【Grant-in-Aid for Scientific Research (S)】
Science and Engineering (Chemistry)

Title of Project : Laser Ionization Mass Spectrometry Using an Ultrashort Optical Pulse in the Vacuum Ultraviolet Region

Totaro Imasaka
(Kyushu University, Graduate School of Engineering, Professor)

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Research Area : Analytical Chemistry
Keyword : Laser Spectrometry

【Purpose and Background of the Research】

Mass spectrometry is one of the advanced methods for the analysis of organic compounds. When laser ionization mass spectrometry is combined with gas chromatography, it is possible to measure more than one thousand compounds with excellent sensitivity. However, it is, sometimes, difficult to measure explosives, nerve gases, and pesticides and observe their molecular ions.

In this project, we study laser ionization mass spectrometry using an ultrashort optical pulse emitting in the vacuum ultraviolet (VUV) - deep ultraviolet (DUV) region and apply it trace analysis of explosives such as triacetone triperoxide, nerve gases such as metabolites of sarin, and a variety of pesticides. We investigate their photoionization processes and develop a new type of mass spectrometer useful for the measurements of the explosives used in terrorist attacks and of the nerve gasses used as massive destruction weapons.

【Research Methods】

We introduce a two-color beam consisting of a Ti:sapphire laser (800 nm) and of a laser (1200 nm) generated by means of optical parametric amplification into a hydrogen gas for molecular phase modulation. A probe beam, which is the harmonic emission of the Ti:sapphire laser, is introduced into the hydrogen gas to generate numerous emission lines extending from the VUV to DUV regions, as shown below.

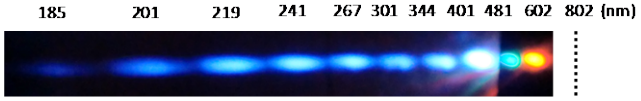

Fig. 1 Spectrograph of VUV-DUV laser

In this study, one or two of them will be used as an ionization source in mass spectrometry. We measure explosives such as triacetone triperoxide, trinitrotoluene, and other aliphatic nitro compounds through processes of resonant two-photon ionization, non-resonant two-photon ionization, resonant two-color two-photon ionization, and multiphoton ionization using a near-infrared laser.

【Expected Research Achievements and Scientific Significance】

Nerve gases such as SRN, explosives such as TATP and RDX, and pesticides such as CTPS have no aromatic rings and have P=O, P=S, O-O, C-Cl, and nitro groups, which are easily dissociated to form fragments in mass spectrometry. Using an ultrashort optical pulse in the VUV-DUV region, it would be possible to measure a molecular ion even for these explosives and nerve gases.

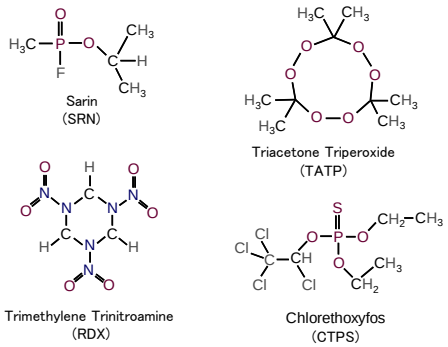

Fig. 2 Chemical Structure of Analytes

【Publications Relevant to the Project】

・Y. -C. Chang, T. Imasaka, Simple Pretreatment Procedure Combined with Gas Chromatography/ Multiphoton Ionization/Mass Spectrometry for the Analysis of Dioxins in Soil Samples Obtained after the Tōhoku Earthquake, Anal. Chem. 85, 349-354 (2013).

・T. Imasaka, Gas Chromatography/Multiphoton Ionization/Time-of-Flight Mass Spectrometry Using a Femtosecond Laser, Anal. Bioanal. Chem., 405, 6907-6912 (2013).

【Term of Project】 FY2014-2018

【Budget Allocation】 150,100 Thousand Yen

【Homepage Address and Other Contact Information】

http://imasaka.cstf.kyushu-u.ac.jp/