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Commentary | *Open Access*

Commentary on Terahertz reconfigurable metasensor for specific recognition multiple and mixed chemical substances based on AIT fingerprint enhancement

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In the terahertz band, large molecular proteins and other substances exhibit direct characteristic absorption due to the vibrational energy levels of intermolecular chemical bonds, such as van der Waals bonds and hydrogen bonds, falling within the terahertz range. When metamaterial structures interact with the substances being detected, the principle of absorption-induced transparency (AIT) causes narrowband absorption peaks of the detected substances to appear within the broadband resonance generated by the metamaterial structure itself. The emergence of these narrowband absorption peaks indicates the presence of the detected substances, thus allowing these peaks to be understood as the "fingerprint" of the substances. However, previously designed metamaterial structures could only detect the fingerprint spectra of one biochemical substance at a time, posing a significant challenge for the simultaneous detection of multiple and mixed biochemical substances.

A research team led by Professor Lin Chen from the University of Shanghai for Science and Technology published a paper titled "Terahertz reconfigurable metasensor for specific recognition of multiple and mixed chemical substances based on AIT fingerprint enhancement" in the journal *Talanta* [1]. The team proposed a reconfigurable terahertz "target-ring structure" sensor capable of simultaneously detecting multiple biochemical substances and their mixtures. In this "target-ring structure," each "ring" corresponds to the dipole resonance frequency of a specific biochemical substance's fingerprint spectrum. Therefore, by determining the number of rings in the target-ring structure, it is possible to simultaneously detect the fingerprint spectra of multiple and mixed trace substances. In their proof-of-concept experiment, the team designed a "five-ring" structure and selected four food safety-related chemical substances—α-lactose (a baby food diluent), benzoic acid (a preservative), vitamin B2 (an important dietary ingredient), and 2,5-dichloroaniline (a key pesticide compound)—along with their mixtures. Using a circuit model combined with parameter optimization between the rings, the team precisely

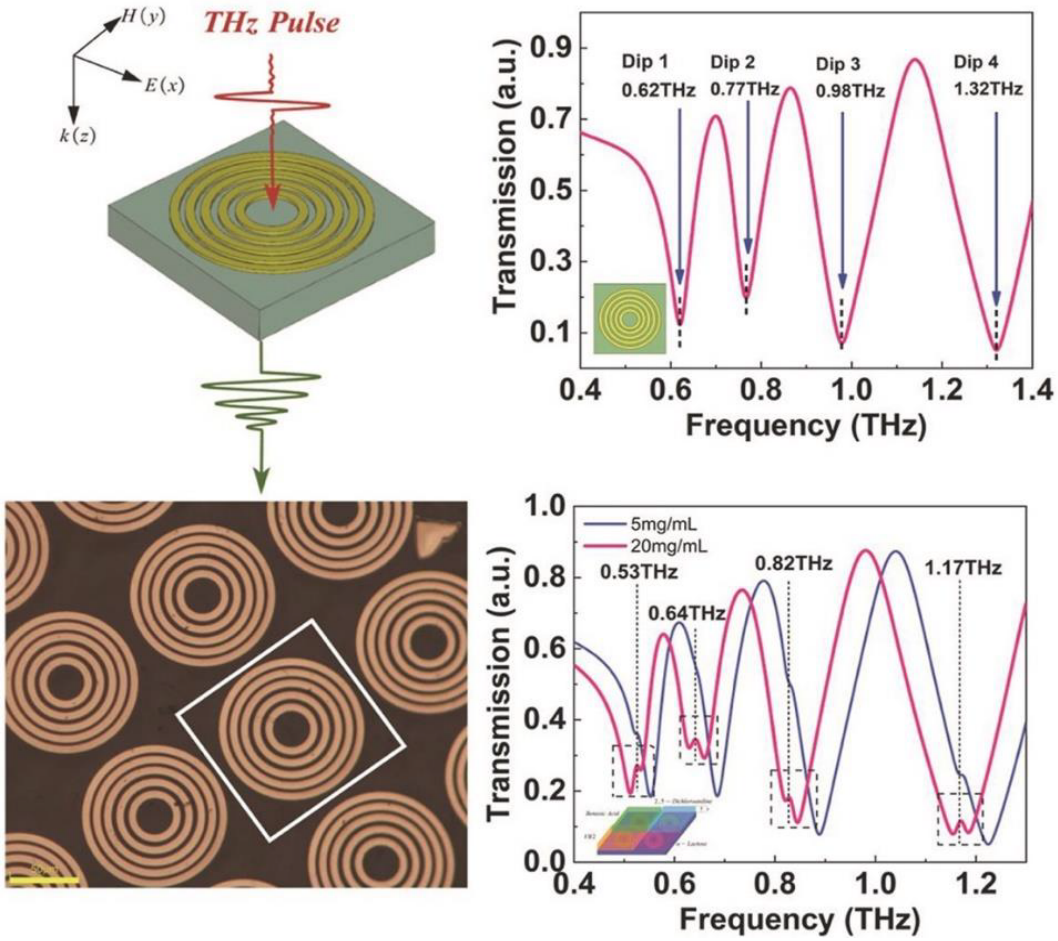

Figure 1:

determined the resonance frequencies of the rings to match the fingerprint spectra of the aforementioned food safety-related chemical molecules. This allowed the AIT effect to be excited at the respective fingerprint frequencies, enabling the specific recognition of the molecules and their mixtures. The experimental detection limits for the four chemical substances were 8.61 mg/ml, 6.96 mg/ml, 7.54 mg/ml, and 8.35 mg/ml, respectively. Further analysis using one-way ANOVA showed that the probability of detection errors for the four substances was less than 0.001.

In summary, this "target-ring structure" matches the dipole resonance frequencies of different rings with the fingerprint spectra of various biochemical substances, utilizing the AIT effect to achieve simultaneous detection and identification of multiple trace biochemical molecules' terahertz fingerprint spectra. The unique feature of this structure is its ability to customize the number of rings and their spacing in the "target-ring" based on the fingerprint spectra of different biochemical substances, enabling a "reconfigurable" function. The "target-ring structure" proposed by the research team can also be extended to applications such as trace drug component detection and environmental monitoring of trace solid waste, demonstrating broad application prospects.

10. References

1. Lihao Huang, Hongyan Cao, Lin Chen*, Yi Ma, Yihan Yang, Xiaoyang Liu, Wenqi Wang, Yiming Zhu, Songlin Zhuang, Terahertz reconfigurable metasensor for specific recognition multiple and mixed chemical substances based on AIT fingerprint enhancement, Talanta 269, 125481 (2024).