challenge.

The researchers coated NH<sub>2</sub>-MIL-125, crystalline microporous material with a <u>high affinity</u> to analytes, on the surface of  $TiO_2$  nanowires with a corndog-like core-sheath pillar (CSP) architecture. NH<sub>2</sub>-MIL-125 adsorbs selectively and locally concentrates target molecules, while  $TiO_2$  provides the <u>active sites</u> for the sensing reaction and conducts the electrical sensing signal.

The essential question of CSP (MO, MOF) is how to create a perfect energy-band-matched MOF/MO interface that can effectively generate and separate light-excited charge carriers to produce active oxygen species.

The researchers developed a two-step seed-assisted solvothermal method to fabricate this type of CSP architecture, the desired visible-light-active and analyte-accessible MOF/MO interface was achieved by  $NH_2$ -MIL-125 coupled with TiO<sub>2</sub>. They not only revealed the novel structure of CSP TiO<sub>2</sub>,  $NH_2$ -MIL-125), but also solved fundamental



scientific issue in sensing community. It is for the first time that oriented MOF material can be grown on to nanostructured material to realize aligned microchannels.

The researchers clarified that the orientation is a critical factor for MOF material in the application requiring both fast mass and charge transport. With the elaboratively designed structure, CSP TiO<sub>2</sub>, NH<sub>2</sub>-MIL-125) showed excellent parameters of the sensing architecture used for explosive analytes.

The fabricated device showed experimentally reached limit of detection (~0.8 ppq, hexogeon) is  $10^3$  times lower than the lowest one achieved by sniffer dog or all sensing techniques without analyte pre–concentration. CSP TiO<sub>2</sub>, NH<sub>2</sub>-MIL-125) achieved non-contact and real-time detection of hexogen with an amount as low as 5 mg and a distance as long as 8 m. It also exhibited remarkable selectivity and stability, and short response times of 0.14 min.

This study combines fundamental understanding of a sensing mechanism with practical chemical threat detection. In a broader perspective, the marriage of MOs with MOFs provides a <u>paradigm shift</u> in designing exceptional high-performance of sensing materials for promoting the development of next-generation sensing techniques.

**More information:** Wei-Hua Deng et al, Non-contact real-time detection of trace nitro-explosives by MOF composites visible-light chemiresistor, *National Science Review* (2022). DOI: 10.1093/nsr/nwac143

Provided by Chinese Academy of Sciences



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