DETECTION AND IDENTIFICATION OF EXPLOSIVES AND ILLICIT DRUGSBY TERAHERTZ SPECTROSCOPY TECHNOLOGY

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1. Introduction

Events over the past decade have demonstrated the need for ever more effective security screening and contraband detection against an increasing number of threats and substances [1]-[4]. In this paper, we have researched the RDX, γ-HNIW, DNT, MA, PETN, Semtex-H and Ketamine to find the characteristic of those materials. Furthermore, the RDX, PETN, Semtex-H, Ketamine have been studied in the frequency range. In order to identify the explosive and illicit drug efficiently with high accuracy, the fuzzy neural network is applied to our work.

2. EXPERIMENTAL SETUP

In our work, six kinds of explosives and three kinds of illicit drugs are studied. We have utilized the method of the free-space electric –optical sampling to measure the time resolution spectra of those nine compounds and obtained their absorption spectra after the data processing.

THz time-domain spectroscopy (THz-TDS) as a newly technique of THz technology has been widely used in the sensing and imaging field since it has the advantage of insensitive to the thermal background and high signal-to-noise ratio compared with the tradition Fourier transform infrared spectroscopy. In THz-TDS, interaction of an ultrafast with a terahertz emitter generates a THz pulse. The terahertz pulse is then focused at the sample, and the transmitted light is detected. Neglecting scattering, the THz light is attenuated by the sample via absorption. The ratio of the incident electric field strength ($E_i(\omega)$) is given by:

$$\frac{E_i(\omega)}{E_t(\omega)} = T[\tilde{n}(\omega)]\exp[-\frac{\alpha(\omega)d}{2} + \frac{i\tilde{n}(\omega)\omega d}{c}] \tag{1}$$

$$T[\tilde{n}(\omega)] = -\frac{4\tilde{n}(\omega)}{(\tilde{n}(\omega)+1)^2} \tag{2}$$

Where d is the thickness of the sample, ω is the frequency of the radiation, c is the speed of light in vacuum, $T[\tilde{n}(\omega)]$ is the reflection losses at the sample surface, $\tilde{n}(\omega)$ is the refractive index, and $\alpha(\omega)$ is the absorption coefficient. Over the course of a THz-TDS experiment, a molecular resonance is probed by moving the delay stage to vary the overlap between the terahertz pulse and the probe pulse. The resulting data are Fourier transformed to yield the spectral power density, where features characteristic of the sample are seen. Using E_S as the electric field passing through the sample, and E_R as the electric field passing through the reference, the absorption coefficient is calculated according to:

$$\alpha(\omega) = \frac{2}{d}[-\mathrm{Re}\left[\ln\left[\frac{E_S(\omega)}{E_R(\omega)}\right]\right] + \ln\left[\frac{4\tilde{n}(\omega)}{(\tilde{n}(\omega)+1)^2}\right]] \tag{3}$$

In our experiment, the setup of THz-TDS is shown in Fig.1.

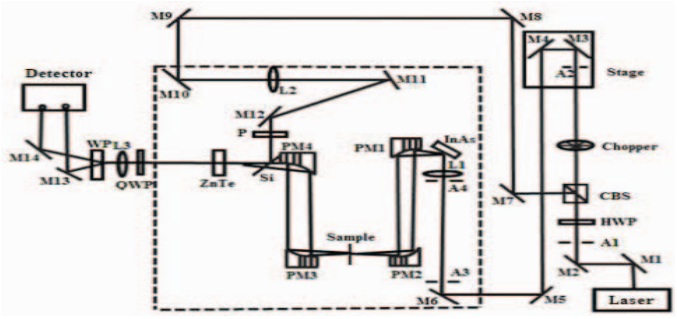

Fig.1 Schematic experiment setup of the THz-TDS spectrometer

3. Results and Discussion

In Fig.2 we show the measured absorption spectra and refractive index of various common explosive constituents RDX, and PETN. We note from these measurements that there are clear and unique spectral features corresponding to each of the explosives. These results agree well with previous reports[8],but with extended spectral coverage(5-120cm^{-1}), and superior spectral resolution(1cm^{-1}). These signatures also appears to be distinct from the spectral features of harmless materials such as

pharmaceutical compounds and illicit drugs.

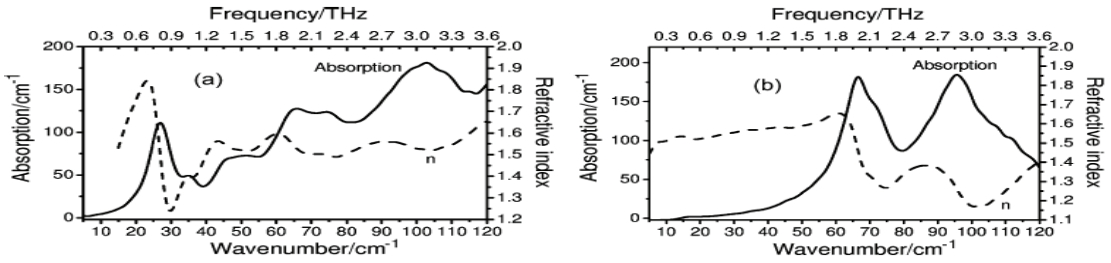

Fig.2 *The THz absorption spectra (solid line) and refractive index (dashed line) of : (a) RDX and (b) PETN.*

The obtained results indicate that the different kinds of explosives and illicit drugs have the different absorption characteristics, which can be used to identify these threats. In order to identify those different kinds of explosives and illicit drugs, we have applied the fuzzy neural network (FNN) to our present work.

Based on the classification model, we have carried out a FNN identification on 9 kinds of explosives and illicit drugs, which are RDX, γ-HNIW, DNT, MA, MDA, MDMA, PETN, Semtex-H and Ketamine. Among 180 materials data (9 patterns, each having 20 absorption peaks), 90 data were regarded as the samples of training, each pattern having 10 samples. The remaining were used for testing. For the training set, the FNN can identify them at the accuracy of 100% after training; while the accuracy for the test data is 89%. These results demonstrate that the designed FNN is effective. Table 1 lists some identification results.

Table 1 *Part of recognition of the fuzzy neural network*

Object vector / Sample vector	1	2	3	4	5	6	7	8	9	Expected output
	Actual output									
1 RDX	1									1
2 r-HNIW		1								2
3 MA			1							3
4- Ketamine				1						4
5 DNT					1					5
6 Semetex-H						1				6
7 MDA							1			7
8 MDMA								1		8
9 PETN									1	9

4. Conclusion

Terahertz spectroscopy technology has demonstrated the capabilities to both detect and identify explosives and illicit drugs. We have studied some explosives and illicit drugs and obtained the absorption spectra of these substances by THz-TDS technology. The obtained results show that these materials have characteristic THz fingerprint spectra that can be used to identify these threats in the THz security application. Furthermore, our studies indicate the identification of the explosives and illicit drugs can be realized by utilizing the fuzzy neural network, which is proved to be with high accuracy in the judgment of threats. We therefore believe that there are excellent prospects for using THz-TDS to develop spectroscopic technology for the detection and identification of threats, such as explosives and illicit drugs, that would defeat current metal detection technologies.

5. REFERENCES

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