YOUNG IN ACE

ACE 1100 IMR-MS

APPLICATION NOTE

Air Purifier Performance Test

Scrubber Efficiency Monitoring

Gas Mask Filter Performance Test

Analysis for CWA

YOUNG IN ACE

ACE 1100 IMR-MS

Ion Molecule Reaction Mass Spectrometer

Air Purifier Hazardous Gas Removal Efficiency Test

Monitoring the Efficiency of Scrubber for Hazardous Gas Removal

Gas Mask Filter Performance Test

Chemical Warfare Agents (CWA) Analysis Test

The ACE 1100 IMR-MS (Ion Molecule Reaction Mass Spectrometer) is a mass spectrometer **optimized for qualitative and quantitative analysis of organic compounds.**

By employing **soft chemical ionization (soft CI) method**, the instrument can ionize the target molecules as intact ions or **minimize molecular fragmentation, resulting in clear mass spectra.**

Unlike other equipment that required preprocessing steps, the ACE 1100 IMR-MS **provides fast analysis time with direct sample introduction, allowing real-time monitoring of clear data results.**

The ACE 1100 IMR-MS provides outstanding **precision and repeatability, enabling rapid analysis and high sensitivity.** Furthermore, it offers **user-friendly software for efficient analysis result processing.**

Application Note

Air Cleaner

Test for Air Purifier's Removal Efficiency of Hazardous Gases

According to the Korea Consumer Agency (KCA), air purifiers available in the market exhibit variations in their key performance. Among them, when assessing the removal and deodorization performance of hazardous gases, the average removal rates of five gases, including ammonia, toluene, formaldehyde, acetaldehyde, and formic acid, met the relevant standards for all products. However, the performance varied among different products.

The current test for evaluating the removal efficiency of hazardous gases in Korea follows the group standard test method SPS-KACA002-0132:2022, set by the Korea Air Purification Association. This test method stipulates the use of equipment with a gas cell equipped with FT-IR or higher-grade capabilities. The target components and initial concentration values used in the analysis in Korea are listed in Table 1.

Table 1. Analyzed Components and Concentrations according to SPS-KACA002-0132:2022

Analyte Component	Ammonia (NH_3)	Toluene (C_7H_8)	Formaldehyde (HCHO)	Acetaldehyde (CH_3CHO)	Formic Acid (CH_3COOH)
Concentration	10 ppm	10 ppm	10 ppm	10 ppm	10 ppm

In the United States, the Association of Home Appliance Manufacturers (AHAM) revised the standard test method AHAM AC-4-2022 (Chemical Reduction) to include real-time mass analysis in the standard test method. It also specified the target components and concentration values, as shown in Table 2.

Table 2. Analytical Target Compounds and Concentrations for AHAM AC-4-2022

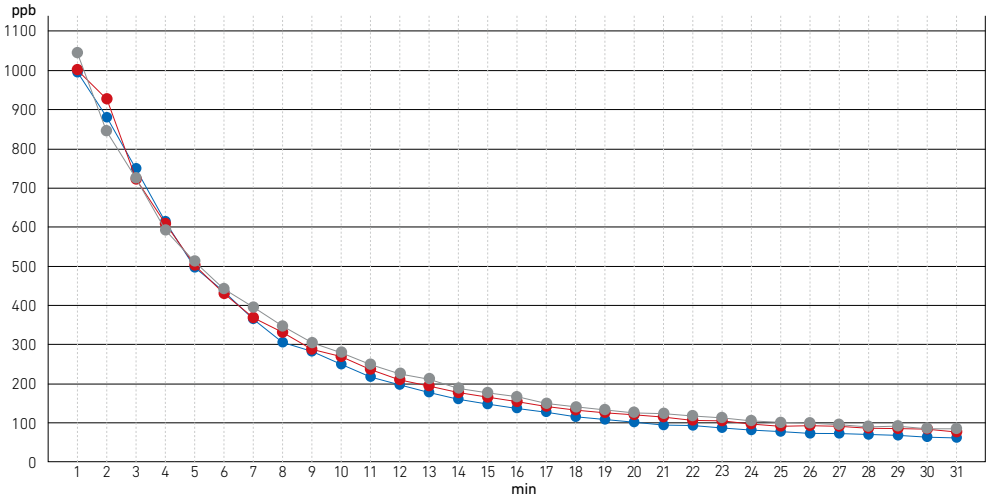
Analyte Component	Ammonia (NH_3)	Toluene (C_7H_8)	Formaldehyde (HCHO)	n-Heptane (C_7H_{16})	d-Limonene ($C_{10}H_{16}$)
Concentration	700 ppb	800 ppb	400 ppb	800 ppb	800 ppb

Currently, in Korea, analysis is conducted using FT-IR (Gas Cell) as prescribed by the test method regulations. However, a disadvantage of using FT-IR (Gas Cell) for real-time measurements is that it is challenging to measure concentrations below 1 ppm.

The ACE 1100 IMR-MS by Young In ACE is a mass analyzer optimized for qualitative and quantitative Volatile Organic Compounds (VOCs) analysis. Unlike GC-MS and LC-MS, which require chromatography equipment (GC, HPLC) for component separation, the ACE 1100 IMR-MS allows immediate real-time analysis results through direct sample introduction.

With the ACE 1100 IMR-MS, the target components specified in the U.S. standard test method AHAM AC-4-2022 (Chemical Reduction) can be measured in real-time for concentration assessment, either individually or simultaneously, with a detection limit as low as 5 ppb. Figure 1 illustrates the evaluation of the ammonia removal efficiency using the ACE 1100 IMR-MS at an initial concentration of 1,000 ppb.

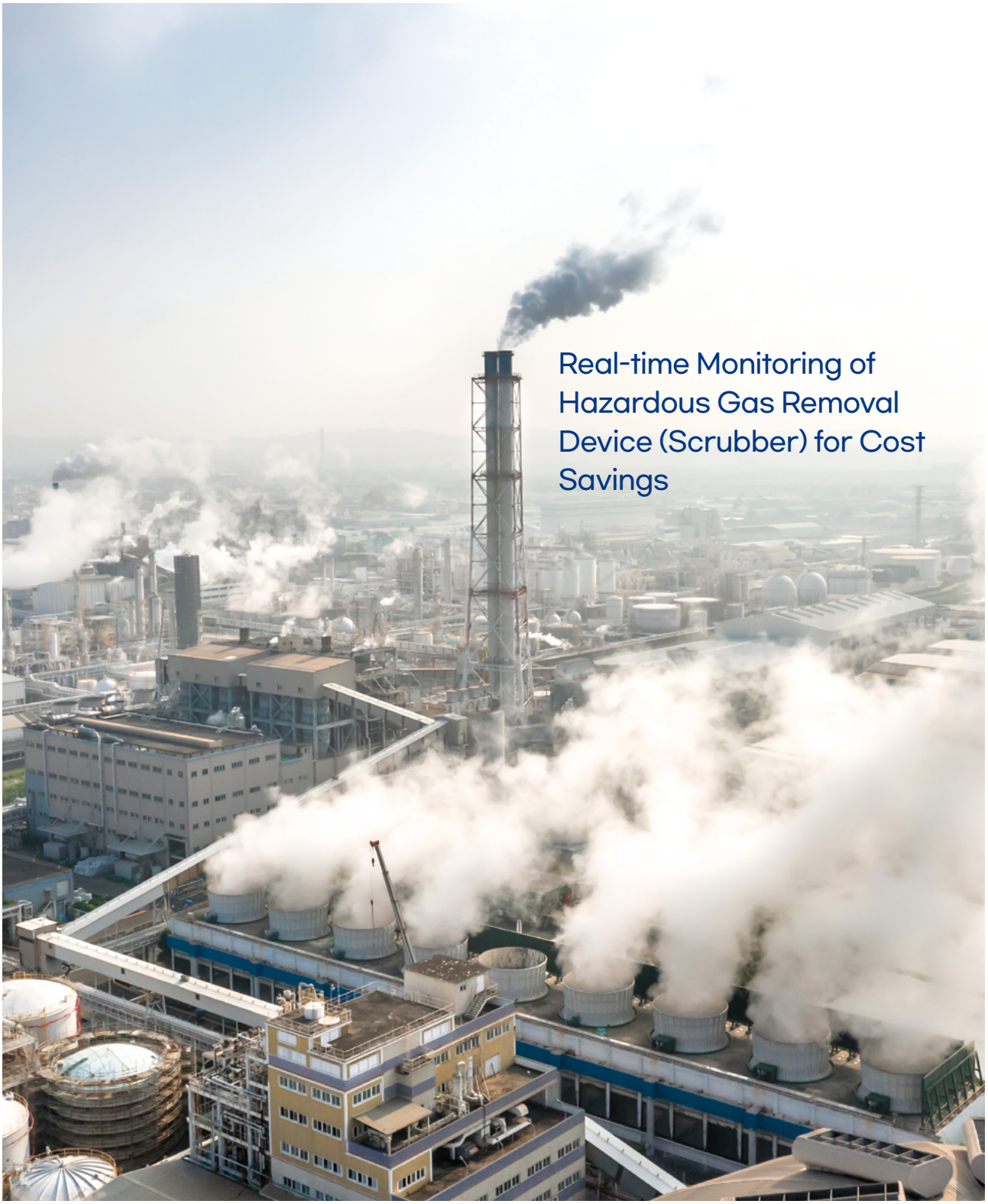
Figure 1. Evaluation of Ammonia Removal Efficiency in Air Purifier using ACE 1100 IMR-MS (3 Replicates)



Reference
"There is a difference in major performance such as air purifier and harmful gas removal", Consumer Times webzine
Korea Air Cleaning Association indoor air purifier group standard SPS-KACA002-0132, AHAM AC-4-2022 (Chemical Reduction)

Application Note

Scrubber



Efficiency Monitoring of Hazardous Gas Removal System Scrubber

Gases emitted from manufacturing plants into the atmosphere are regulated by laws and regulations regarding their emission concentrations. Wet scrubbers are used in these plants to remove hazardous gases before they are discharged into the atmosphere.

When pollutants pass through the scrubber and are released into the atmosphere through the chimney, their concentrations must not exceed the set limits. Accurate and timely measurement of removal efficiency is essential during the process of removing pollutants using a scrubber. This helps confirm the concentration of the discharged gas and prevents inefficient cost increases due to excessive use of removal agents.

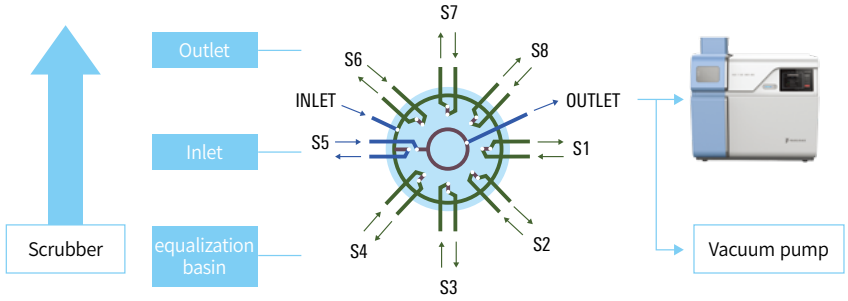
Real-time monitoring through 24-hour continuous measurements at the equalization basin, inlet, and outlet of the scrubber allows efficient management of pollutant removal agents and reduction of maintenance costs for wet scrubbers.

Through real-time concentration monitoring, the amount of removal agents injected into the scrubber can be efficiently adjusted based on the concentrations at the equalization basin and inlet, leading to cost savings by avoiding excessive use of removal agents.

The ACE 1100 IMR-MS from Young In ACE is a mass spectrometer optimized for the qualitative and quantitative analysis of Volatile Organic Compounds (VOCs). It allows for immediate real-time analysis results through direct sample introduction, and its straightforward mass spectrum enables clear result interpretation. With the ability to continuously monitor results 24h/7d, it is suitable for continuous monitoring applications.

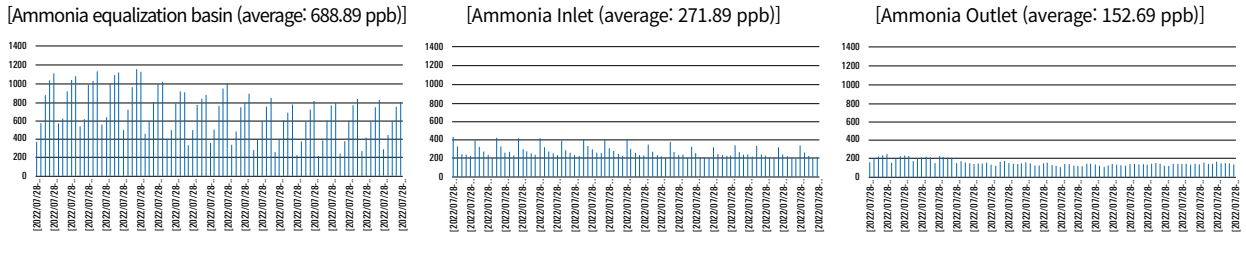
In the Scrubber hazardous substance removal monitoring test, the target components for analysis are 20 designated odor components. Using the ACE 1100 IMR-MS with a 16-port Multi Sampler, real-time monitoring of odor components can be performed sequentially in the equalization basin, inlet, and outlet. An example of equipment installation for this purpose is depicted in Figure 1.

Figure 1. Installation example of a Scrubber efficiency monitoring system using ACE 1100 IMR-MS with 16 port Multi Sampler.



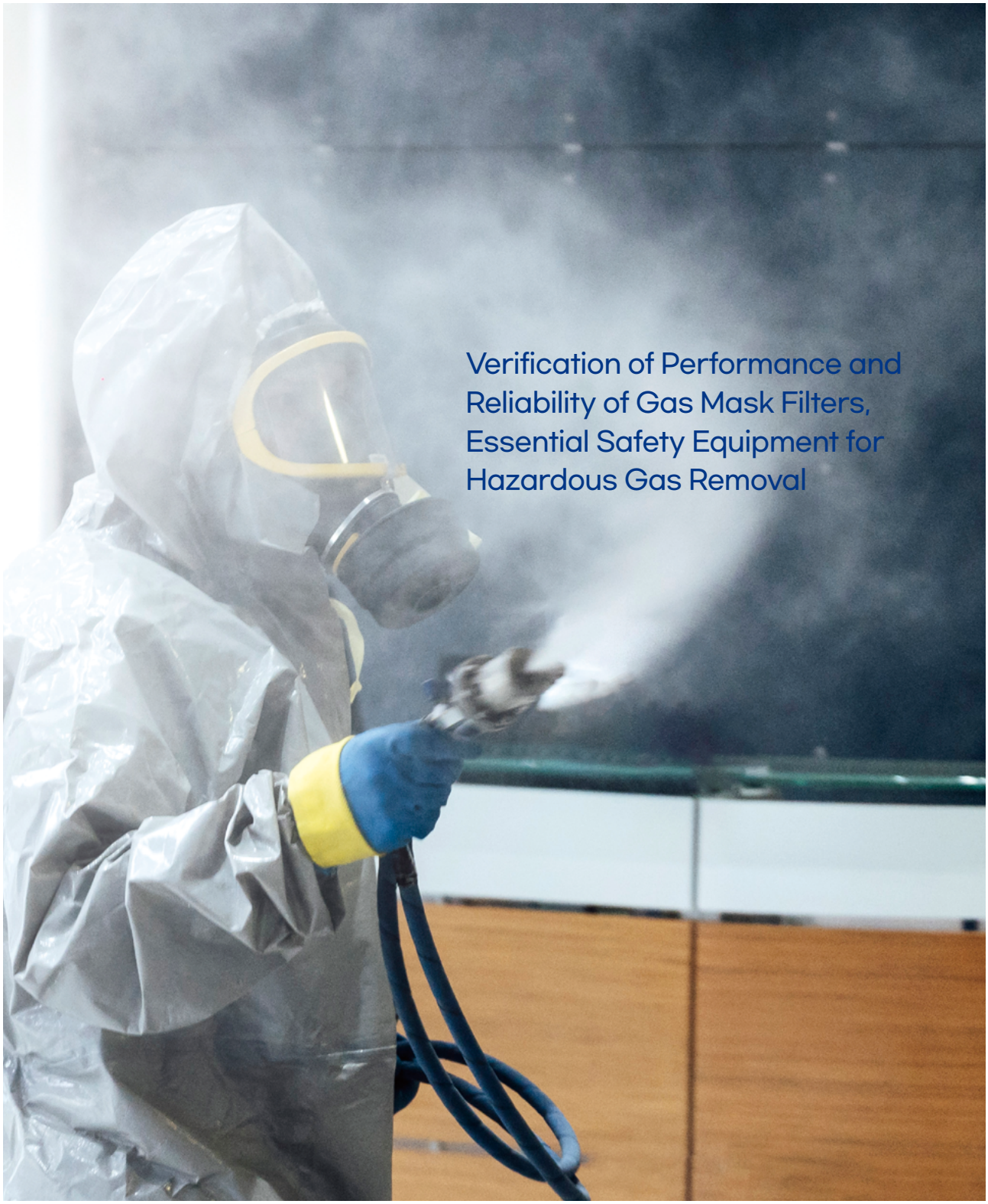
The designated odor components can be monitored for daily average concentrations and for specific time intervals. Figure 2 shows the monitoring results of the daily average concentration of ammonia (NH_3).

Figure 2. Daily average ammonia (NH_3) concentration at scrubber's equalization basin, inlet, and outlet.



Application Note

Gas Mask Filter



Gas Mask Filter Performance Testing

A gas mask is a safety equipment worn to protect the face from inhaling or being exposed to harmful chemical agents, biological agents, radioactive substances, etc. Gas mask filters vary depending on the agents they are designed to block. To validate the performance and reliability of gas mask filters, it is essential to conduct tests on the filters' efficiency in removing hazardous substances and their lifespan. The test measures the time taken from the initial removal of the harmful substance to reaching the designated concentration for determining the filter's lifespan.

The ACE 1100 IMR-MS by Young In Ace is a mass spectrometer optimized for qualitative and quantitative volatile organic compounds (VOCs) analysis. Using chemical ionization, it ionizes the target molecules intact or minimizes molecular fragmentation, enabling a clear interpretation of results through simple mass spectra.

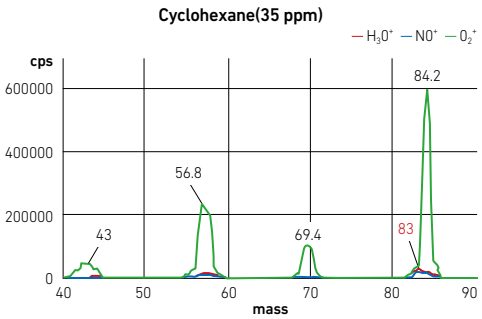
Using the ACE 1100 IMR-MS, performance testing for removing cyclohexane (C_6H_{12}) and carbon tetrachloride (CCl_4) in gas mask filters can be conducted. Cyclohexane is commonly used as a solvent in cleaning agents and adhesives, and exposure to it can cause skin irritation, headaches, and loss of consciousness. Carbon tetrachloride poses risks such as loss of consciousness, liver, and kidney damage. The intake concentration and lifespan determination concentration criteria are provided in Table 1, and the mass spectra at the lifespan determination concentration are presented in Figures 1 and 2.

Table 1. Concentrations for Cyclohexane and Carbon Tetrachloride Removal Performance

Inlet Concentration	→	Initial Removal Concentration	→	Lifespan Determination Concentration
800 ppm		0 ppm		35 ppm

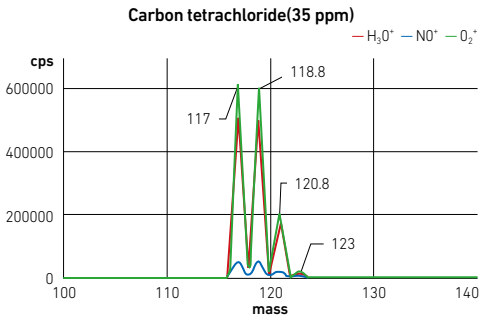
The testing procedure involves introducing the two compounds at a concentration of 800 ppm into the gas mask filter and measuring the initial removal concentration of 0 ppm due to filter adsorption. Subsequently, the time taken for the concentration of the component to reach the final concentration of 35 ppm, depending on the filter's adsorption capacity, is measured to assess the performance of the gas mask filter.

Figure 1. Mass Spectrum of Cyclohexane at 35 ppm



Reagent ion	Product ion	m/z
H_3O^+	$C_4H_8^+$	64
	$C_5H_9^+$	69
	$C_6H_{11}^+$	83
	$C_6H_{12}^+$	84
NO^+	$C_6H_{11}^+$	83
	$C_6H_{12}^+$	84
O_2^+	$C_3H_7^+$	43
	$C_4H_8^+$	56
	$C_5H_9^+$	69
	$C_6H_{12}^+$	84

Figure 2. Mass Spectrum of Carbon Tetrachloride at 35 ppm

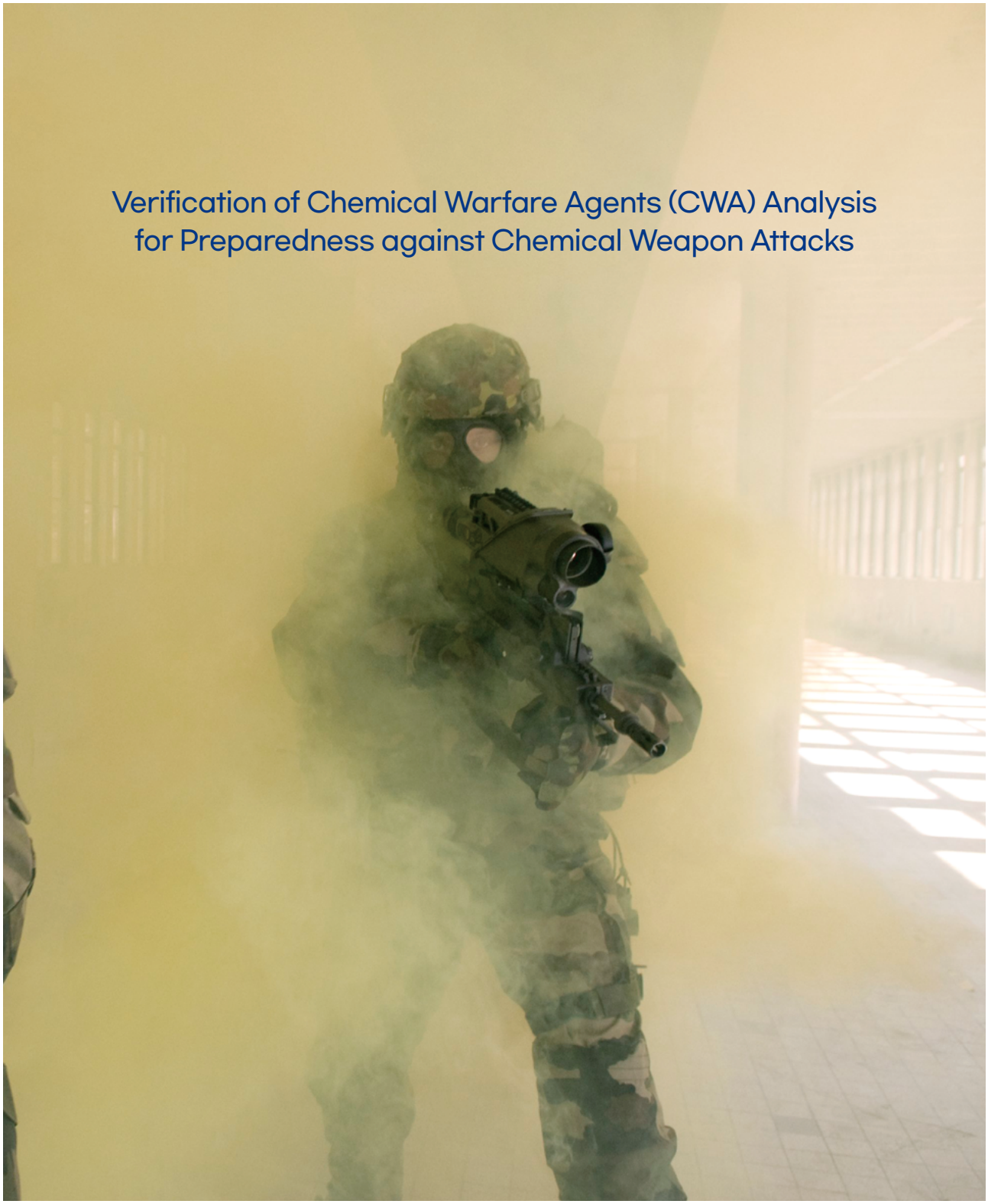


Reagent ion	Product ion	m/z
H_3O^+	$C^{35}Cl_3^+$	117
	$C^{35}Cl_2{}^{37}Cl^+$	119
	$C^{35}Cl^{37}Cl_2^+$	121
	$C^{37}Cl_3^+$	123
NO^+	$C^{35}Cl_3^+$	117
	$C^{35}Cl_2{}^{37}Cl^+$	119
	$C^{35}Cl^{37}Cl_2^+$	121
	$C^{37}Cl_3^+$	123
O_2^+	$C^{35}Cl_3^+$	117
	$C^{35}Cl_2{}^{37}Cl^+$	118.8
	$C^{35}Cl^{37}Cl_2^+$	120.8
	$C^{37}Cl_3^+$	123

Application Note

Chemical Agent

Verification of Chemical Warfare Agents (CWA) Analysis for Preparedness against Chemical Weapon Attacks



Chemical Warfare Agents (CWA) Analysis Test

Chemical Warfare Agents (CWA) are classified into various categories based on their effects, including blood agents, blister agents, choking agents, nerve agents, incapacitating agents, riot control agents, and toxins. A list of representative CWA is provided in Table 1. Analytical verification of CWA is an essential technique for chemical defense, including the identification and confirmation of chemical weapons and related substances in the event of a chemical attack, including terrorist attacks.

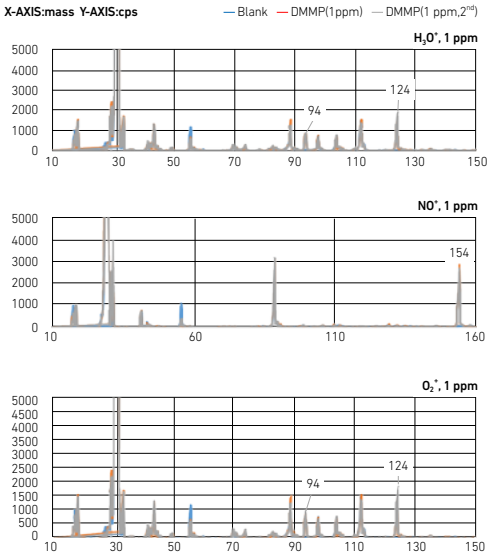
The ACE 1100 IMR-MS, developed by Young In ACE, is an optimized mass spectrometer for the analysis of Volatile Organic Compounds (VOCs), making it suitable for CWA analysis research. Unlike GC-MS or LC-MS systems, which require component separation, the ACE 1100 IMR-MS provides real-time analysis results through direct sample introduction. It utilizes chemical ionization methods to ionize molecules intact or minimize fragmentation, resulting in clear mass spectra.

ACE 1100 IMR-MS enables real-time qualitative and quantitative analysis of CWAs, providing information on their types and concentration levels. Due to the high toxicity of CWAs, direct experimentation is difficult, so simulant compounds with similar molecular structures and properties were used in the experiments. Figure 1 and Figure 2 show the scanning data of simulant compounds (DMMP and 2-CEES) obtained using ACE IMR-MS.

Table 1. List of Chemical Warfare Agents (CWAs)

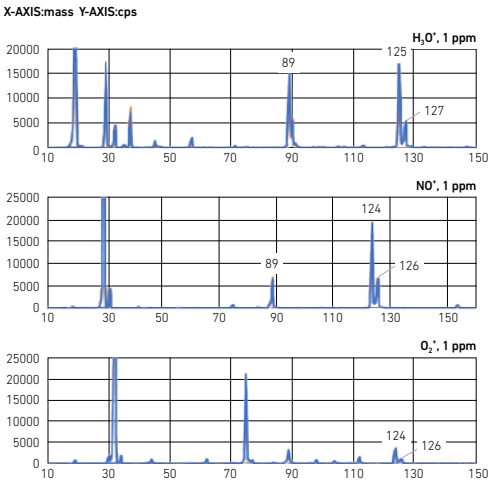
CWA	Chemical formula	CAS No.	Molar mass
Mustard gas (H)	$C_4H_8Cl_2S$	505-60-2	159.08
Sarin (GB)	$C_4H_{10}FO_2P$	107-44-8	140.11
Soman (GD)	$C_7H_{16}FO_2P$	96-64-0	182.19
Tabun (GA)	$C_5H_{11}N_2O_2P$	77-81-6	162.13
Phosgene (CG)	$COCl_2$	75-44-5	98.92

Figure 1. Scanning data of DMMP



	Product ion	Product ion mass
H_3O^+	$C_3H_9PO_3H^+$	125
NO^+	$C_3H_9PO_3NO^+$	154
O_2^+	$C_2H_7PO_2^+$	94
	$C_3H_9PO_3^+$	124

Figure 2. Scanning data of 2-CEES



	Product ion	Product ion mass
H_3O^+	$C_4H_9{}^{32}S^+$	89
	$C_4H_9{}^{32}S^{35}ClH^+$	125
	$C_4H_9{}^{32}S^{37}ClH^+$	127
NO^+	$C_4H_9{}^{32}S^+$	89
	$C_4H_9{}^{32}S^{35}Cl^+$	124
	$C_4H_9{}^{32}S^{37}Cl^+$	126
O_2^+	$C_3H_7{}^{32}S^+$	75
	$C_4H_9{}^{32}S^{35}Cl^+$	124

Given the diversity of CWA, the effective use of antidotes and detoxification agents is crucial. Analytical processes that enable rapid identification of the components are essential for this purpose. Based on the results of IMR-MS analysis, prompt detoxification or decontamination can be carried out.

Detoxification: The process of eliminating or inhibiting/neutralizing the effects of toxic substances that have already entered the body.
Decontamination: The process of removing/neutralizing/inhibiting toxic substances dispersed on external surfaces, equipment, or facilities.

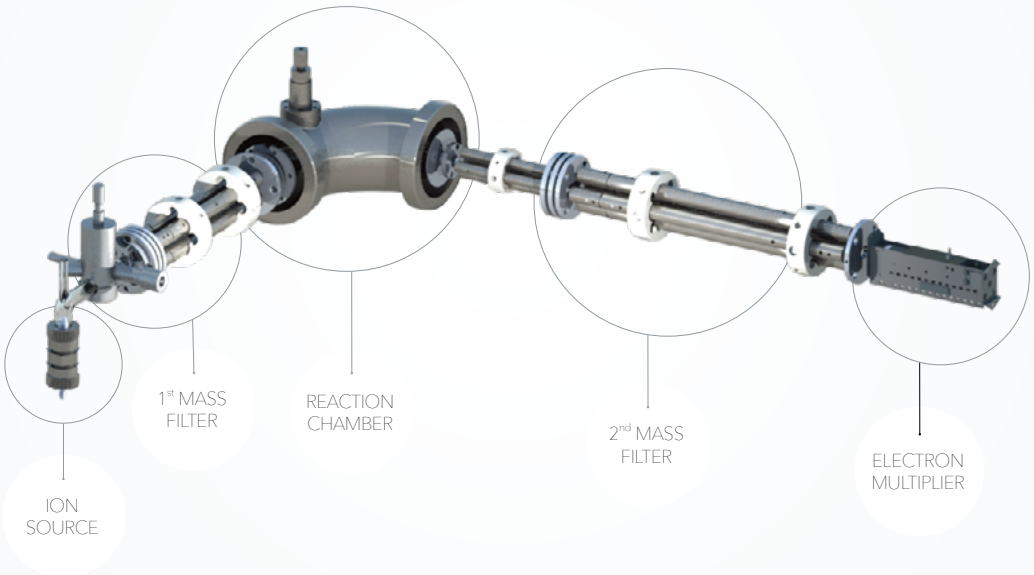
Reference
"Key Issues Relating to the Chemical Weapons Convention (CWC) and Organization for the Prohibition of Chemical Weapons (OPCW)", Ministry of Foreign Affairs
Kyungjong Oh et al. (2002), A study on the catalytic decomposition reaction of dimethyl methylphosphonate (DMMP), Theories and Applications of Chem. Eng., 2002, Vol. 8, no. 2

Principle of Analysis & Configuration

ACE 1100 IMR-MS uses a soft chemical ionization method and it ionizes the sample molecule itself or minimizes the fragmentation of the target molecule. This ionization method assists achieve a simple and accurate mass spectrum.

Reagent ion production (precursor ion) → Reagent ion selection → Reaction with analytes (ionization) → Qualification/ Quantitation

① Reagent ion(Precursor ion) production using microwave plasma
② Selective transfer technology of Reagent ions using mass filter
③ Direct sample loading technology(Patent registration number:10-2132977)
④ Quantitative control technology for ionization reaction between sample and Reagent ion(ionization of sample molecules, chemical ionization)
⑤ Separation technology by mass of sample molecules using the second mass filter. Precisely control the mass value, RF and DC value therefore only molecular ions selected according to their mass-to-charge ratio pass through the mass filter and reach the detector(Electron multiplier)
⑥ Result acquisition
⑦ Built-in software controls each part of the system and operates data processing for sample analysis results.



Ion Source
Water and air pass through microwave plasma to produce Reagent ions

1st Mass Filter
Select Reagent ions, transfer to the Reaction chamber

Reaction Chamber
Reagent ion and Analyte react to ionize Analyte molecules

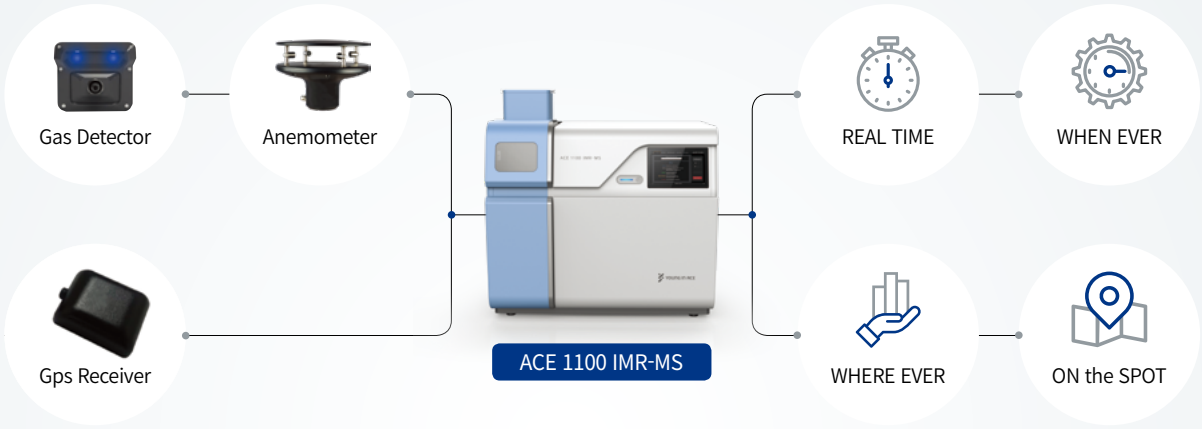
2nd Mass Filter
Separates the ions according to their mass-to-charge ratio

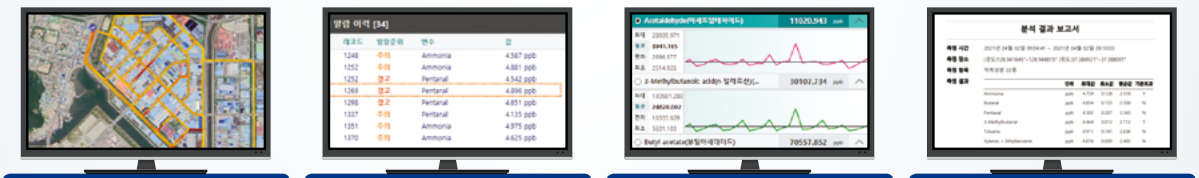
Electron Multiplier
Detects by amplifying signals

Mobile Lab

ACE 1100 IMR-MS is mounted on a vehicle and analyze rapidly on the current spot, working as a Mobile Lab. It enables to minimize pollution and control the site through real-time analysis for quick response to dangerous situations.

- On-site analysis where analysis is required, and immediate monitoring where monitoring is required
- Real-time measurement and analysis of odor substances, hazardous air substances, fine dust, etc. while moving or stationary
- Real-time mapping of pollution levels by pollutants using data visualization and statistical processing software for integrated management of data





Map-based monitoring

- Display the location and the measurement value changed in color symbols on the map
- Grid, Line, Circle can be selected as desired symbols

Real-time alarm check

- Alarm history can be checked according to the value set in real-time

Reporting analysis variable

- Display measurement statistics and history by device and variable in numerical and chart form

Analysis results report

- Automatically log analysis result data
- Save as PDF file

ACE 1100 IMR-MS

Features

FAST analysis
Direct analysis, save time without sample preparation and separation procedures

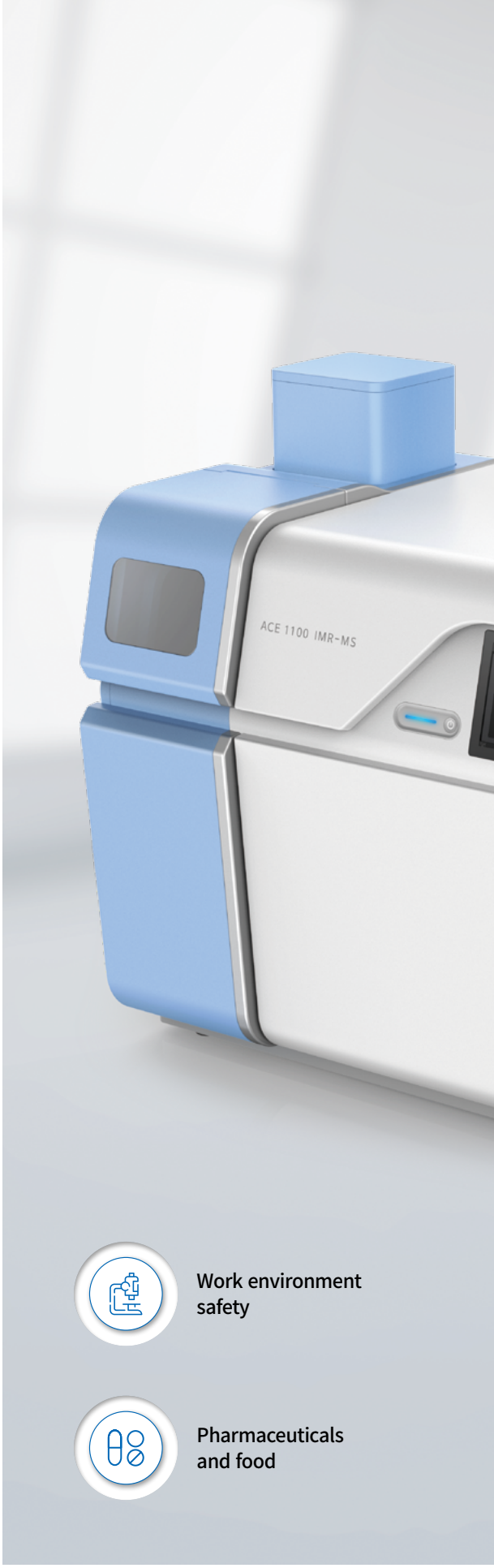
REAL-TIME analysis
Immediately getting a result with real-time analysis within tens of seconds

ACCURATE results
Clear interpretation of results with simple mass spectrum
Ionize the parent molecule itself using chemical ionization

ON-LINE monitoring
Continues result acquisition(24hrs/7days)

MOBILE LAB
Mounted in vehicle for Mobile Lab
Immediate analysis on-site

EASE OF USE
Easy data processing with software
Expert and beginner can operate easily



Application

Air and Water Pollutant

Odor-causing substances

Work environment safety

Indoor air quality
(Sick building syndrome, automotive interior material)

Petrochemical

Pharmaceuticals and food

Semiconductor process contaminants

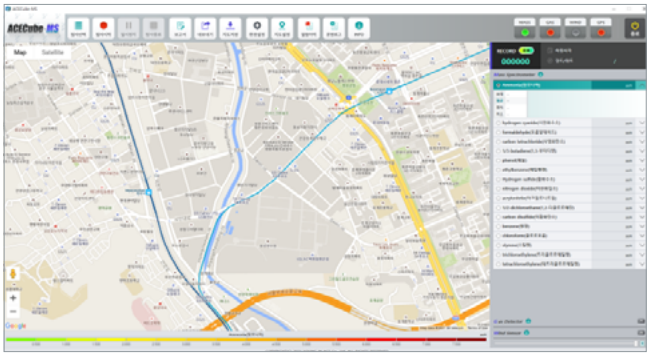
Rapid diagnostics

Software

ACE 1100 IMR-MS has built-in software developed by Young In Ace, making it easy for users to operate the equipment. From the operation of the equipment to the data processing of the analysis results, it can be used according to the options customized by the user.

Built-in SW
Operation setting for ACE 1100 IMR-MS
Monitoring Analysis Results, System Control

ACECube
Analysis method setup, qualitative/quantitative analysis
Analytes library, Analysis data processing



ACECube-MS
On-site real-time monitoring
Analyzing data according to GPS while driving
Running with equipment, interlocking devices

ACE 1100
IMR-MS

APPLICATION NOTE

- FAST
- ON-LINE monitoring
- REAL-TIME
- MOBILE LAB
- ACCURATE
- EASE OF USE

영인에이스

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