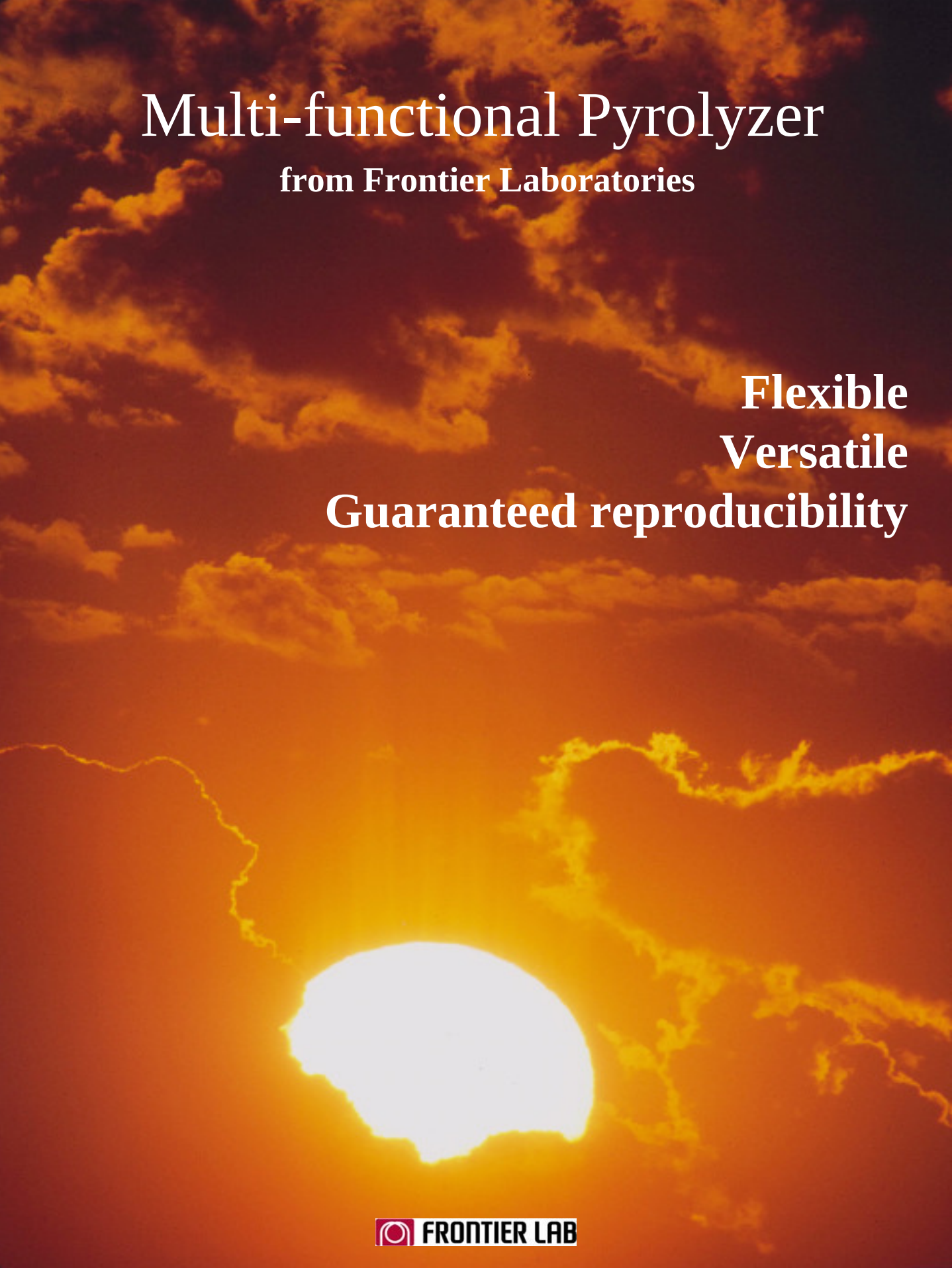
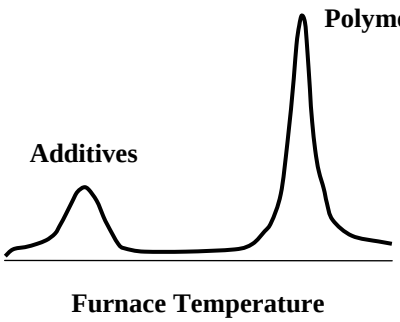

Multi-functional Pyrolyzer
from Frontier Laboratories
Flexible
Versatile
Guaranteed reproducibility
FRONTIER LAB

Versatile

This is the most versatile of any Gas Chromatographic inlet system available. Most liquids and solids can be chemically characterized using five powerful thermal techniques.



Evolved Gas Analysis (EGA)

EGA provides a thermal profile of the sample. A short 2.5 m deactivated capillary tube connects the Frontier multi-functional pyrolyzer and the GC detector. As the sample temperature increases, compounds "evolve" from the sample matrix and are detected. EGA enables the scientist to determine to complexity of the sample, the presence of volatile compounds and the proper pyrolysis temperature.

Thermal Desorption (TD)

The furnace temperature is programmed up and compounds are desorbed as a function of their boiling points. The compounds are first trapped at the head of the column and then chromatographically separated and detected.

Pyrolysis (Py) – "Single shot"

Pyrolysis is used for macromolecular and other non-volatile materials. When a sample is rapidly heated (<20msec) to high temperatures, chemical bonds are broken. The resulting fragments are chromatographically separated, producing a pyrogram. The pyrogram is used to characterize the nature of the original sample.

Thermal Desorption / pyrolysis - "Double-Shot" Analysis - GC/MS

"Double-Shot" is the unique combination of *Thermal Desorption (TD) and Pyrolysis (Py).* TD is used to identify volatile compounds in the sample such as residual solvents, reaction products, monomers, and additives like antioxidants and stabilizers. Py is used to characterize the polymer.

Heart cut - EGA GC/MS Analysis

The EGA thermogram is used to profile the sample components. Each fraction of the sample can be automatically collected, analyzed and characterized using heart cutting techniques.

Flexible

A full range of accessories are available which give the multi-functional pyrolyzer the flexibility needed for optimum performance in all operating modes.

Carrier gas selector

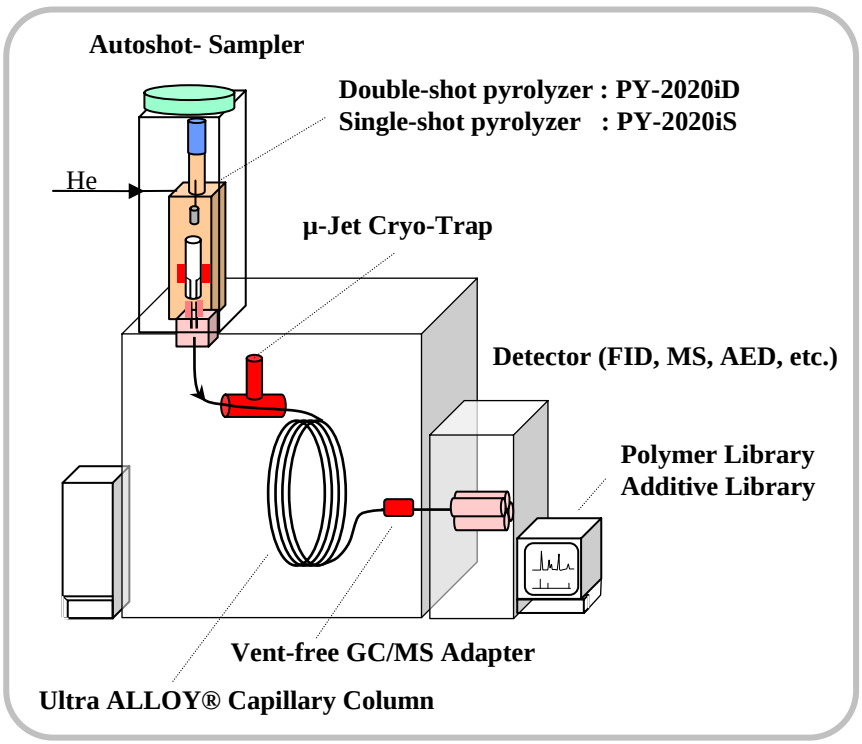
Enables the operator to select between two gases. Helium is nominally used. Air and oxygen are used when performing reactive pyrolysis.

Selective sampler

Sample fractions can be automatically vented (i.e., cut) or directed to the analytical column.

Micro-jet cyro trap

Compounds are focused at the head of the column prior to analysis. Liquid nitrogen cools the trap to -196ºC.



F-Search for polymer identification

Utilizes a patented search algorithm to tentatively identify samples based on their pyrogram or EGA thermogram and additives.

Vent-free GC/MS adapter

Enables the operator to change columns without venting the MS. Switching between the EGA mode and one of the other modes is simple. MS recovery time is less than 2 minutes.

Ultra-ALLOY® EGA Tube and capillary columns

A patented multi-step process yields a deactivated stainless steel surface which is stable at temperatures greater than 400ºC. Ultra-ALLOY columns and EGA tubes are the prefect match for all modes of the multi-functional pyrolyzer.

Detailed Sample Characterization

Double-Shot™ Analysis : *Unique combination of Thermal Desorption and Pyrolysis*

Thermal Desorption (TD)

The sample cup is dropped into the µ-furnace at 40°C. The furnace is programmed to 320ºC at 20ºC/min. The volatile compounds are re-concentrated using µ-jet cold trap. The *GC* subsequently separates the desorbed volatile compounds. The mass spectrum are used to identify each compound using F-Search Additive Library.

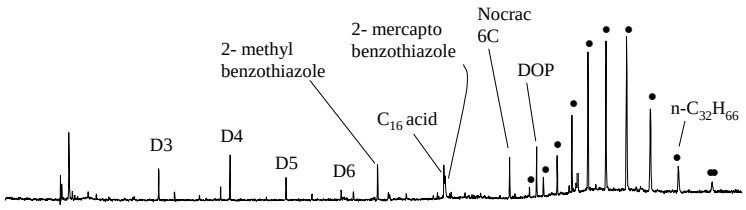
Pyrolysis (Py)

Once the thermal desorption is complete, the sample cup is lifted out of the µ-furnace. The µ-furnace is heated to 600ºC and the sample cup is dropped back into the furnace. The non-volatile portion of the sample is pyrolyzed. The pyrogram can be matched with standard pyrograms using the F-Search Pyrolysis Library.

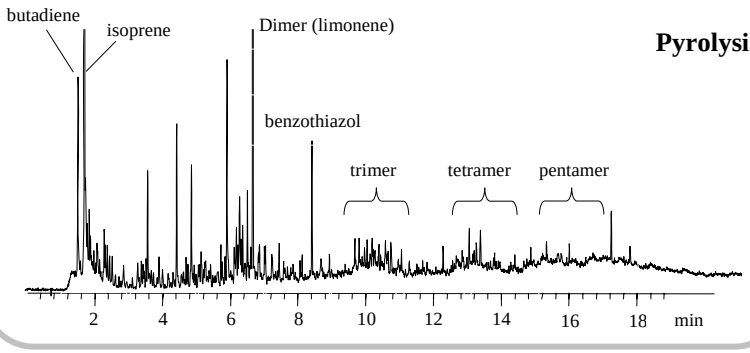
Chromatograms of a formulated rubber sample

Column: Ultra ALLOY-5 (MS/HT), 30m x 0.25mm id, 0.25 µm film)
Column temp: 40 – 320°C (20°C/min), 50 µg sample

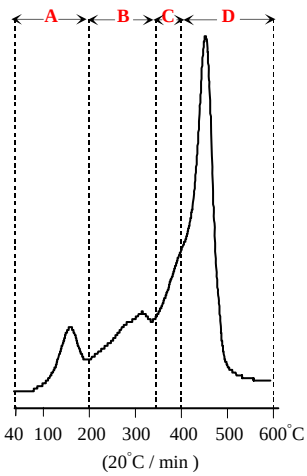
Thermal Desorption



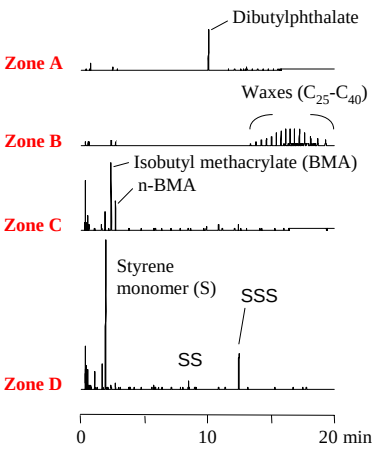
Pyrolysis



EGA analysis of a composite ceramic/polymer



GC/MS analysis of each EGA zone



Heart-cut EGA-GC Analysis

It may be important to characterize all fractions of a sample. Low boiling fractions may be additives: plasticizers, anti-oxidants, etc.. Other fractions may reveal an impurity, or explain the reasons for process problems. Each heart-cut can be characterized by GC/MS. Pyrolysis of the higher boiling fractions is used to identify a specific polymer blend using Frontier's F-search polymer libraries .

For more information: frontier-lab.com

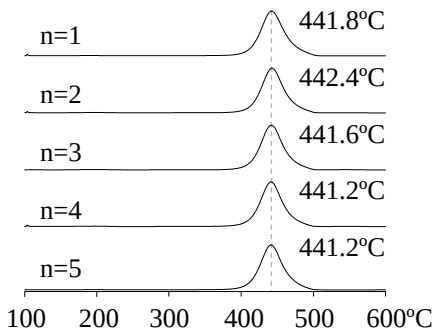
Reproducible

GUARANTEED REPRODUCIBILITY!

Frontier is the only manufacturer that publishes a reproducibility specification for their pyrolyzer. Frontier guarantees that the styrene trimer to monomer ratio (SSS/S) will be less than 3%RSD. The amazing reproducibility of the Frontier system can be attributed to the simplicity and ease of placing the sample in the Eco-cup, the patented design of the vertical µ-furnace, the inertness of the sample path and the elimination of all dead volumes. Frontier provides a level of precision and accuracy never before seen in pyrolysis-GC/MS.

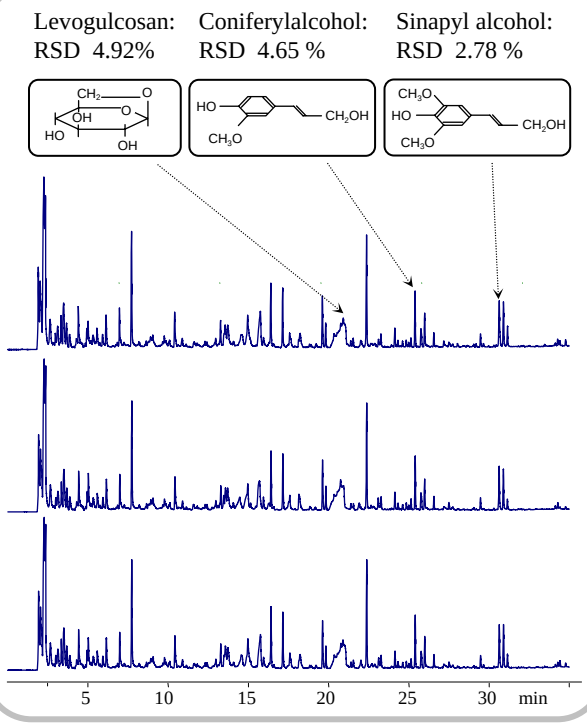
These two examples illustrate the reproducibly of the system in two of the most common modes of operation. Meaningful heart-cut fractions can only be obtained if the system can reproducibility analyze sample after sample. Look at the data and judge for yourself.

EGA of polystyrene (RSD 0.11%)



Pyrolysis temp.: 100~600ºC (20ºC/min)
EGA capillary tube: 2.5m X 0.15mm id L
GC oven temp.: 300ºC
Injection temp.: 320ºC
Sample: 30µg
Detector : FID

Pyrolysis of Eucalyptus wood

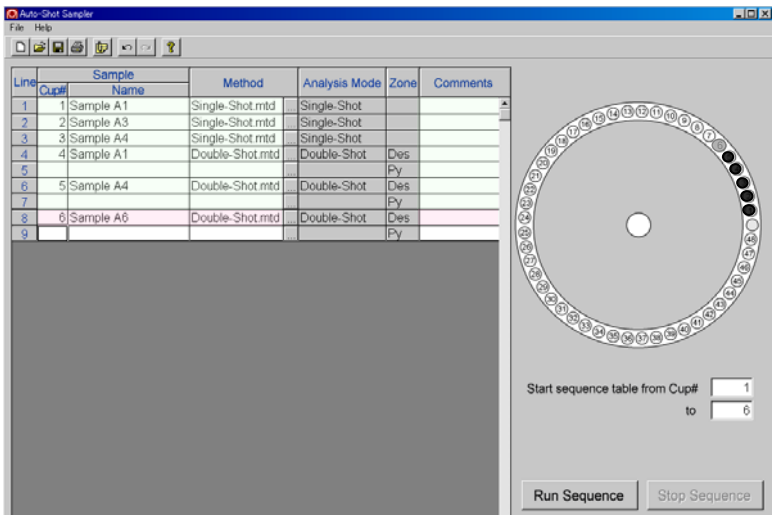


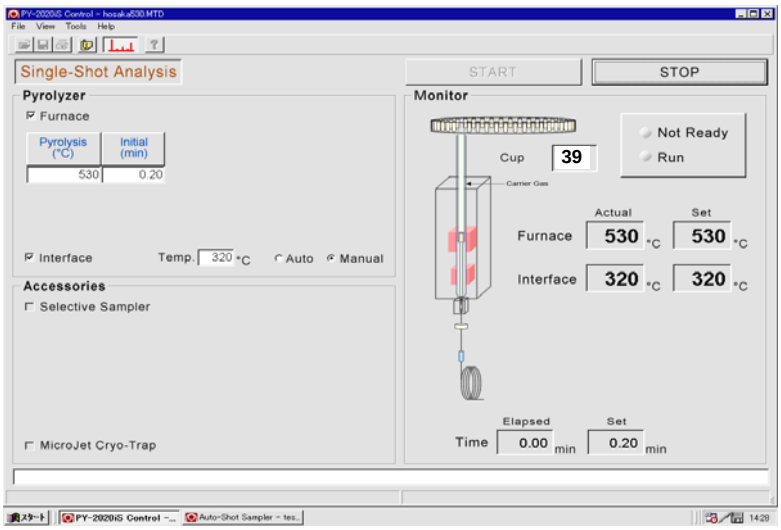
PY:2020iD, UA5(MS/HT)-30M-0.25F, He: 1 ml/min.
split ratio: 1/50, FID, Sample: 100 µg

Automated Autoshot-Sampler

48 sample Autoshot-Sampler and the Frontier multi-functional pyrolyzer provide guaranteed reproducibility in all operating modes – automatically.

Samples may be analyzed in sequence or at random. The complete sample method is set up using Frontier's software installed on the PC controlling the GC. Status is monitored on-screen. Samples already analyzed are noted in green, and the samples to be analyzed are shown in red.





This is a representative screen. It displays the mode of operation for the sample being analyzed as well as the current status of the inlet. The number of the sample being analyzed, position of the cup and the carrier gas flow rate are displayed in real time.

For more information: frontier-lab.com

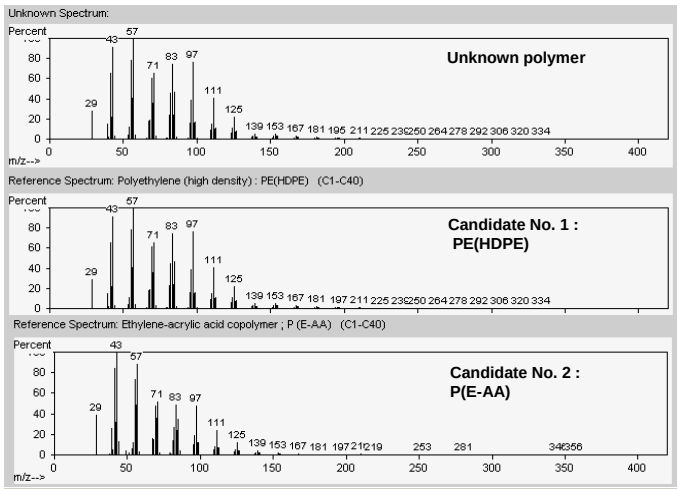
Polymer Identification

Frontier Laboratories' F-Search contains EGA & pyrogram polymer libraries. The libraries use a patented search algorithm which enables the chemist to identify unknown polymeric materials rapidly and unambiguously. The libraries contain averaged data for 164 pyrograms and EGA thermograms. The chemist can easily edit or customize the libraries to fit specific chemical applications.

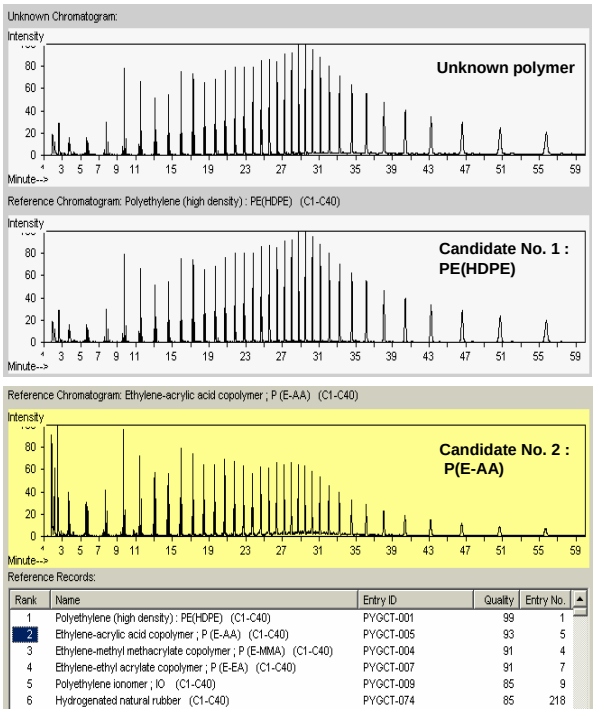
F-Search is compatible with GC/MS data obtained using Agilent, Shimadzu, and JEOL instruments. Data generated using GC/MS systems manufactured by other companies can also be interpreted after converting them to a NetCDF (AIA) file.

The partial results from a typical library search are illustrated below

The average spectrum of the unknown along with the averaged spectrum of the two best matches are shown. A table showing match quality is also presented.



Rank	Name	Entry ID	Quality
1	Polyethylene (high density) : PE(HDPE) (C1-C40)	PYGCT-001	99
2	Ethylene-acrylic acid copolymer ; P (E-AA) (C1-C40)	PYGCT-005	93
3	Ethylene-methyl methacrylate copolymer ; P (E-MMA) (C1-C40)	PYGCT-004	91
4	Ethylene-ethyl acrylate copolymer ; P (E-EA) (C1-C40)	PYGCT-007	91
5	Polyethylene ionomer ; IO (C1-C40)	PYGCT-009	85



Rank	Name	Entry ID	Quality	Entry No.
1	Polyethylene (high density) : PE(HDPE) (C1-C40)	PYGCT-001	99	1
2	Ethylene-acrylic acid copolymer ; P (E-AA) (C1-C40)	PYGCT-005	93	5
3	Ethylene-methyl methacrylate copolymer ; P (E-MMA) (C1-C40)	PYGCT-004	91	4
4	Ethylene-ethyl acrylate copolymer ; P (E-EA) (C1-C40)	PYGCT-007	91	7
5	Polyethylene ionomer ; IO (C1-C40)	PYGCT-009	85	9
6	Hydrogenated natural rubber (C1-C40)	PYGCT-074	85	218

A Comparison of the pyrograms to the unknown data is also shown.

Do you want to learn more about the most flexible, versatile, reproducible pyrolyzer ever?

Information about the system, any of the accessories discussed, technical data sheets on the various modes of operation and overall system performance is available from Frontier Laboratories. The application library, also available from Frontier Laboratories has over 100 briefs for your review and is posted on the Frontier-lab web page.

Multi-functional pyrolyzer

Autoshot-Sampler

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FRONTIER LAB

Specification of PY-2020iD and PY-2020iS

September 1, 2009

(The system consists of pyrolysis furnace with interface, sampler, temperature controller, standard accessories, and options)

MODEL	Double-Shot Pyrolyzer PY-2020iD (Patent No:2742492)	Single-Shot Pyrolyzer PY-2020iS
1. PERFORMANCE	*Guaranteed performance*	*Guaranteed performance*
1. Reproducibility of pyrogram	1. Polystyrene Monomer(S) and trimer(SSS) ratio (FID): SS/S(%):14±1%, RSD: less than 2% for Trimer vs. Monomer peaks of S pyrogram at 550°C	Same as left
2. Full deactivation and minimum dead space of Py/GC flow path up to the column outlet	2. No peak tailing with polar test compounds	Same as left
2. HEATING & SAMPLING	*Vertical type of micro-furnace (Double cartridge heating system)*	
• **PY furnace** (patent pending)	*Heat & Cooling by compressed gas*	*Heating only*
Sample introduction	Free fall push button system	Same as left
Pyrolysis tubing	Quartz	Same as left
Temp. control range & stab.	40～800°C (1°C step), ±1°C for each set temp	100～800°C (same as left)
Cooling time	30 min (600 to 50°C, Auto ITF mode)	N.A.
• **Interface (ITF)**		
ITF needle	Deactivated needle by multi-layer treatment	Same as left
Heater	Cartridge heater	
Temp Control range	RT - 400°C (1°C step)	
Temp stability	±1°C for each set temp	
• **Sampler**	Double(DBL) sampler (Sample cup moves up/down for thermal desorption from sample holding position at room temp and/or drops down to the furnace for flash pyrolysis by gravity)	Single-Shot (SGL) sampler (Sample cup drops down to the furnace for flash pyrolysis by gravity)
• **Sample Cup** (patent pending) Eco-Cup F (Small/ Large)	All deactivated stainless steel cup & stick Small:50 and large:80 µl	Same as left
• **Liquid Sampler**	Liquid sample can inject with a regular micro-syringe	Same as left
3. TEMP CONTROLLER	*PC control (Install an exclusive software in PC for GC or GC/MS)*	
• **Functions**	SGL/DBL, EGA multi-temp prog, Automatic Heart-cut EGA Sampling, Interface temp, Monitor, File, Function, Date/Time, Maintenance	SGL/DBL, ITF temp, Maintenance
•**TEMP Control** Furnace	40～800°C（1°C step）	40～800°C（1°C step）
ITF	40～400°C (1°C step) Auto/Manual mode	40～400°C（1°C step） Manual mode
• **Furnace Temp Programming**	Setting: 4 steps of multi temperature programming	N.A.
Prog. Rate	1～100°C /min (1°C /min step)	
Holding time	1～999.9 min (0.1 min step)	
Pyrolysis time	1～999.9 min (0.1 min step)	
• **Over heating Protection**	PY：820°C, ITF: 420°C	Same as left
• **External Communication**	RS-232C	Same as left
• **Control Software (Required PC environment)**	Runs on Windows Vista, XP, 2000, 98 and NT (SP4) OS: Windows Vista, XP, 98, NT (SP4) Media driver: CD Hard disc space: >5MB Display resolution: Higher than 1024 X 768 Interface: RS-232C D-sub 9 pins (male)	Same as left
4. Standard Accessories	(one year consumable kit)	
• Pyrolysis tube (Quartz)	2 pieces	Same as left
• Ultra ALLOY Capillary Column	UA-5 (5%diphenyl), 30m (0.25mm id) 0.25µm	Same as left
• EGA tube for EGA analysis	2.5 m (0.15 mm id) (Deactivated metal tube)	N.A.
• Standard sample	1 ml [polystyrene(6µg/µl) with fatty acid esters mixture]	1 ml (polystyrene, 6µg/µl)
• Tool, sample cup etc.	1 set	Same as left
5. Miscellaneous		
• Power requirement	AC110V ±10% (50/60 Hz） 4A	Same as left
• Size (W x D x H)/ (kg)		
Pyrolyzer	76 x125 x 260 mm / 1.6kg	76 x125 x 215 mm / 1.4kg
Temperature controller	160 x 280 x 360 mm / 5.4kg	Same as left
• Recommended GC	Agilent 7890,6890,5975GC/MSD, Shimadzu 2010, 2014, QP-2010,QP-5050, Thermo Fisher TRACE GC	Same as left
• User preparation:	Compressed gas; N_2 or Air (400-600Kpa) for cooling the furnace.	(not necessary to prepare compressed Air)
6. Options	Auto-Shot Sampler, F-Search (EGA/Pyrogram/Pyrolyzates polymer and additive library) , Micro Jet Cryo-Trap, Carrier Gas Selector, Selective Sampler, Magic Chemisorber, Vent-free GC/MS Adapter, Ultra ALLOY Capillary Column	