Chapter 11

Real Time Monitoring Mass Spectrometry: Walkthrough Portal to Detect Improvised Explosive Devices

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ABSTRACT

Monitoring or detection of illicit chemicals has become one of the most important issues worldwide due to the spreading global use of explosives and illicit drugs. To improve security, the authors have started developing a real time monitoring technology based on mass spectrometry. In this technology, a sample gas is directly introduced into an ion source without any pre-treatments of the sample gas, and ions produced by the ion source are analyzed by a mass spectrometer. Various organic compounds can be detected by analyzing the mass number of the observed ions. The real time monitoring technology has been applied to monitor environmental pollutants such as Polychlorinated Biphenyls (PCBs) and to detect explosives, chemical warfare agents, and illicit drugs. High-throughput detection of an improvised explosive has also been successfully demonstrated by the real time monitoring technology.

INTRODUCTION

Mass spectrometry is a well-known technique in an analytical chemistry field, which has high sensitivity and high selectivity. However, it is difficult to analyze mixtures and crude samples for mass spectrometry due to several reasons; for example, mixtures cause complicated mass spectra, which are difficult to make interpretation of the mass spectra, and an existence of impurities in the crude sample decreases ionization efficiencies of sample molecules at an ion source of a mass
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spectrometer. To avoid these problems, several pre-treatment processes such as extraction, concentration and separation are adopted before the mass analysis. Figure 1(a) shows a typical mass analysis procedure in a chemical laboratory. Especially, a combination of a separation technique, such as gas chromatography and liquid chromatography, and mass spectrometry is so popular to obtain simple mass spectra and high sensitivity. The pre-treatment procedure in laboratory is time-consuming processes and needs several minutes or several hours in a typical analysis situation.

In the last two decades, the use of mass spectrometry has been strongly demanded for the screening or detection of hazardous materials such as environmental pollutants (Wise & Guerin, 1997, p. 26A), explosives, and illicit drugs at a contaminated site or a security checkpoint to reduce false alarms by using its high sensitivity and selectivity. To respond the social needs for mass spectrometry, we have started to develop a real time detection system by using mass spectrometry.

In our system, almost all the pre-treatment processes are omitted. In the monitoring or detection of a vaporized sample, the sample gas is directly introduced into an ion source of a mass spectrometer as shown in Figure 1(b). The mass analysis process that includes ionization of the gaseous sample molecules and mass analysis of the ionized molecules is fast, and the typical analyzing interval is 0.1 s/scan. Therefore, the change in concentration of chemicals included in the sample gas is continuously monitored by the mass spectrometer. The vapor detection procedure is useful to monitor or detect volatile compounds such as environmental pollutants, chemical warfare agents, improvised explosives, and inflammable liquids.

In the detection of fine particles attached onto an object to be checked, on the other hand, a vaporization step (heating process) is needed to obtain gaseous molecules as shown Figure 1(c). The vaporization step needs 10 s. The particle detection procedure is useful to detect non-volatile compounds such as military explosives and illicit drugs.

We name these methods shown in Figures 1(b) and (c) as a real time monitoring mass spectrometry. To develop the real time monitoring mass spectrometry, improvements in sensitivity, selectivity, and robustness are important technological issues.

Figure 1. Analysis procedures in mass spectrometry for (a) typical analysis at chemical laboratory, (b) real time monitoring mass spectrometry for vapor detection, and (c) real time monitoring mass spectrometry for particle detection