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Excellence in Science

1956
The first gas chromatograph
in Japan

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Shimadzu GC 60 year anniversary

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2017
Barrier Discharge Ionization Detector (BID) – NEW Nexis GC-2030 System

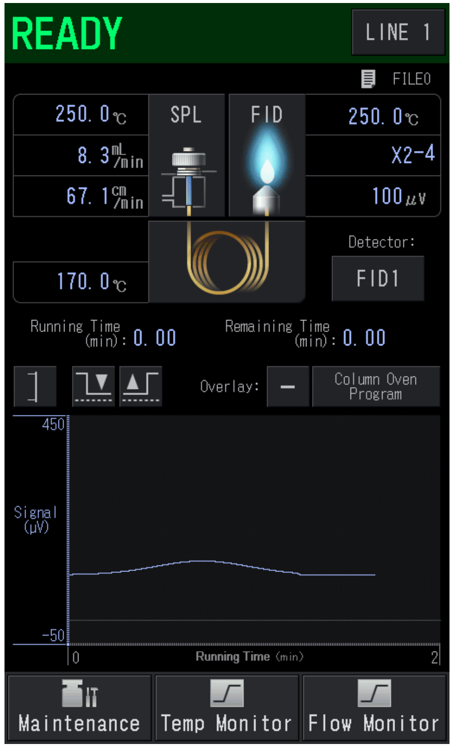
SHIMADZU

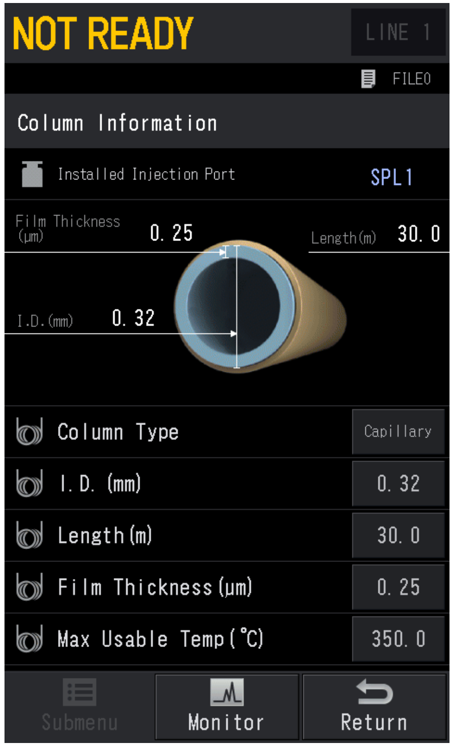
Color Touch Screen

State-of-the-art User Interface
Intuitive and simple touch control

Each GC comes equipped
with a touch screen

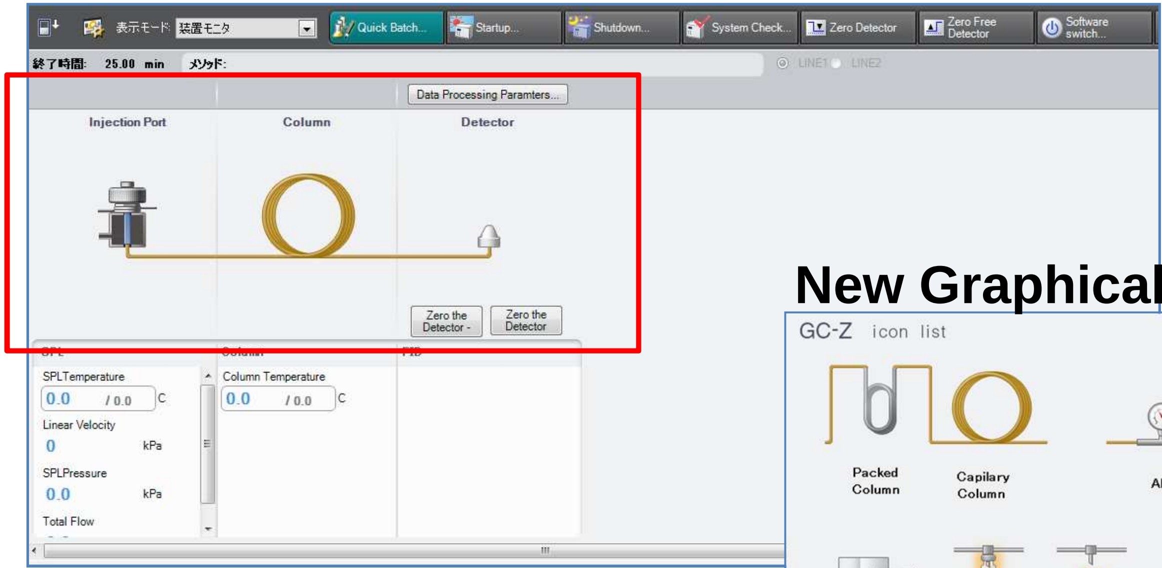
Controls are Intuitive & Simple

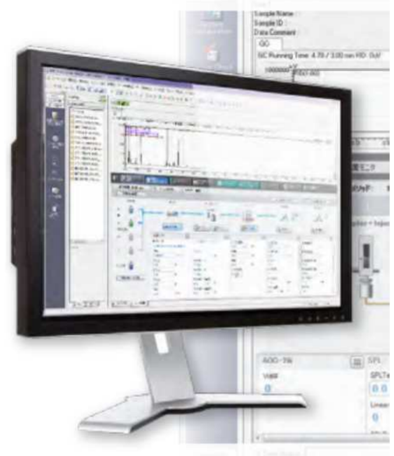




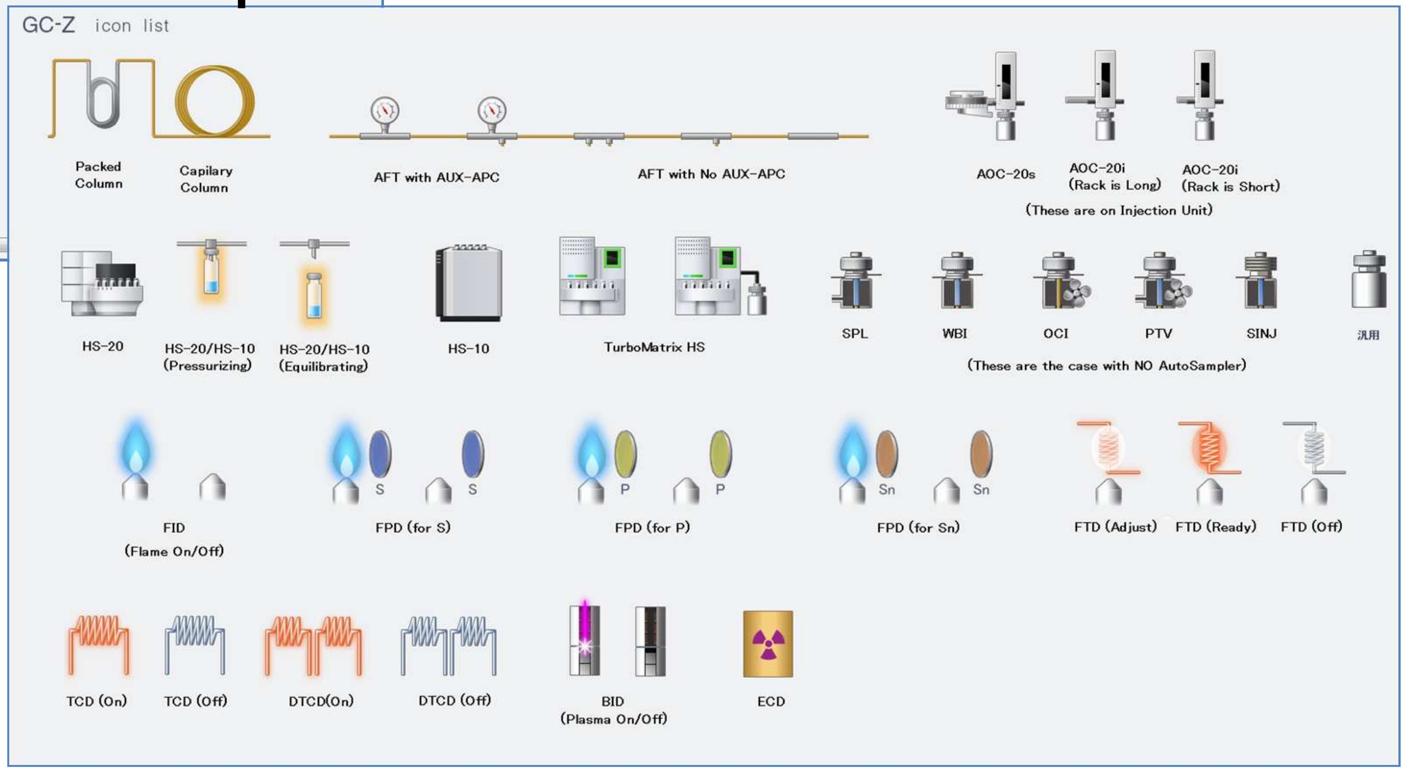
New LabSolutions GC

The new graphical interface is both intuitive and easy.





New Graphical Icons



LabSolution Direct Functionality

LabSolutions Direct Enables Remotely Controlled Monitoring from Anywhere

LabSolutions Direct is a new LabSolutions series remote access tool used to remotely control or monitor GC systems via a simple user interface on a commercially-available smartphone or tablet computer. Consequently, analyses can be performed while remotely monitoring the status of instruments from locations away from the analysis laboratory.

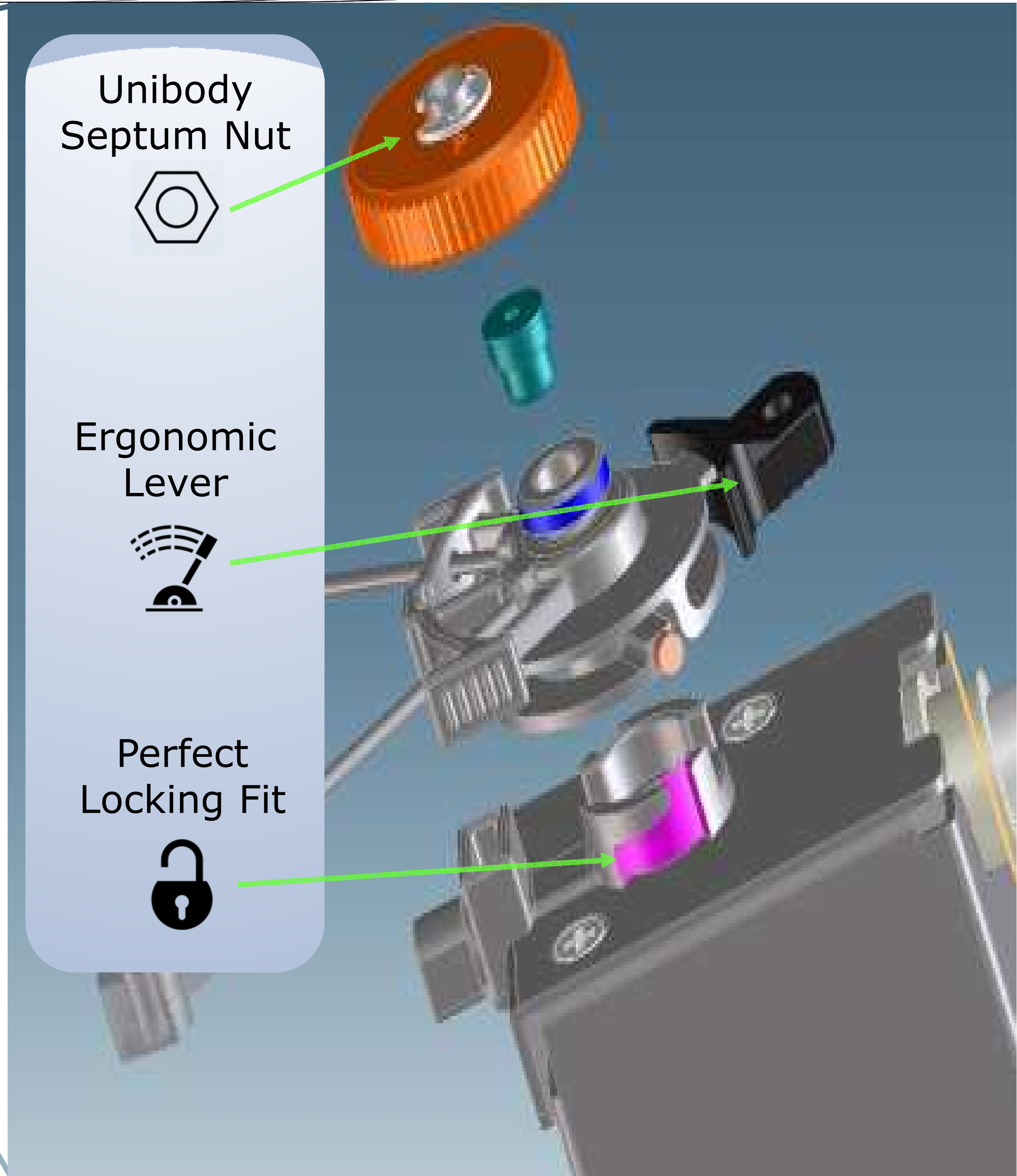
* Optional

Directly access a GC unit in the laboratory from a smartphone or tablet computer

Tool Free: ClickTek

SPL-2030

Completely Tool Free

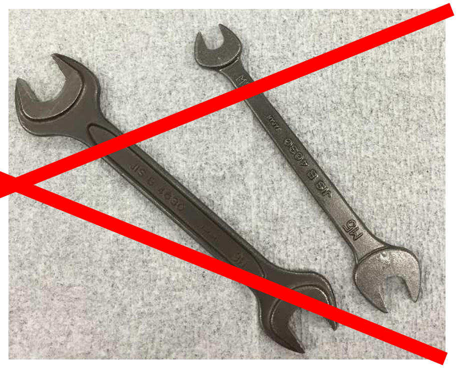


SHIMADZU

ClickTek Tool Free Column Connector

Completely Tool Free

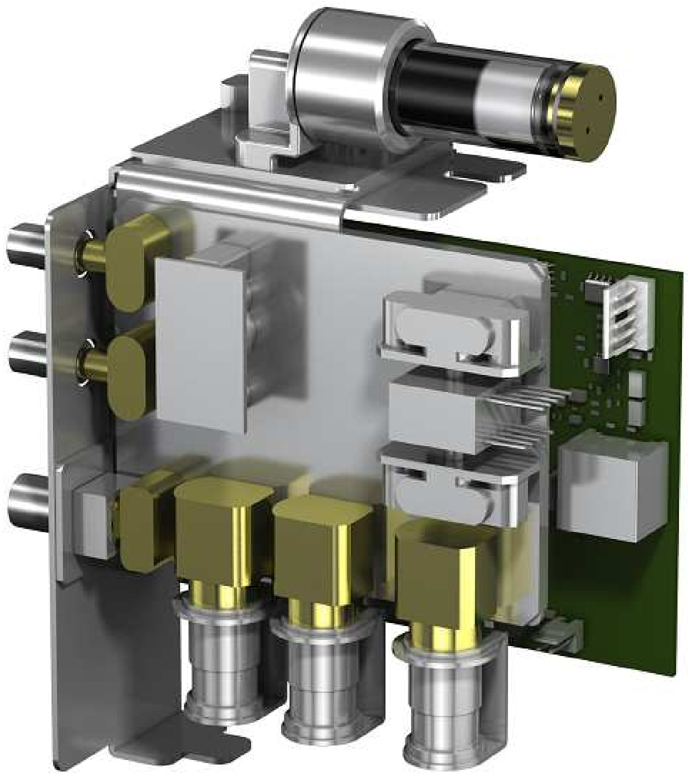
Clicktek Connector



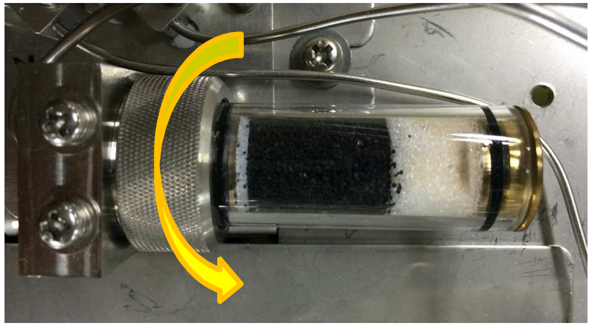
With the new ClickTek connector you can be sure that
the connection is secure because the connector snaps into place.

Split Line Filter

Tool free maintenance of split line filter.



AFC-2030



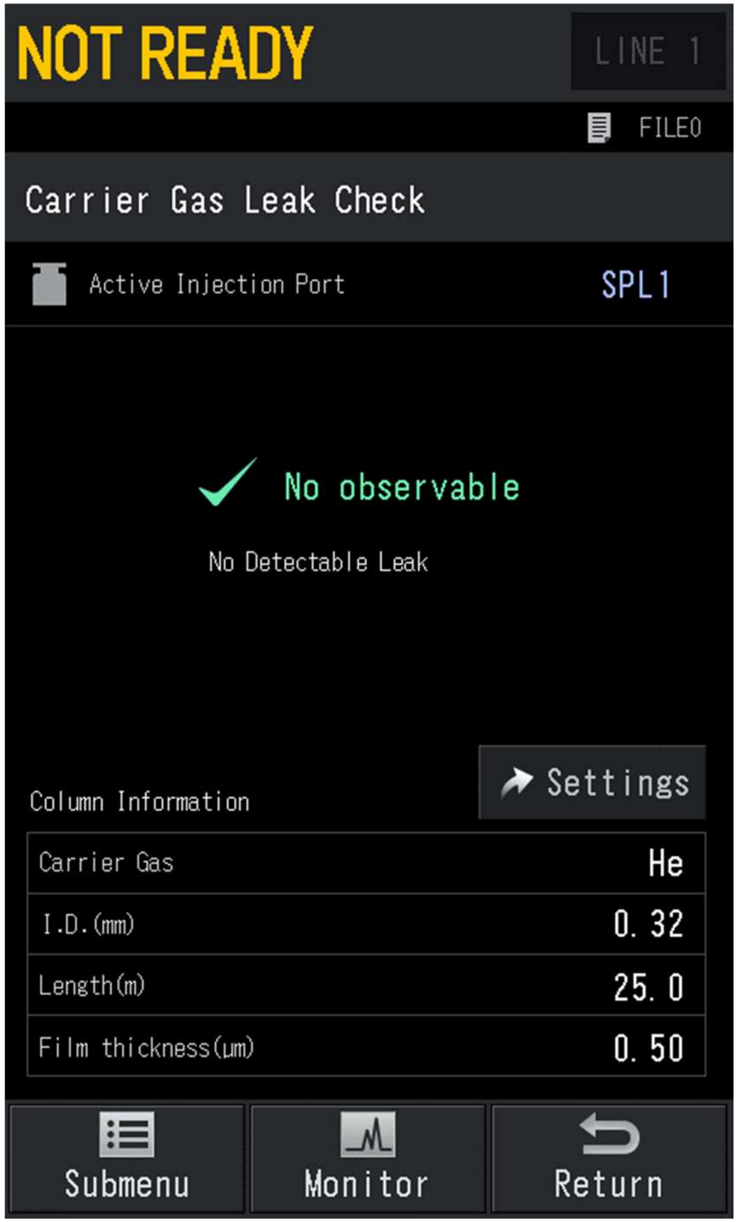
You can view the filter material.

Former Filter　　New Filter
（Activated Charcoal＋ Silica Gel ）

Oven Light

LED lighting is provided to illuminate the inside of the oven.

Automated Leak Check



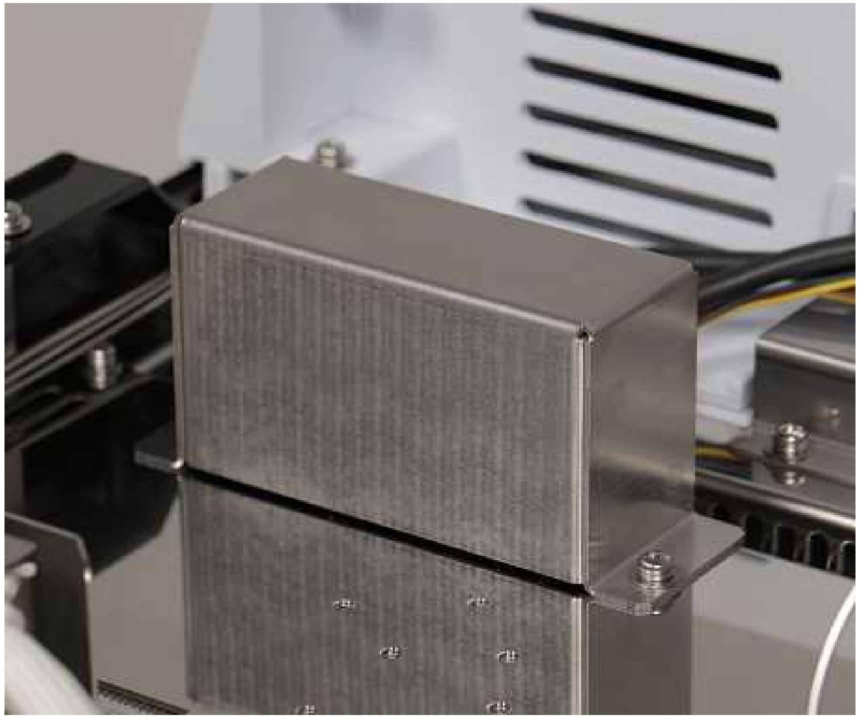
Automatically check for leaks in your GC

- The GC shuts off both the purge and split lines, while keeping the pressure constant. The total flow and the column flow is then recorded. After a few seconds, the pressure is increased and the changes in both total and column flow is monitored to check for irregularities.

Hydrogen Sensor

H2 Sensor supports safety usage of H2 carrier gas

The GC-2030 offers a built-in hydrogen sensor. It not only maintains a safe standby mode for early detection of any potential leaks, it also shuts OFF the main power supply to prevent accidents in the event the hydrogen leakage rate increases. The main unit also includes an automatic carrier gas leak check function, which is very helpful when using hydrogen as a carrier gas.



Hydrogen Sensor

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3 Lines

3 injection ports or 2 SPL + 1 HS-20

SPL-2030 or OCI(PTV)

HS-20

SPL-2030 or OCI(PTV)

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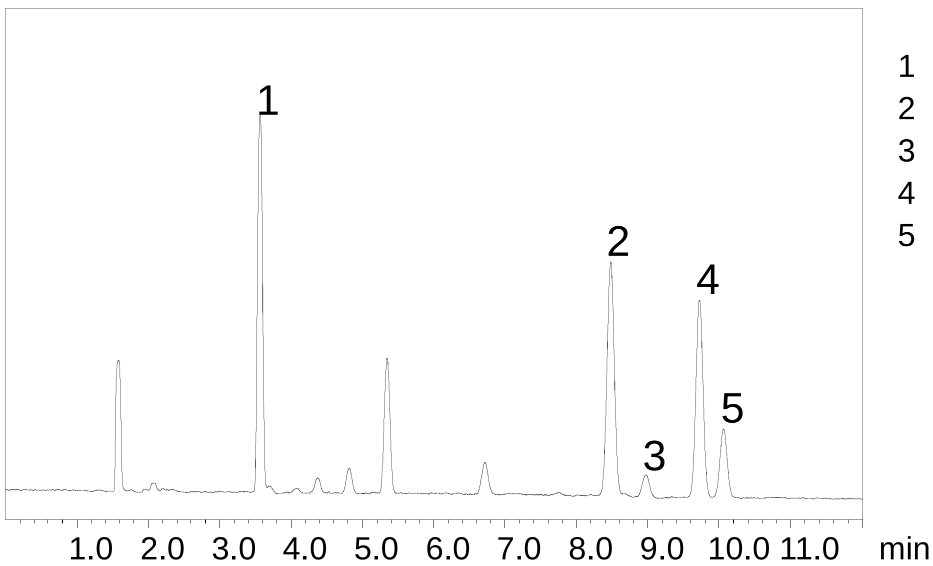
Flame Ionization Detector

Analysis of Residual Solvents in Pharmaceuticals

FID-2030 can reliably measure target components such as residual solvents in pharmaceuticals, which requires especially high sensitivity.

FID（MDQ 1.2pgC/s: World's Best)



1 1,1-Dichloroethene
2 1,1,1-Trichloroethane
3 Carbontetrachloride
4 Benzene
5 1,2-Dichloroethane

Class 1 Standard Solution: Procedure A

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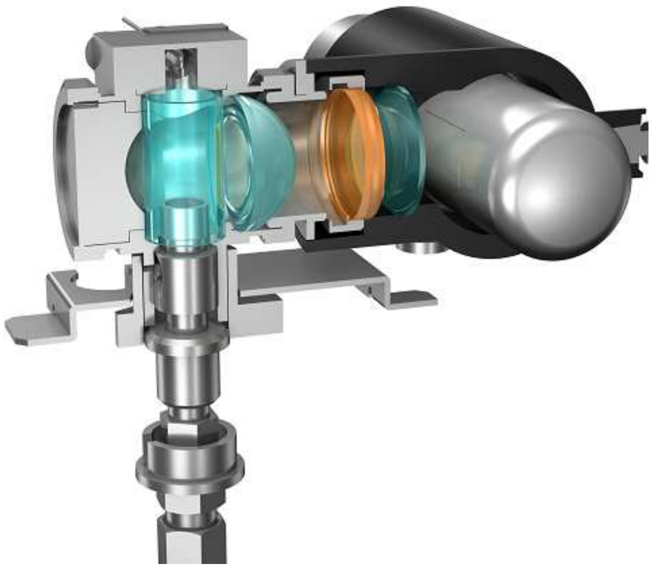
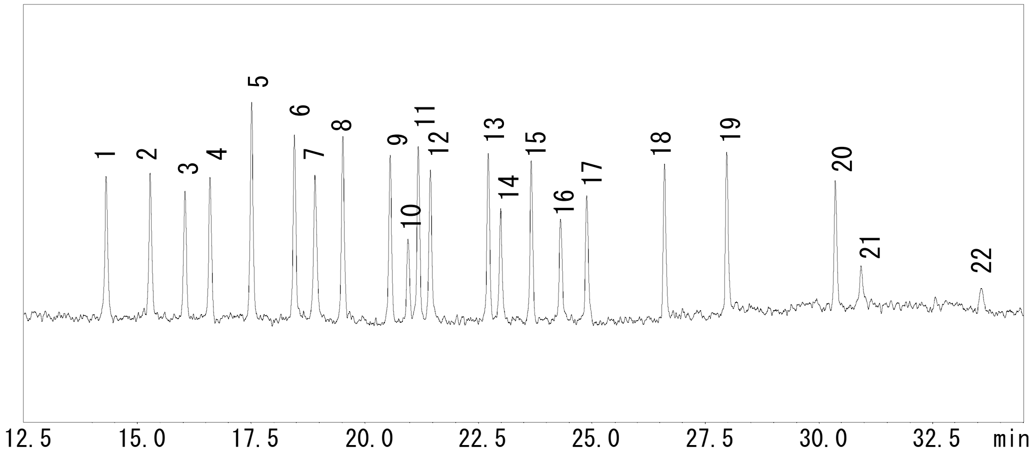
Flame Photometric Detector

Analysis of Organophosphorus Pesticides in Food



The flame photometric detector (FPD-2030) features an optimized nozzle shape and a more advanced dual-focus system, which results in the world’s highest sensitivity. It can detect ultra-trace quantities of organic phosphorus pesticides in food.



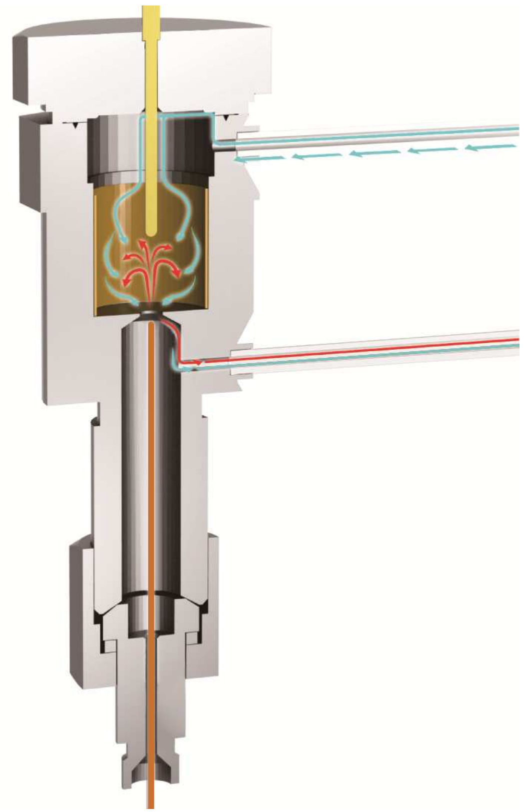
Splitless Analysis of 5 ppb Organic Phosphorus Pesticides

1.Ethoprophos
2.Phorate
3.Thiometon
4.Terbufos
5.Etrimfos
6.DichlofentZhion
7.Dimethoate
8.Tolclophos-methyl
9.Chlorpyrifos
10.Formothion
11.Fenthion(MPP)
12.Fenitrothion(MEP)
13.Isofenphos
14.Phenthoate(PAP)
15.Prothiofos
16.Methidathion(DMTP)
17.Butamifos
18.Sulprofos
19.Fensulfothion
20.EPN
21.Phosmet
22.Pyraclofos

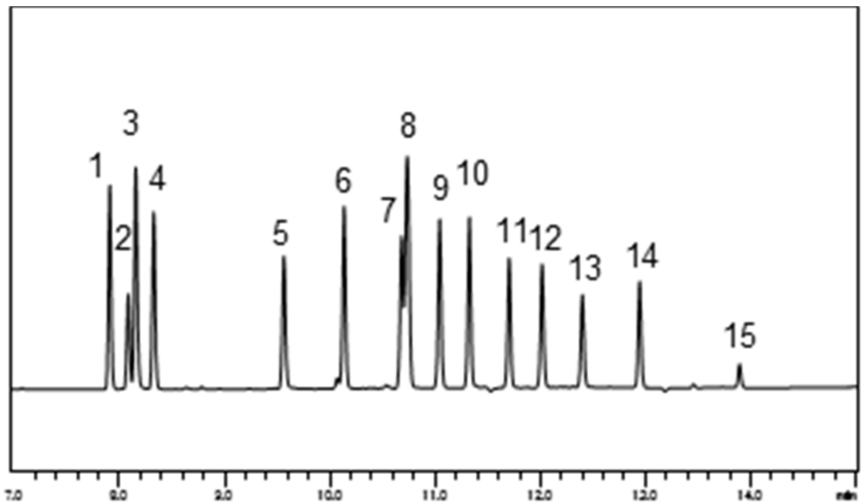
FPD（P:MDQ 45fgP/s S:2pgS/s：World’s Best)

Electron Capture Detector: ECD Exceed

Analysis of Volatile Organic Compounds (VOCs) in Effluent Water



The electron capture detector (ECD-2030) features Shimadzu's proprietary contact-free technology, which dramatically decreases contamination from samples. In addition, the ECD cell structure was optimized to achieve the world's highest ECD performance. It detects ultra-trace quantities of VOCs present in effluent water.



1. α-BHC
2. β-BHC
3. Hexachlorobenzene
4. γ-BHC
5. Heptachlor
6. Aldrin
7. Heptachlor-exo-epoxide
8. Heptachlor-endo-epoxide+oxy-Chlordane
9. cis-Chlordane
10. trans-Chlordane
11. Dieldrin
12. Endrin
13. o,p'-DDT
14. p,p'-DDT
15. Dicofol

ECD (MDQ 4.0fg/s : World's Best)

Analysis of Volatile Organic Compounds (VOCs) in Effluent Water (by Headspace GC)

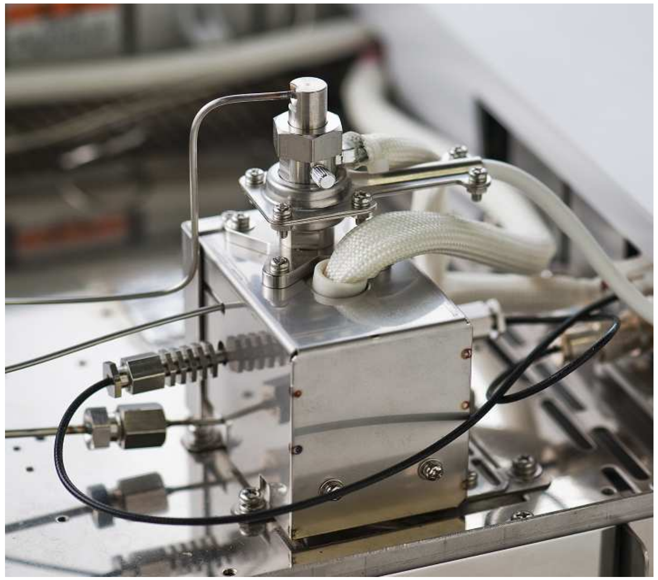
The New Detector BID-2030 Plus

Innovative Plasma Technology for Universal Trace Analysis!

BID-2030 is a completely new universal detector. It employs dielectric barrier discharge plasma for ionizing compounds.

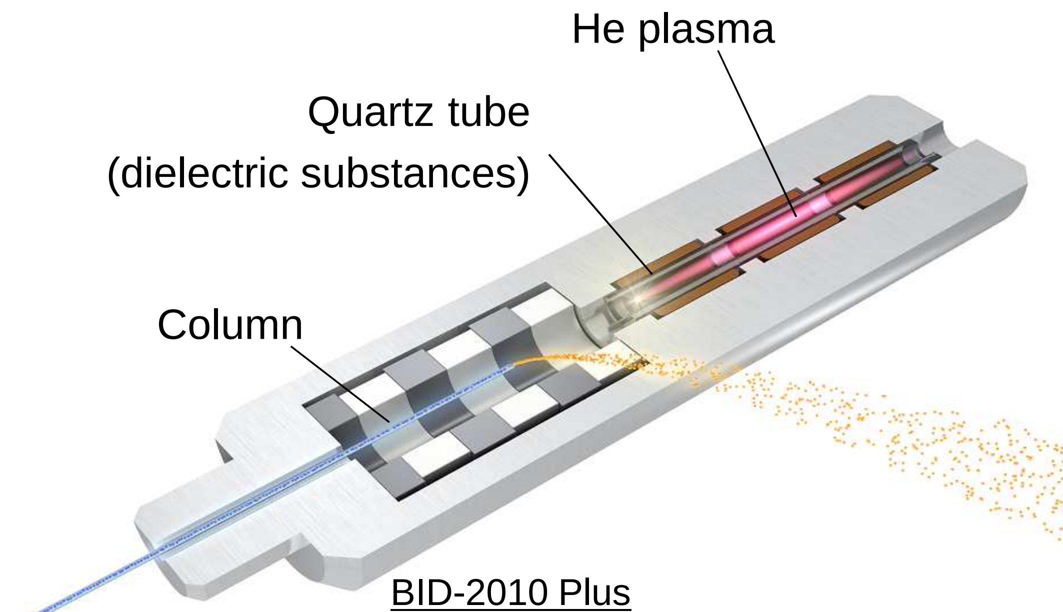
BID is named after the capital letters of “Barrier Discharge Ionization detector”.

Cover part of BID-2010 Plus



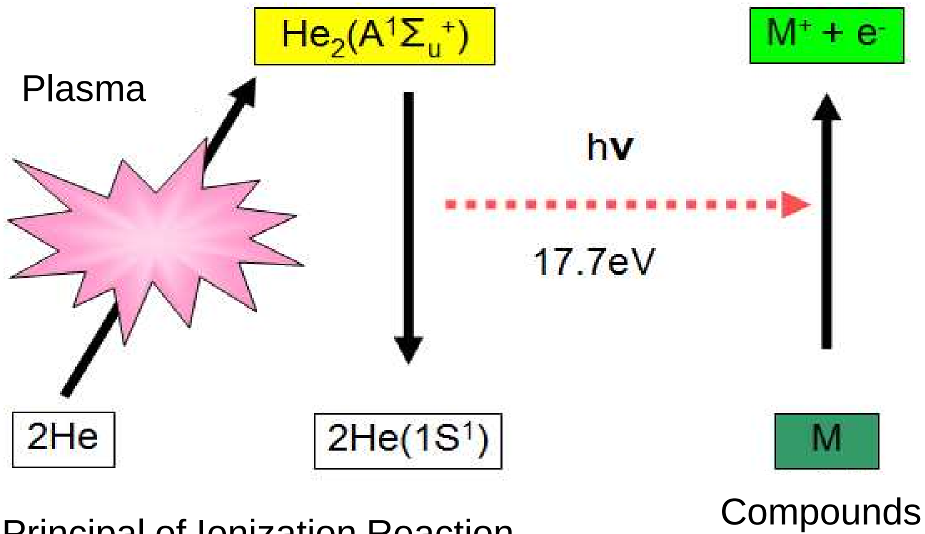
Main body of BID-2010 Plus

BID-2010 Plus Principals for Detection



BID-2010 Plus
Cross Section Drawing

A plasma is generated by applying a high voltage to a quartz dielectric chamber, in the presence of helium. Compounds that elute from the GC column are ionized by this He plasma, then captured with collection electrodes and described as peaks. The photon energy of He is extremely high (17.7 electron volt). Therefore it makes possible to detect every compound except Ne (neon) and He which is the plasma gas, with high sensitivity. The BID is truly the universal plasma detector for next generation.



Principal of Ionization Reaction

The BID was developed thru collaborative research with Dr. Katsuhisa Kitano, Center for Atomic and Molecular Technologies, Graduate School of Engineering, Osaka University, resulting in 3 U.S. patents and 4 patents pending.

Features of BID-2010 Plus

- **1. High Sensitivity**
  Detection Sensitivity over 100x Higher Than TCD, 2x Higher than FID

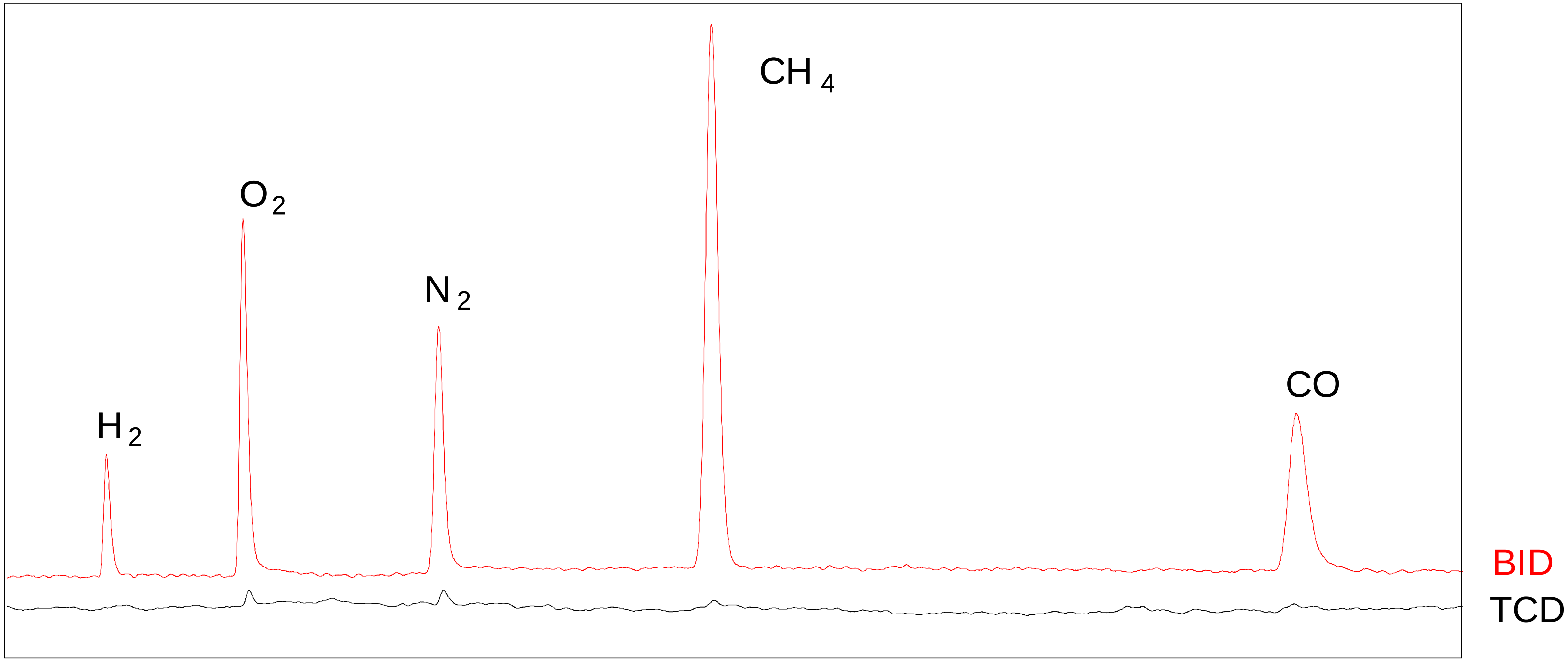
- **2. Novel Universal Detector**
  Single Detector Approach for Your Complex Analyses

- **3. Long-Term Stability**
  Long-Term Stability with New Discharge Design

1. High Sensitivity

Comparison with TCD：Gas sample

Sensitivities were compared using the responses of permanent gases. BID achieved over 200× higher sensitivity for organic compounds and several tens of times higher sensitivity for permanent gases.



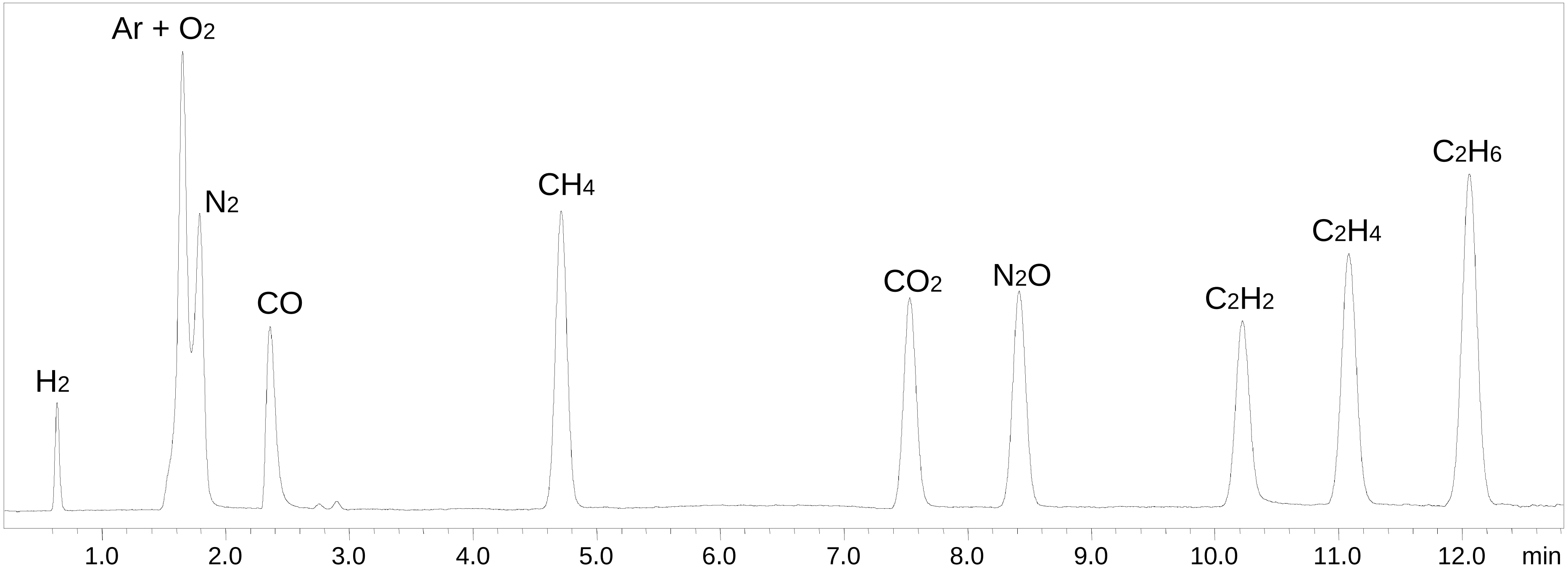
10 ppm concentration each compounent in He,
1:30 split analysis, 500 μL sample volume

1. High Sensitivity

High Sensitivity Analysis of Combination of Permanent Gases and Light Hydrocarbons

With conventional analytical methods, Since this kind of analysis requires a Methanizer* and FID for ppm level CO, CO2, and light hydrocarbons and TCD for permanent gases, the configuration is very complex. Now, in combination with an appropriate column, the single BID can realize mixture of permanent gases and light hydrocarbons with high sensivity.

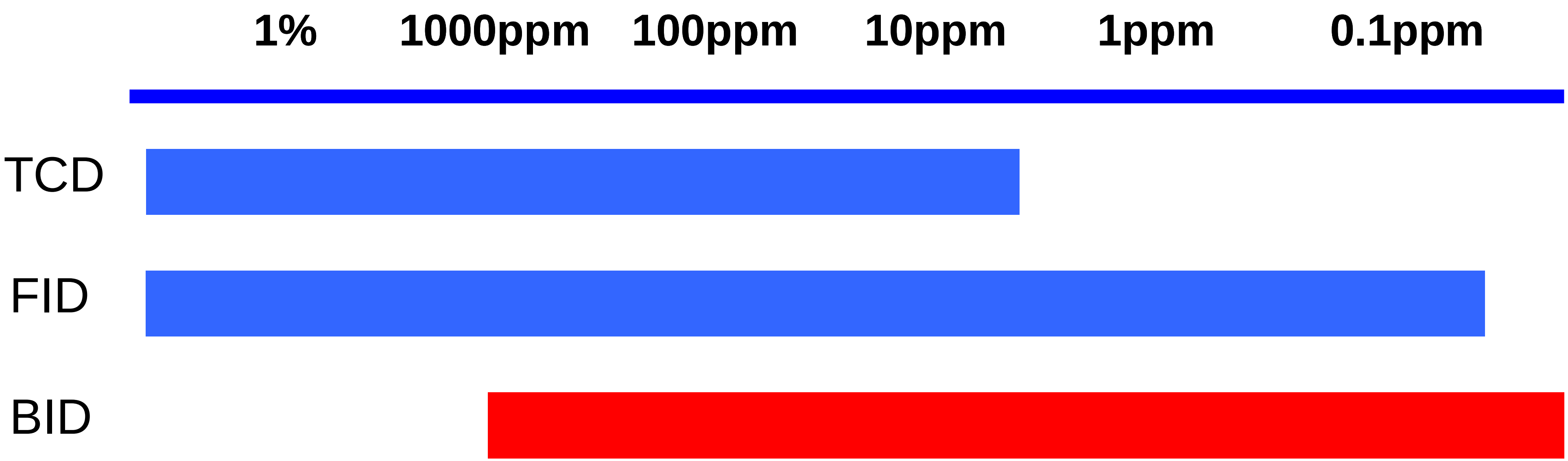
* Methanizer supports reduction reaction to methane with Ni catalyst.



5 ppm concentration each component in He,
1:5 split analysis, 1 mL sample volume

1. High Sensitivity

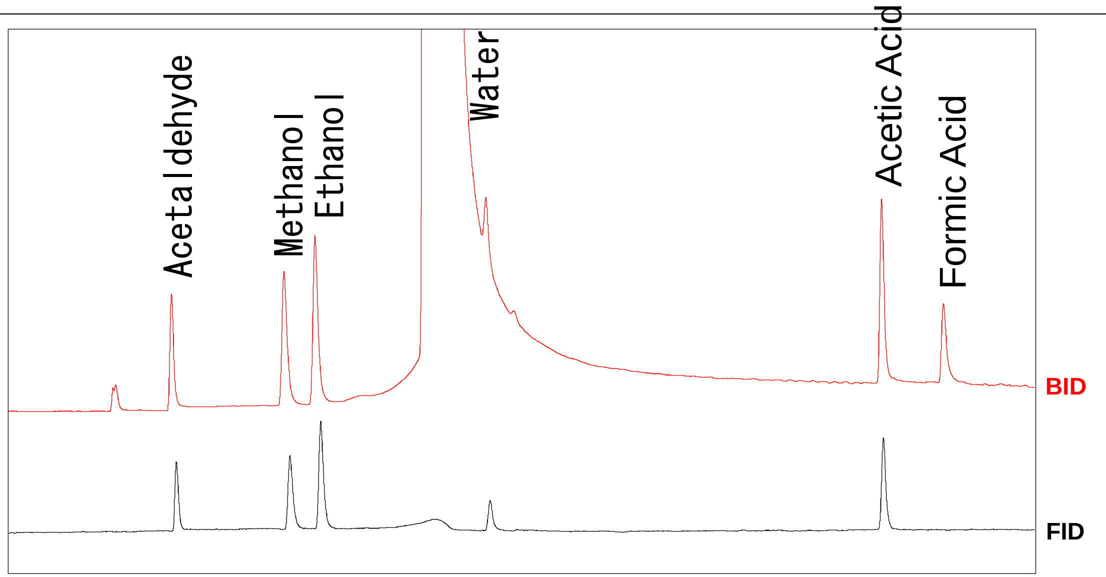
Comparison of Detectable Concentration Ranges



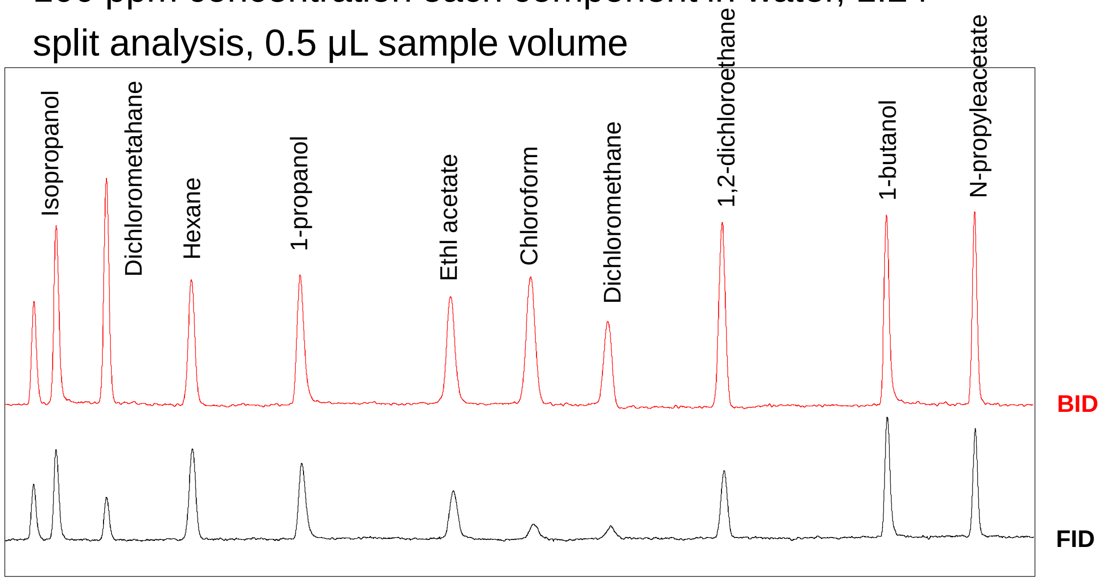
Note1: Due to the characteristic of BID, for % order analysis, recommend FID or TCD.

Note2: The detectable concentration ranges are guidelines only. They differ according to the compound structure, analysis conditions, and the GC instrument.

2. Novel Universal Detector



100 ppm concentration each component in water, 1:24 split analysis, 0.5 μL sample volume



10 ppm concentration each component in n-C6, 1:29 split analysis, 1 μL sample volume

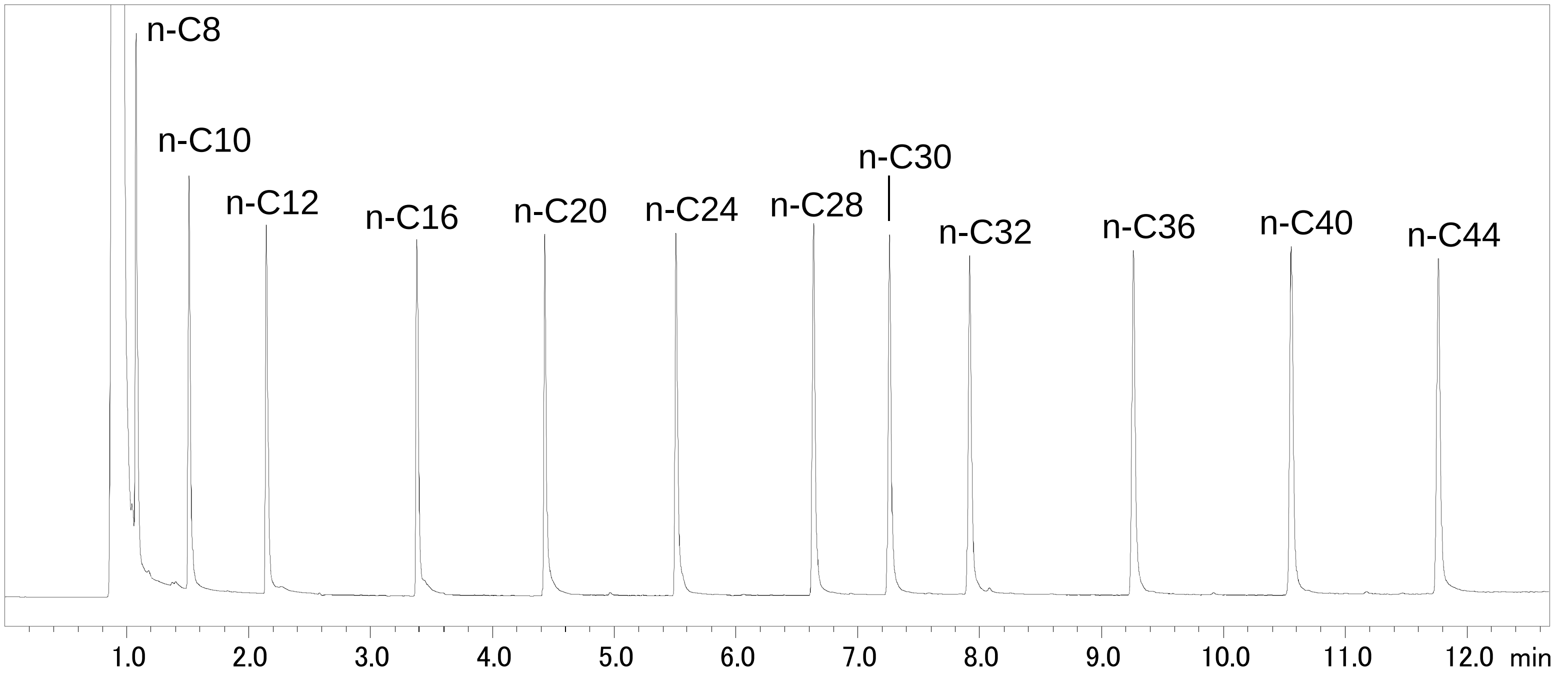
<u>Sensitivity Comparison Between BID and FID</u>

FID does not detect formic acid or formaldehyde because it does not show any responses to C of carbonyl group or carboxyl group (C=O). In addition, FID tends to exhibit lower sensitivity for compounds containing the hydroxyl group (-OH), aldehyde group (-CHO), or halogens (fluorine (F), chlorine (Cl), etc.) than for other hydrocarbon compounds. In contrast, the BID achieves superior sensitivity to such compounds, with less variation in relative response between compounds.

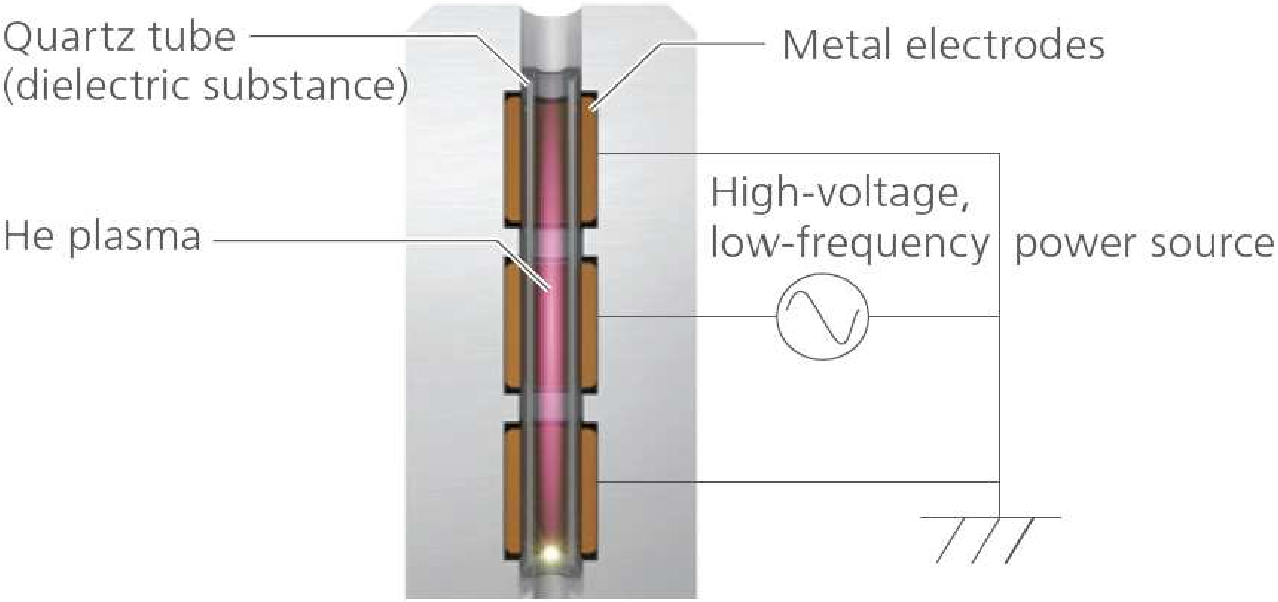
2. Novel Universal Detector

Handles High Boiling Point Components

Maximum operating temperature of BID is 350 °C. This allows n-paraffine mixture up to n-C44(boiling point: 545 °C) at increasing column temperature to 340 °C. BID supports analysis of high boiling point liquid samples in addition to gas samples.



3. Long-Term Stability



The barrier discharge technology of BID realizes a structure that plasma does not contact directly with the electrodes. In addition, temperature of the generated plasma is close to the room temperature. This feature keeps the electrodes at low temperature and deterioration of the electrode does not occur almost permanently. It leads to stable analysis in the long-term.

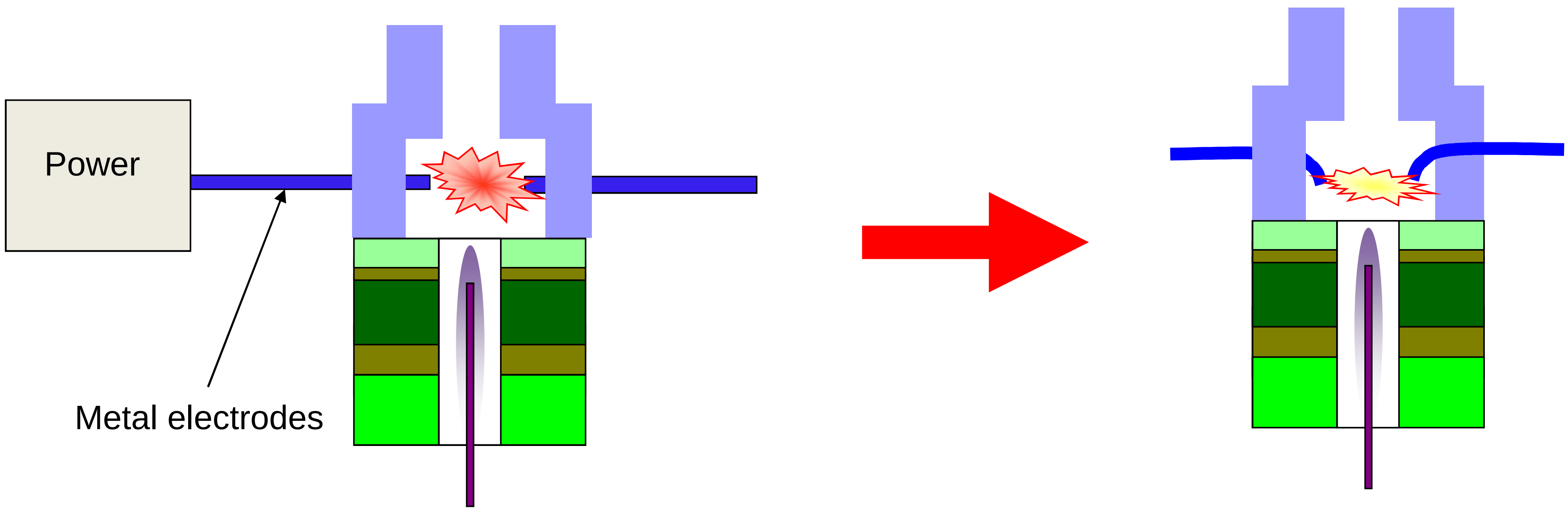
Low-temperature plasma

Barrier discharge = Protection of electrodes

-> Realizes Long-term stable analysis

3. Long-Term Stability

Conventional discharge technique is called “spark discharge”.



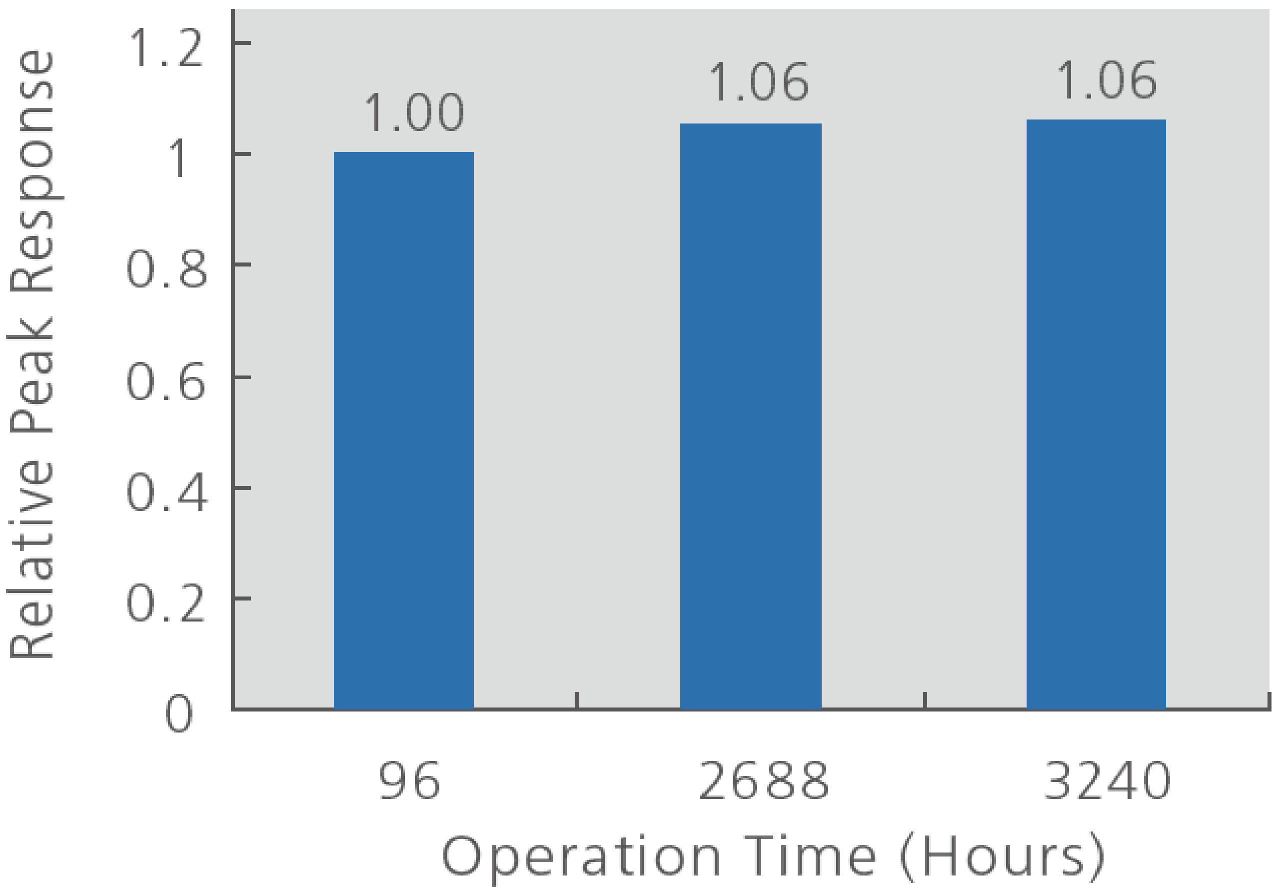
Electrodes are exposed, therefore deterioration of electrodes are fast.

The schematic heats electrodes by spark. This affects stability at analysis.

3. Long-Term Stability

Evaluation of Long-Term Stability

A sensitivity fluctuation test was performed for operation times of 96, 2,688, and 3,240 hours. When relative intensities of 2,688 and 3,240 hours vs. peak intensity at 96 hours are calculated, the difference was negligible.



3. Long-Term Stability

Repeatability of Trace Gas Analysis

A series of sample loop analyses was performed at 5 ppm concentration of each component. The calculated area repeatability showed RSD% of 0.84 – 1.80.

	H_2	CO	CH_4	CO_2	N_2O	C_2H_2	C_2H_4	C_2H_6
1	2263	10988	24335	26144	22263	14507	32211	45399
2	2240	10936	23998	26184	22043	14466	32808	44402
3	2280	10932	24752	26537	22435	14781	32986	44883
4	2336	10462	24032	26413	22250	14705	32386	45049
5	2237	11009	23660	26413	22515	15210	32312	45202
6	2216	11058	24172	26348	22398	14915	32909	44878
7	2230	10949	23955	27004	22604	14941	32838	45059
8	2291	10956	24687	26642	22659	14992	32871	45295
9	2253	11011	24379	26550	22426	15246	33058	45515
10	2237	11189	24741	26679	22685	15075	32792	45751
Ave.	2258	10949	24271	26491	22428	14884	32717	45143
RSD%	**1.57**	**1.71**	**1.54**	**0.95**	**0.90**	**1.80**	**0.92**	**0.84**

Applications

1. Analysis of Reaction Products in Artificial Photosynthesis Research
2. Analysis of Impurities in Ethylene
3. Analysis of Lithium Ion Battery Gas
4. Trace analysis of greenhouse gases
5. Carbone monoxide in Blood

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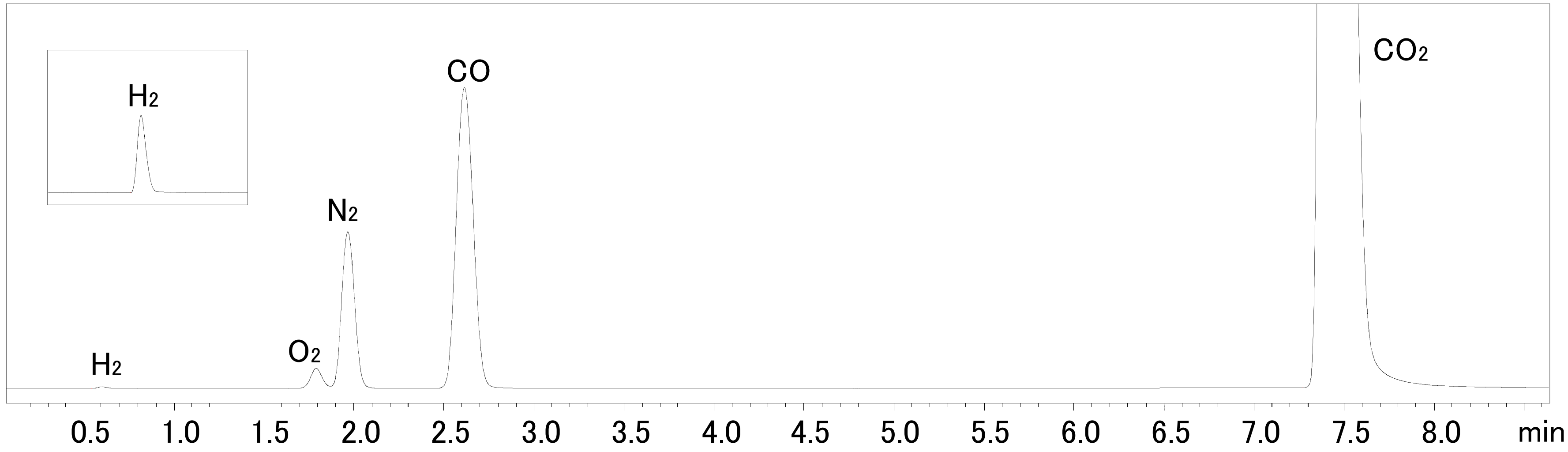
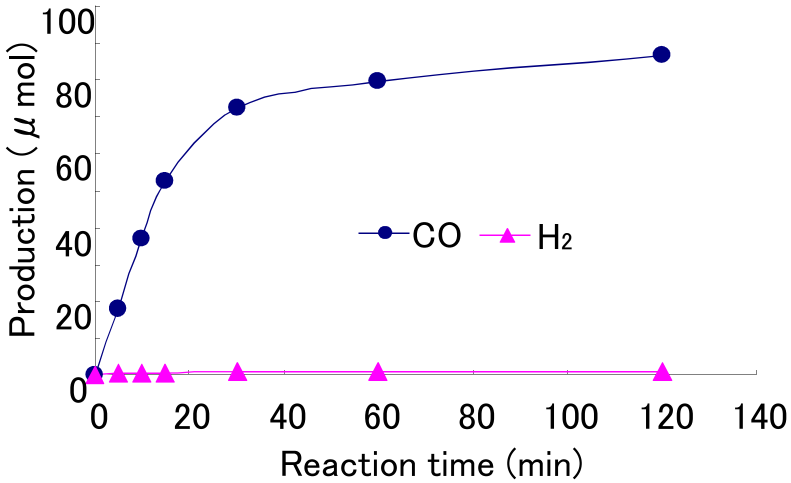
Analysis of Reaction Products in Artificial Photosynthesis Research

Artificial photosynthesis is a technique to capture energy from the sun and store it chemically.
It is expected to become the 4th renewable energy source along with photovoltaic, solar thermal, and biomass. Shown below is a result of simultaneous analysis of CO and H_2, which are generated in a photochemical-carbon dioxide reduction reaction.





The production amount of CO is rapidly increased, then slows as the reaction nears completion.

The Tracera GC system allows simultaneous, high-sensitivity measurement of CO and H_2 using a single detector and carrier gas.

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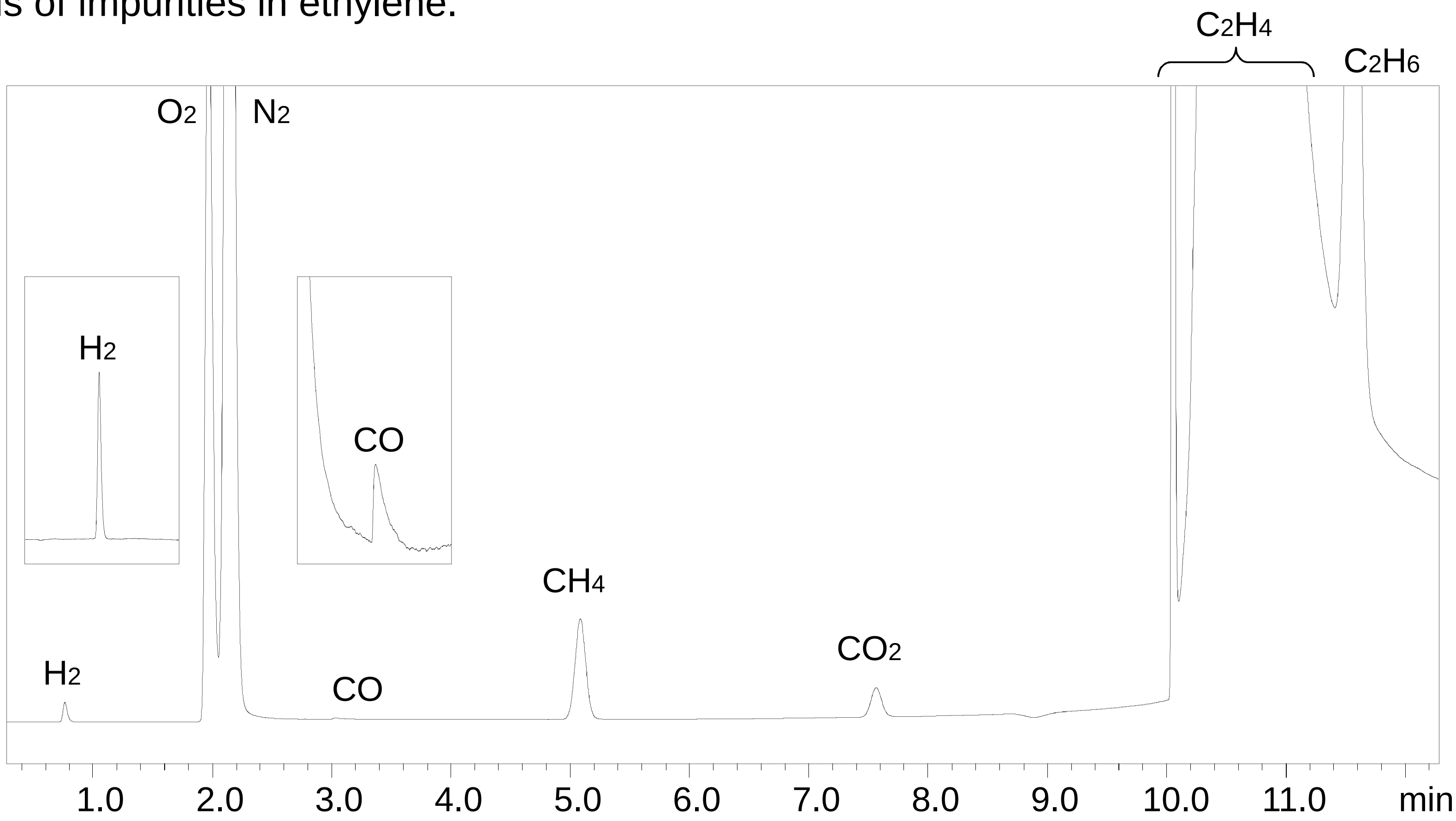
Analysis of Impurities in Ethylene

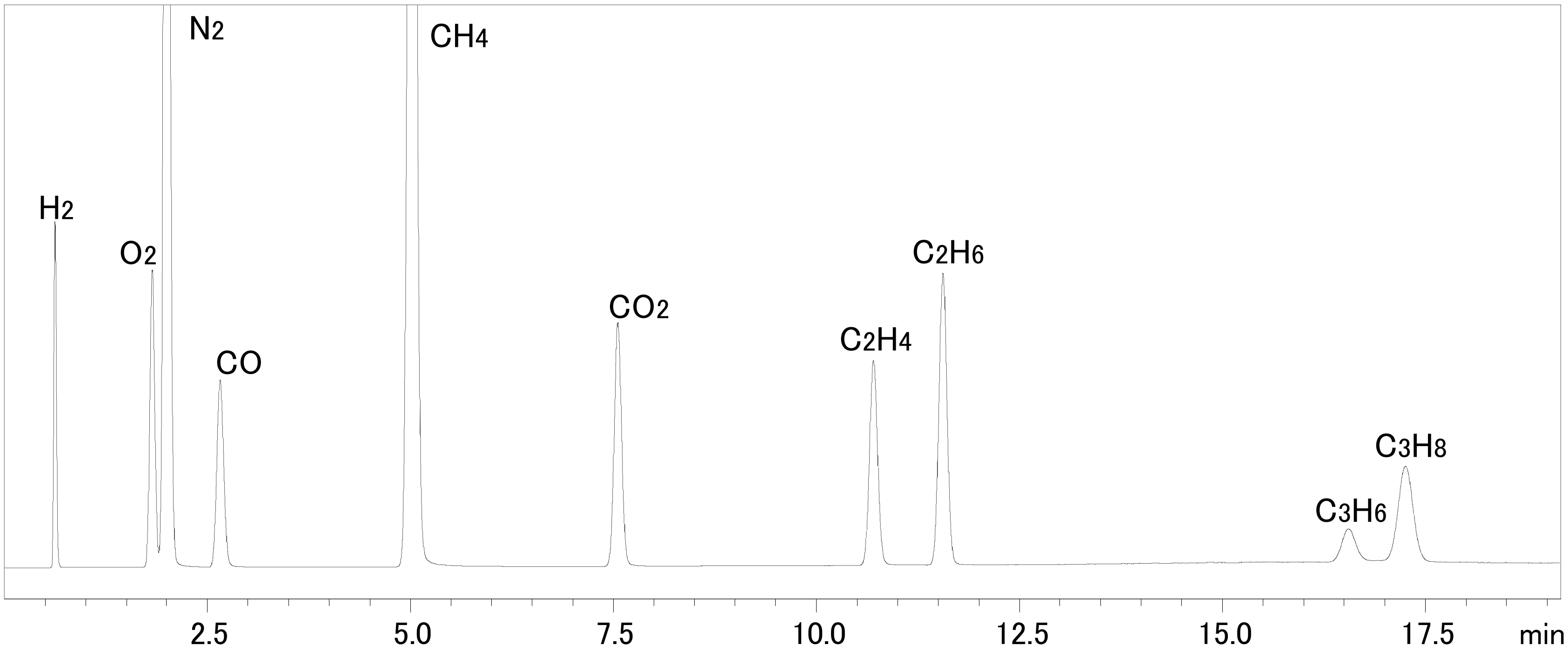
Ethylene is an important chemical used as a starting material in the production of many polymers. The purity of ethylene feedstock is essential to know. Below is an example of the analysis of impurities in ethylene.



H_2(30 ppm), CO(2 ppm), CO_2（15ppm）, and CH_4(30 ppm) are detected as trace impurities. The Tracera GC system allows simultaneous, high-sensitivity measurement of the permanent gases and light hydrocarbon impurities using a single detector and carrier gas.

Analysis of Lithium Ion Battery Gas

To evaluate the deterioration of lithium ion batteries, analysis of the gas produced during decay is required. The gas components are ideal for analysis by the Tracera system. Shown below is an example of the decay gas of lithium ion batteries.



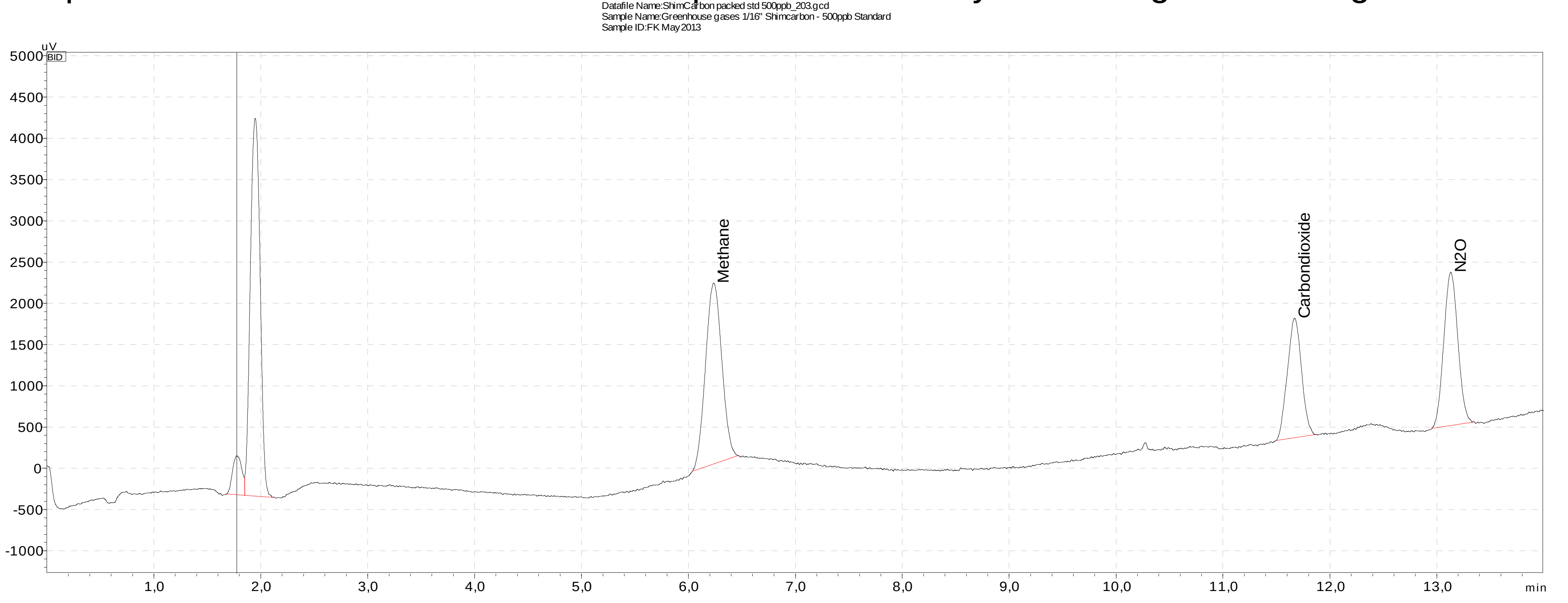
H_2	4.81%
O_2	2.04%
N_2	20.3%
CO	2.02%
CH_4	10.4%
CO_2	2.06%
C_2H_4	1.02%
C_2H_6	1.02%
C_3H_6	0.512%
C_3H_8	0.505%

The decay gas is extracted from a lithium ion battery, diluted, then introduced into the gas chromatograph. The Tracera GC system allows simultaneous, high-sensitivity measurement of the lithium ion decay gases using a single detector and carrier gas.

Trace greenhouse gas measurements

High Sensitivity Analysis of Greenhouse gases

So far measurement the Greenhouse gas CH_4, CO_2, and N_2O require a complex GC system with up to 3 detectors in order to achieve the required detection limits (e.g. <100ppb for N_2O). These requirements can be achieved with a simple one column system using BID as single detector.



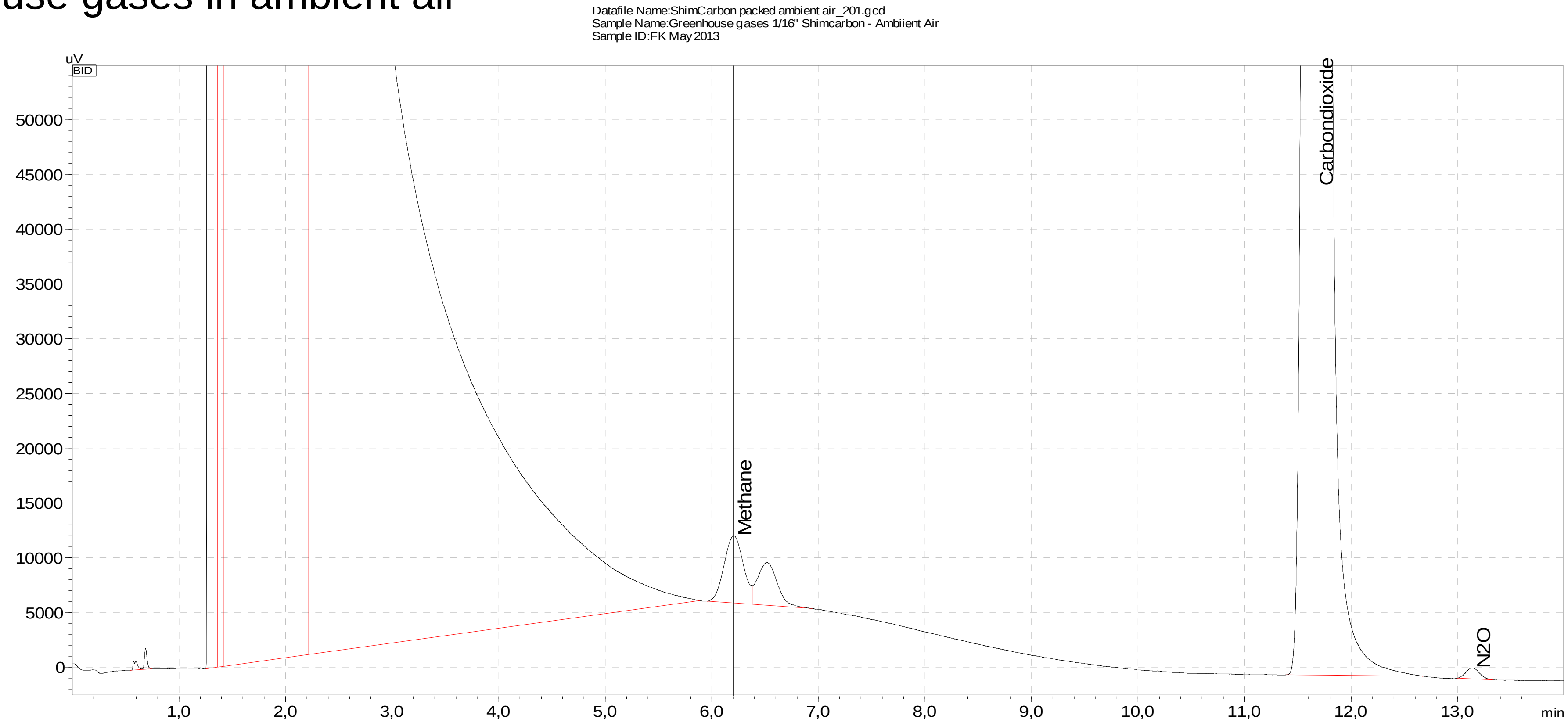
Greenhouse gas standard 500ppb methane, carbon dioxide and nitrous oxide.

Direct injection from 1ml sample loop on 2m 1/16" ShinCarbon ST micro packed column.

Trace greenhouse gas measurements

High Sensitivity Analysis of Greenhouse gases

Greenhouse gases in ambient air



Name	Ret. Time	Area	Height	Conc.	Unit
Methane	6,203	77362	6144	1664	ppb
Carbondioxide	11,664	9932381	1060978	371820	ppb
N2O	13,138	8972	1010	264	ppb

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Analysis of Carbone monoxide in Blood by GC-BID

"Forensic Medicine"

- Carbon monoxide(CO) is known as toxic gas. CO is generated by the incomplete combustion, and many poisoning accidents occur.

- In order to judge CO poisoning, CO concentration in the blood is analyzed by GC. TCD was used in the conventional method, but BID was adopted in Japan National Research Institute of Police Science. It is possible to analyze with a small amount of blood sample with high sensitivity BID.

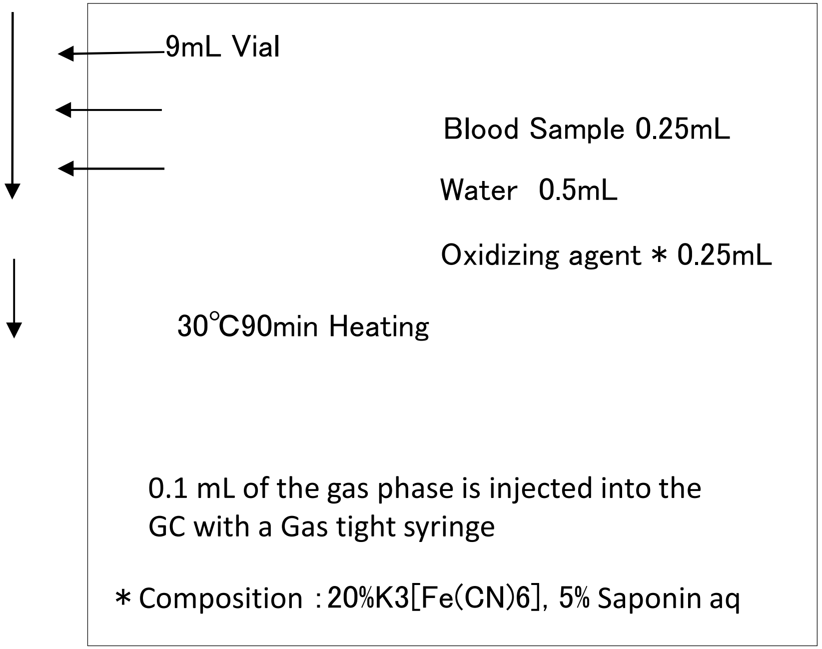

Fig. Example of sample pretreatment

Analysis of Carbone monoxide in Blood by GC-BID

Analysis Conditions

Model	: Tracera (GC-2010 Plus + BID-2010 Plus)						
Column	: RESTEK Rt-Msieve 5A (30 m X 0.53 mm I.D., df = 50 μm) with Particle Trap 2.5 m						
Column Temp.	: 100℃	Inj. Mode	: Split 1:7	Carrier Gas	: He 45cm/sec (constant linear velocity mode)		
Inj.Temp	: 250℃	Det. Temp.	: 280 ˚C	Discharge Gas	: 50 mL/min (He)	Inj. Volume	: 0.1 mL

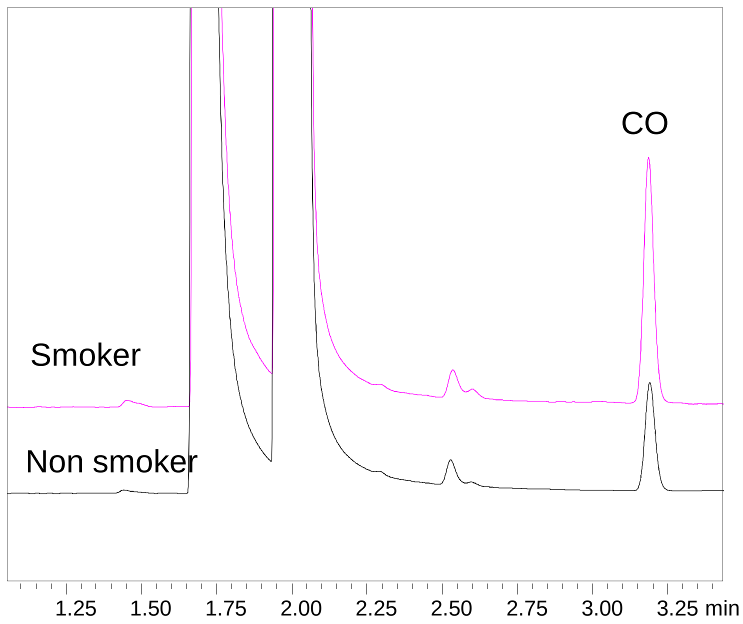

Fig. Comparison between smoker and non smoker

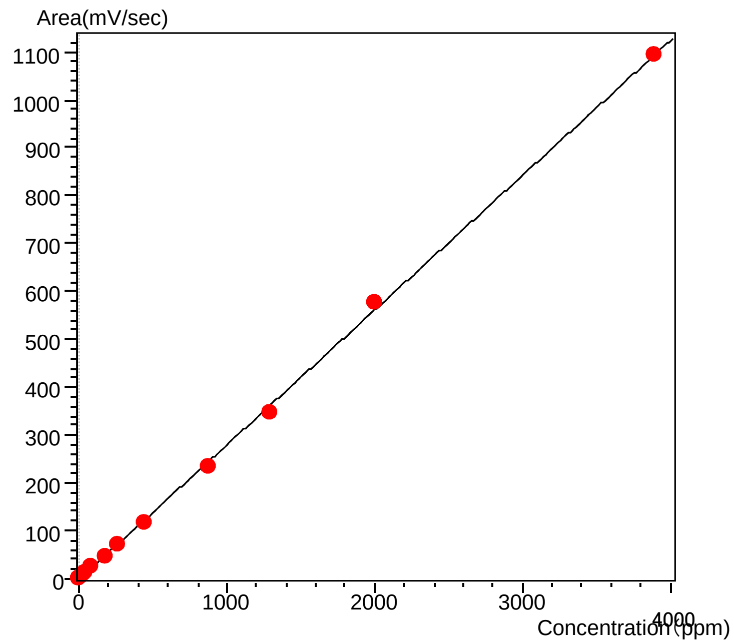

Fig. Calibration curve of 2 - 3900 ppm