6000 Series Pyrolyzer

Pyrolysis

One for All

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CONTENTS

01

What is Pyrolysis?

What is Pyrolysis ?

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Pyro + **lysis** = **Pyrolysis**

“Fire” **“Separating”**

- Pyrolysis is a chemical reaction of organic bond cleavage without the participation of oxygen by pure thermal energy.

01

What is Pyrolysis ?

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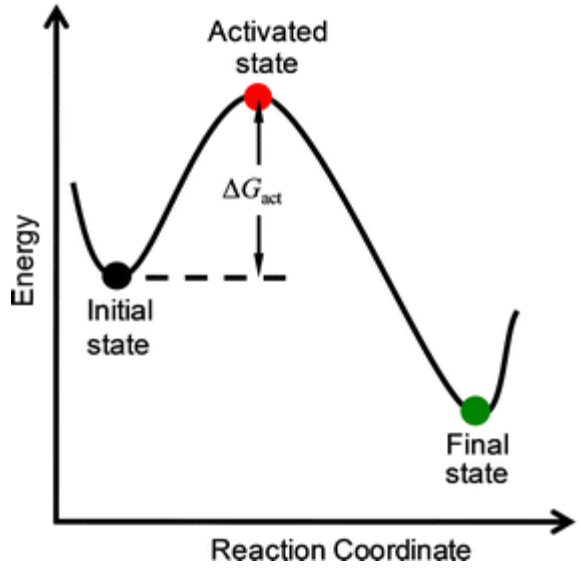
The most important parameter
of analytical pyrolysis is
the precise control of thermal energy



01

What is Pyrolysis ?

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Key Concepts

- The **pyrolysis kinetics** is determined by how thermal energy is introduced
- **Py-GC/MS** is a powerful tool in the identification of pyrolysis products (Pyrogram)
- **Polymer identification** is possible through a **library match** on pyrolysis products as are Thermally Desorbed VOC's such as additives

01

What is Pyrolysis ?

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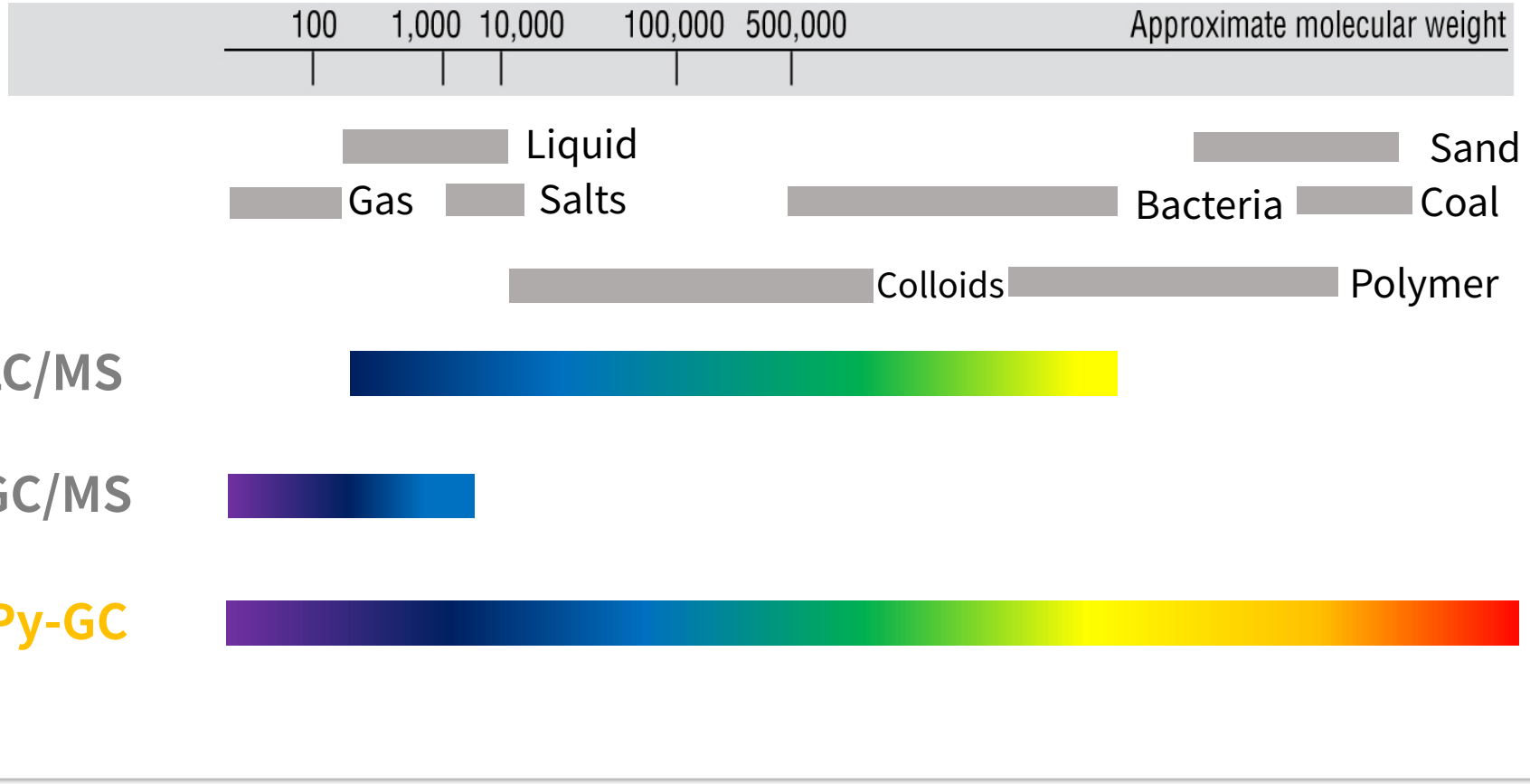
- Pyrolysis significantly expands the analytes for GC



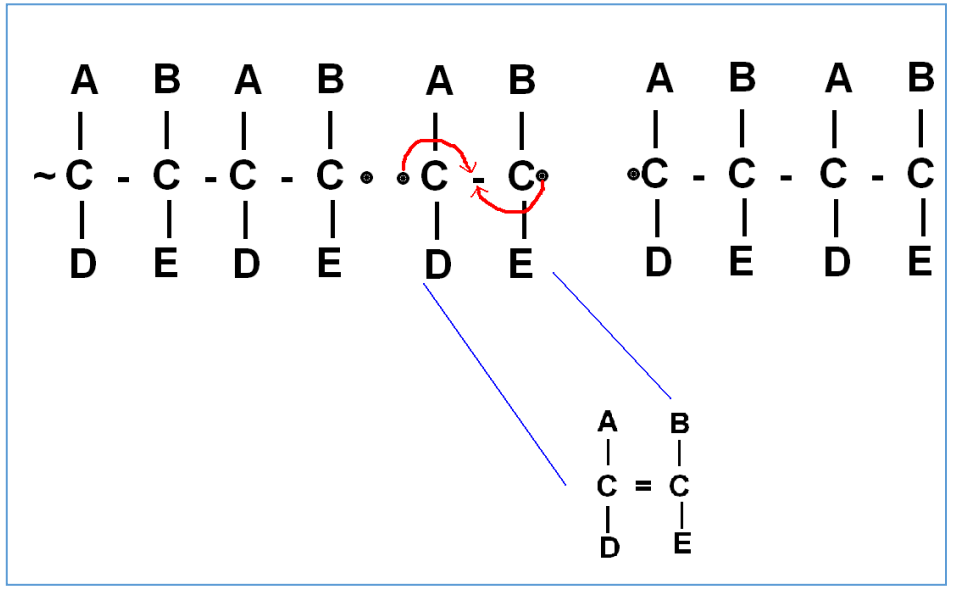
02

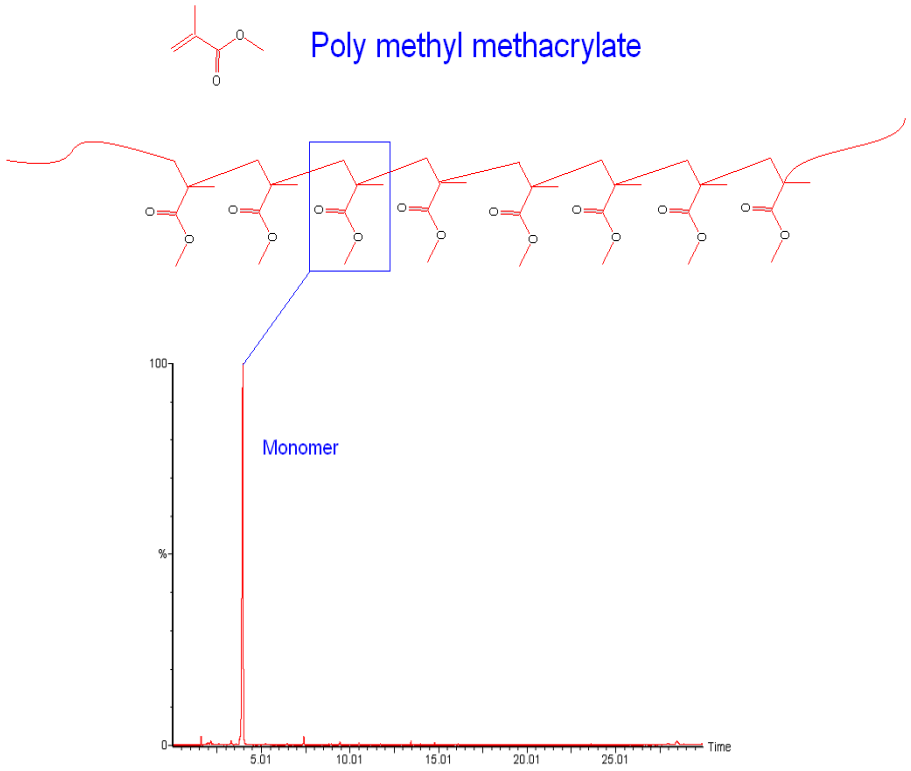
Polymer Degradation Mechanisms (Pyrolysis Kinetics)

Polymer Degradation Mechanisms

- Unzipping

  poly methyl methacrylate

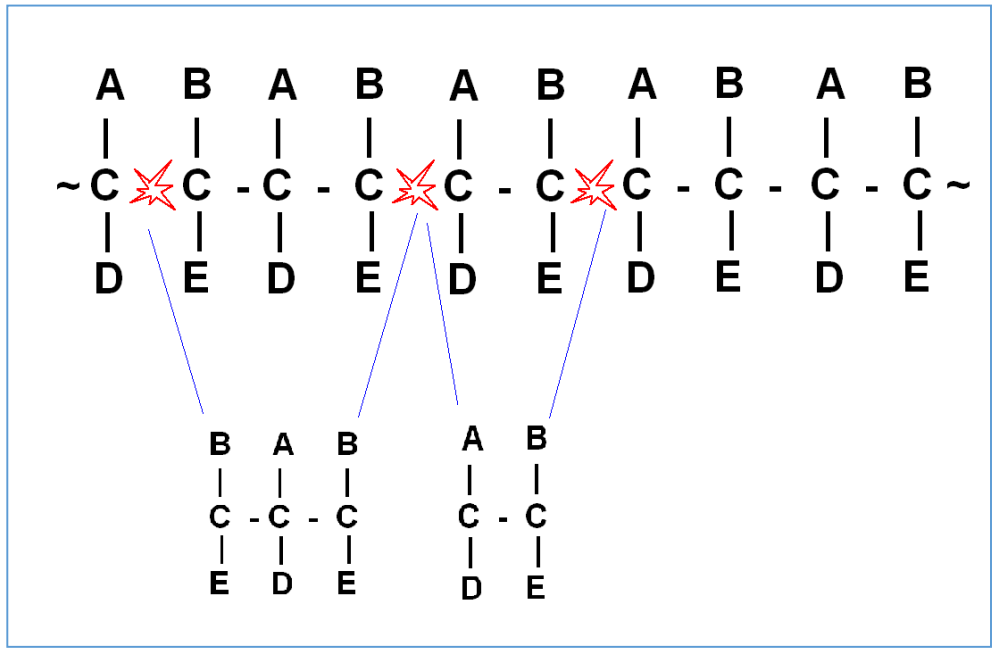


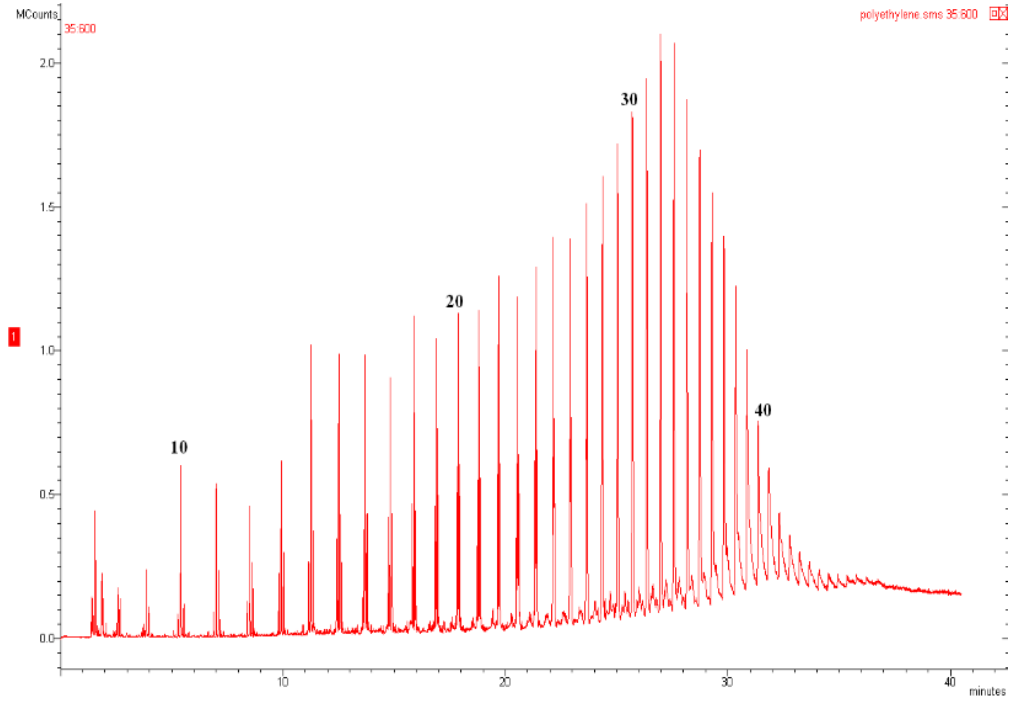


Polymer Degradation Mechanisms

- Random Scission

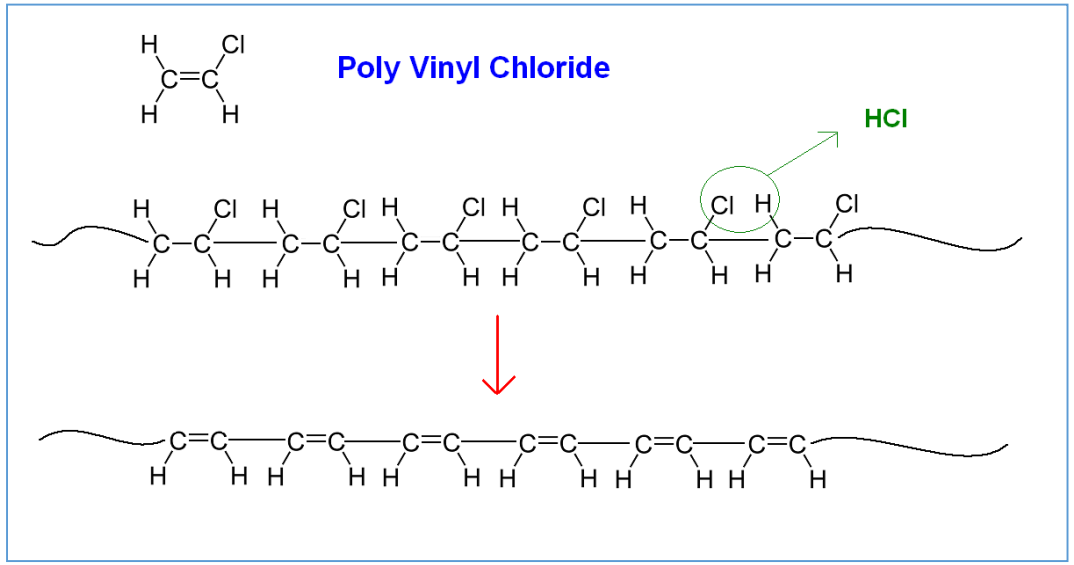
  Polyethylene

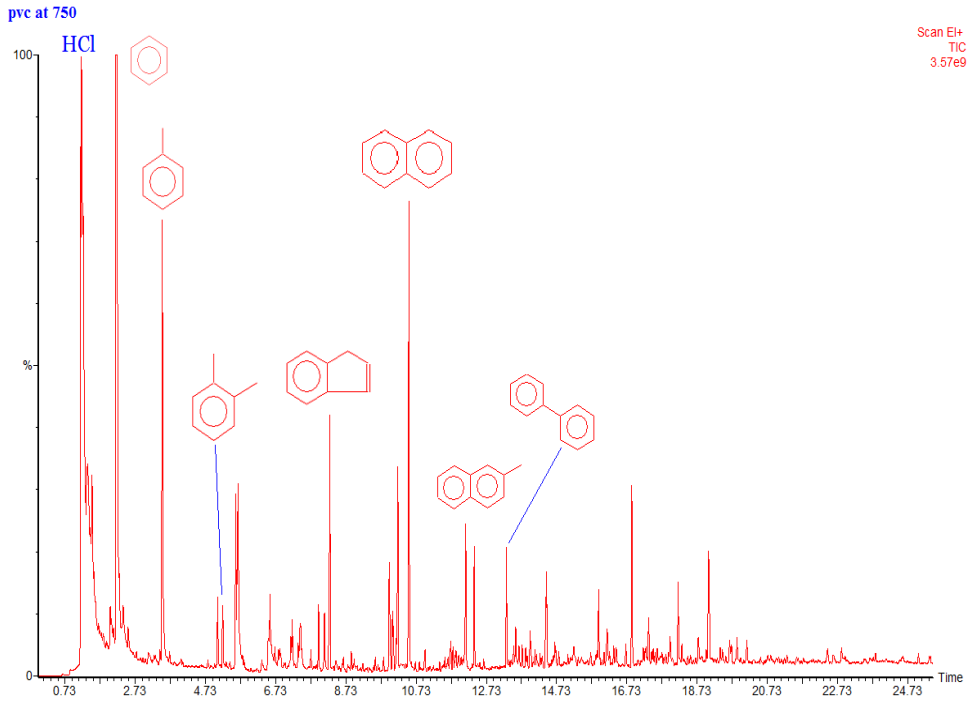




Polymer Degradation Mechanisms

- Side group elimination
  Poly vinyl chloride





03

Multiple Function

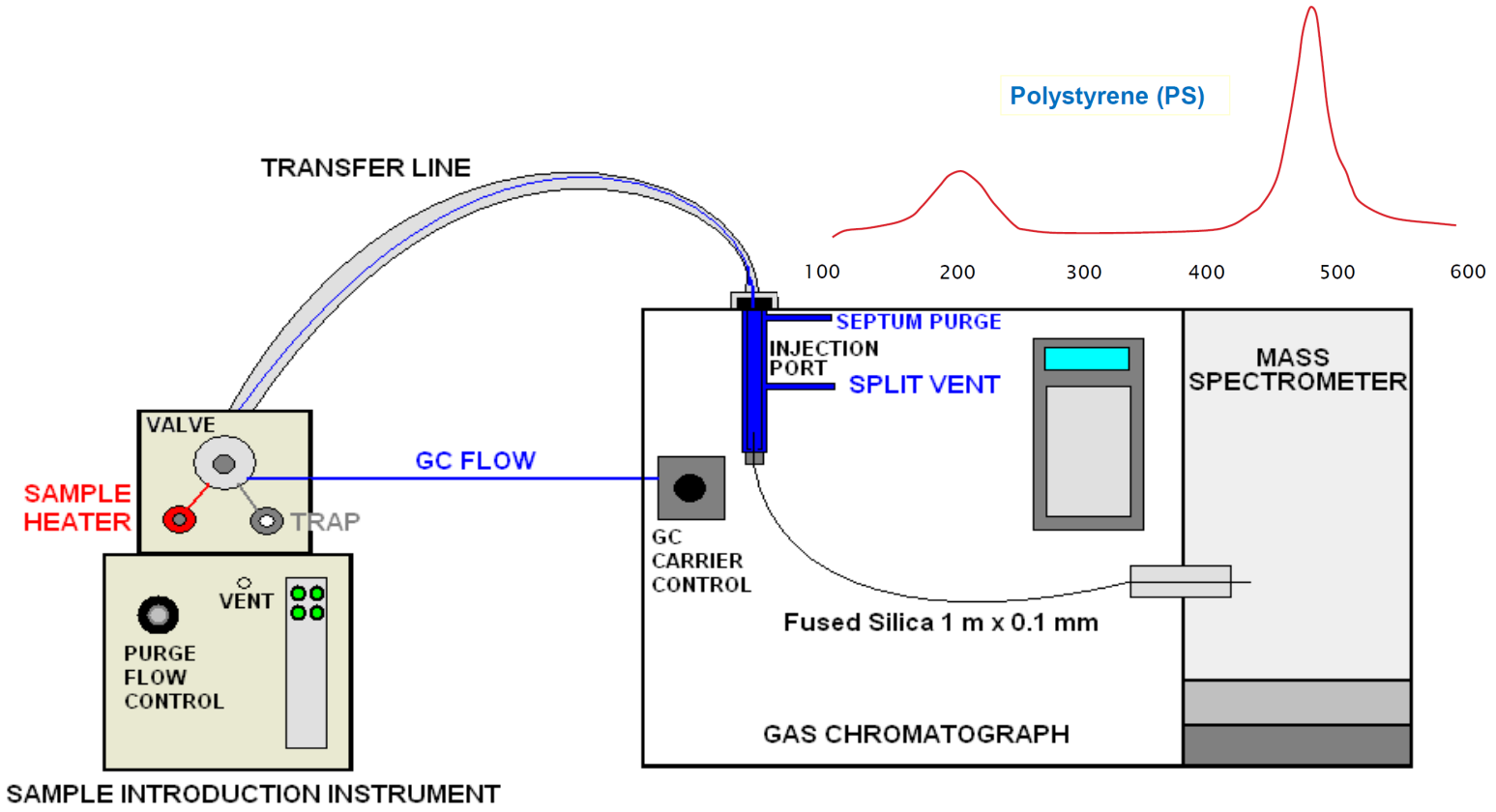
03 Multiple Function

- Additional tool set for qualitative and quantitate analysis

- ✓ Evolved Gas Analysis (EGA)
- ✓ Thermal Desorption
- ✓ Thermal Desorption/Pyrolysis
- ✓ Pyrolysis
  - Flash Pyrolysis
  - Reactive Thermolysis
- ✓ Kinetics
  - Reactant Gas Chemistry
  - Catalysis Chemistry
- ✓ Dynamic Headspace
- ✓ Air Sampling TD with std. tubes

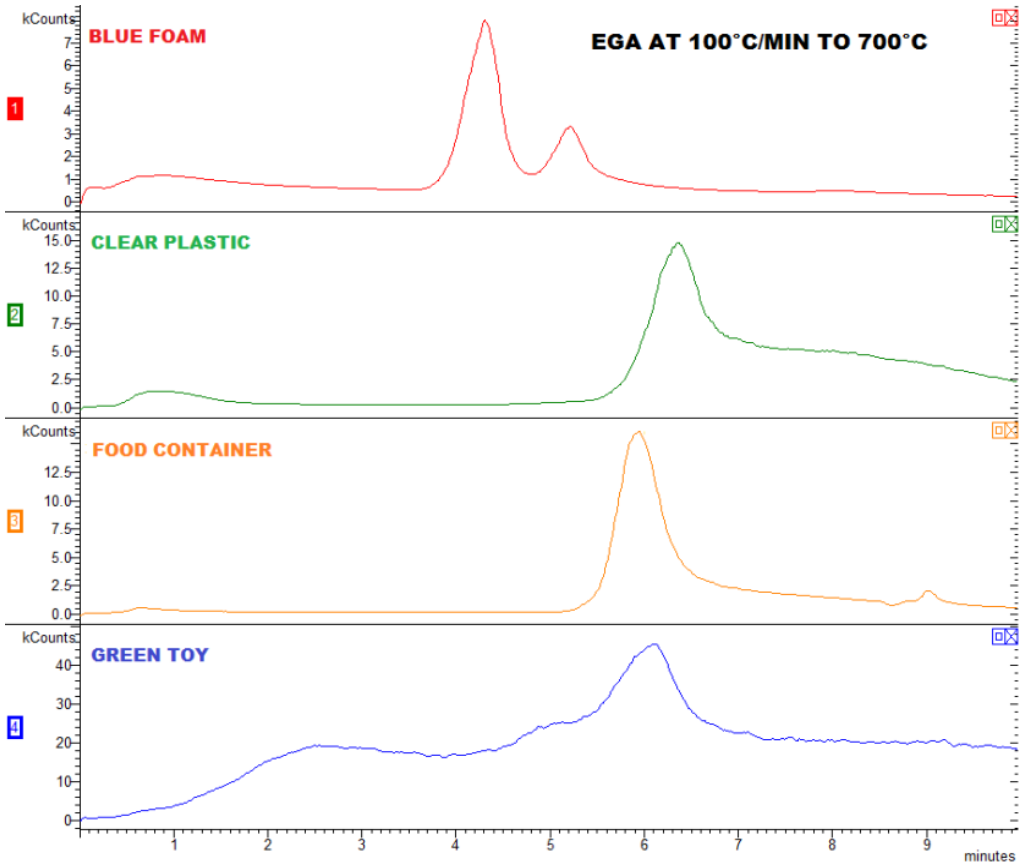
Multiple Function_EGA

- Evolved Gas Analysis (Fast Screening in 10 minutes)



Multiple Function_EGA

- Fast Screening Technique



LIBRARY SEARCH RESULTS

#	Lib.	Match	R.Match	Prob.	Name
1	py	803	803	38.0	Polyurethane foam
2	py	796	796	29.1	Urethane foam with polystyrene
3	py	770	770	8.71	Urethane foam with polystyrene

#	Lib.	Match	R.Match	Prob.	Name
1	py	641	643	17.5	Polycarbonate
2	M	636	735	14.1	Phenol, 4-[[4-amino-3-methylphenyl]amino]-
3	py	623	624	9.11	Epoxy powdercoat

#	Lib.	Match	R.Match	Prob.	Name
1	py	748	749	49.5	Thread, Black, Polyester
2	py	740	740	36.9	PET
3	py	678	685	6.30	Thread, Cotton/Polyester

#	Lib.	Match	R.Match	Prob.	Name
1	py	726	795	42.7	PVC with bis-2ethylhexylphthalate
2	py	703	770	15.6	Packaging, clear, with phthalate
3	py	703	770	15.6	Tygon tubing

Multiple Function_Thermal Desorption

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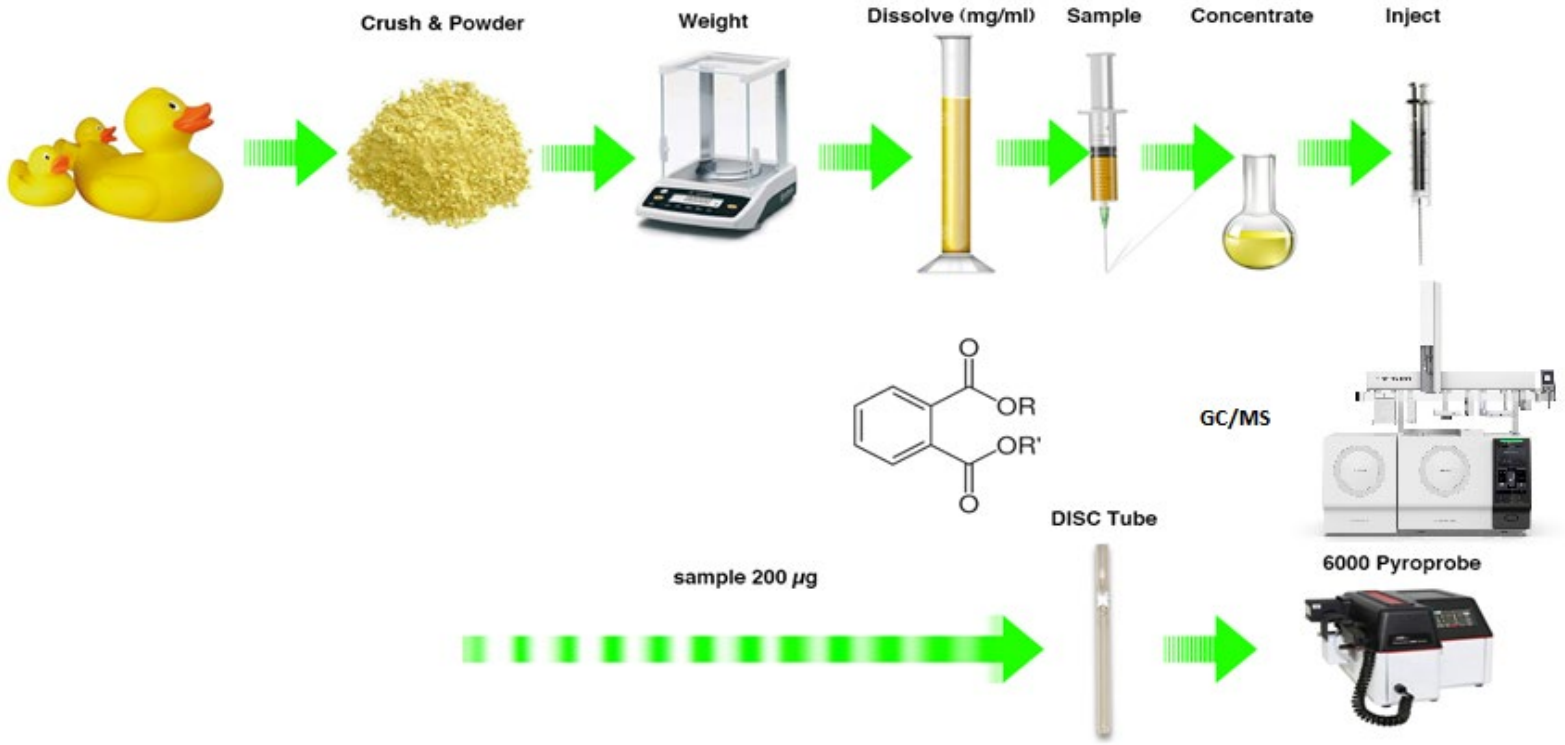
- Phthalates Regulation (ASTM D7823, IEC 62321-8)



Multiple Function_Thermal Desorption

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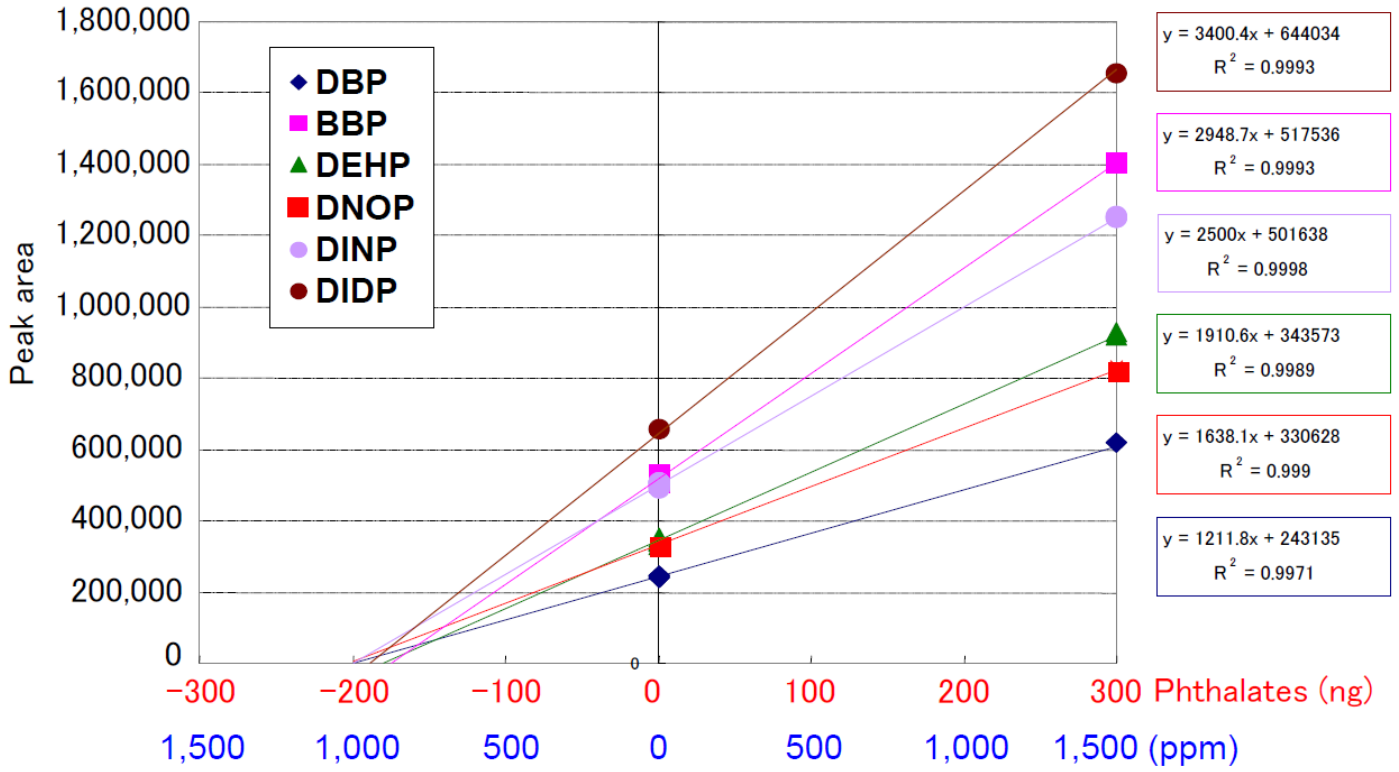
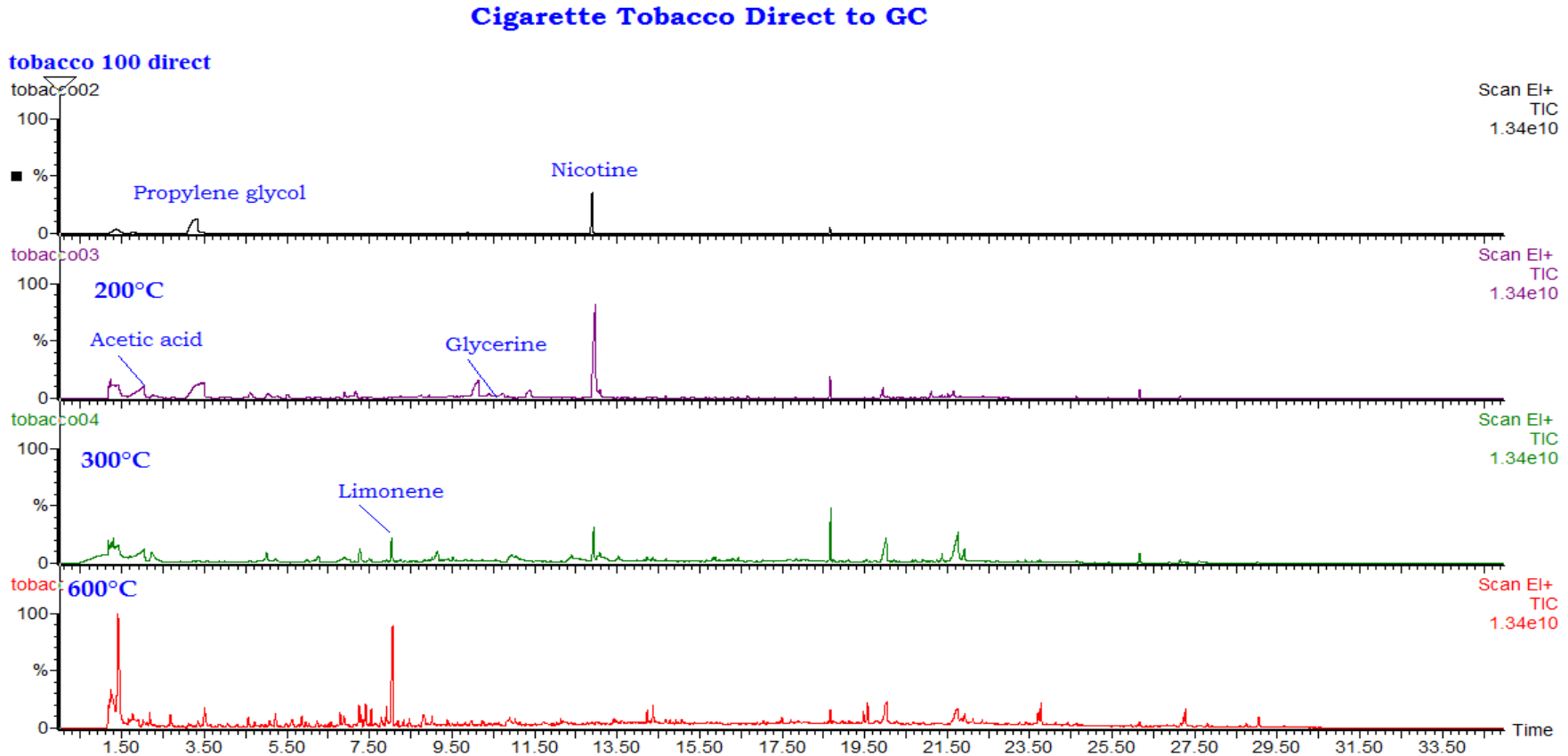
- Phthalates Regulation (ASTM D7823, IEC 62321-8)



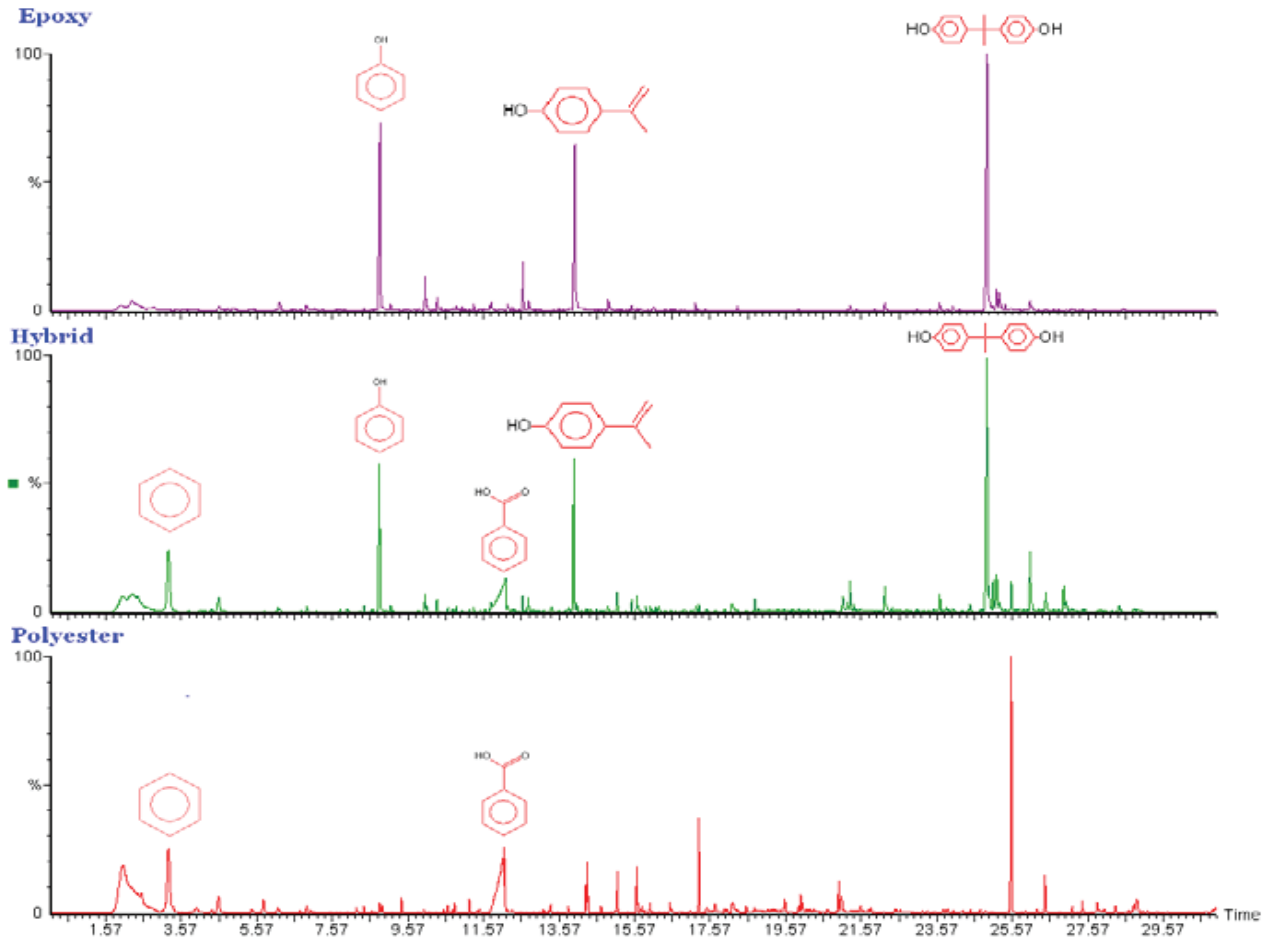
Multiple Function_Coupling TD with Pyrolyzer

- Multiple Temperature Ramp to Analyze Additive and Polymer



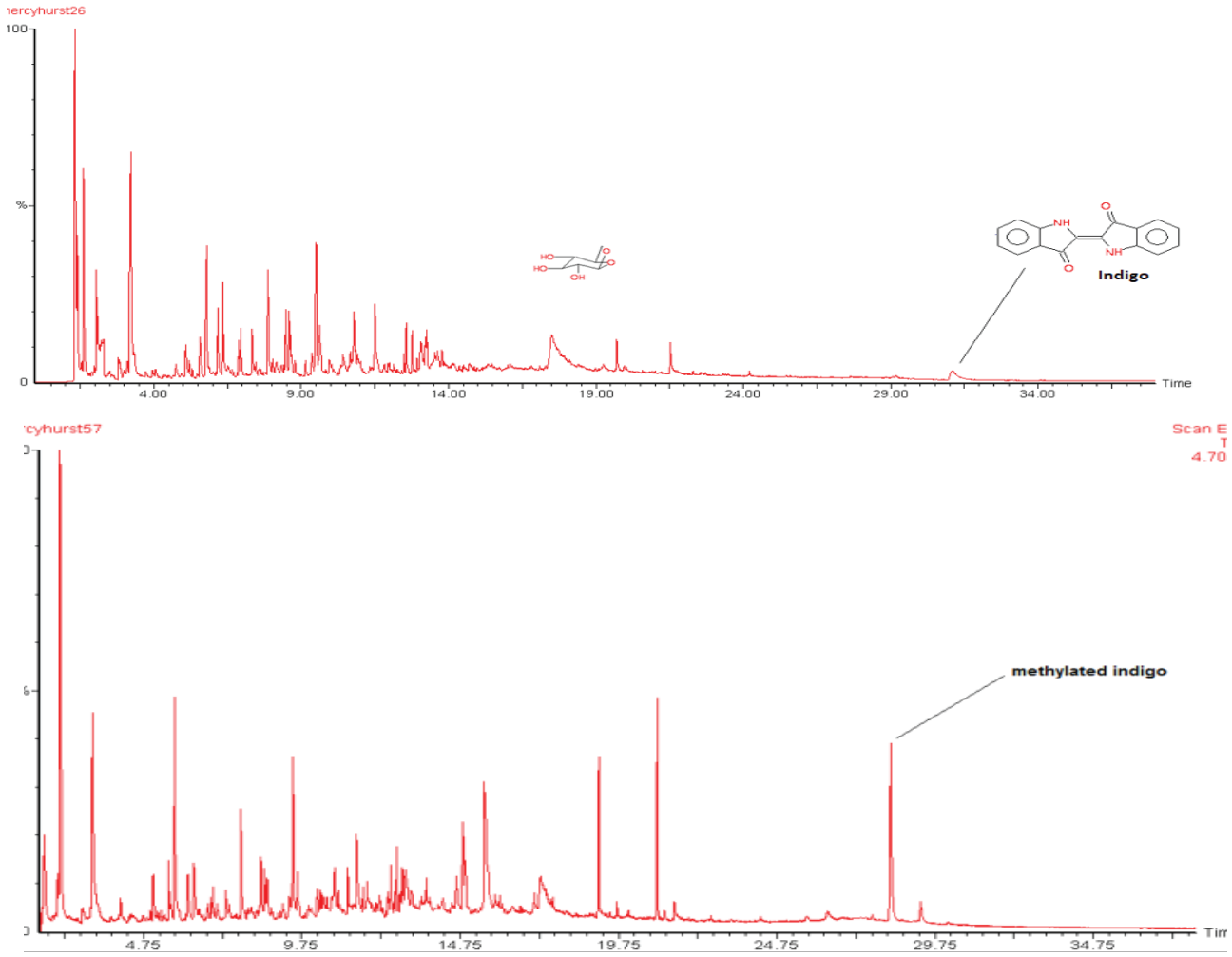
Multiple Function_Flash Pyrolysis

Placing a suspect at the scene of a crime is crucial when solving crimes. This is achievable through the identity of trace evidence. Evidence such as paints, fibers, toner, ink and cosmetics can easily be characterized. In this example, powder-coat paints are differentiated from each other. Epoxy (top pyrogram) is identified by bisphenol A, and isopropyl phenol, while benzoic acid is indicative of polyester (bottom pyrogram). A blend or hybrid (center pyrogram) has pyrolysis products of each.



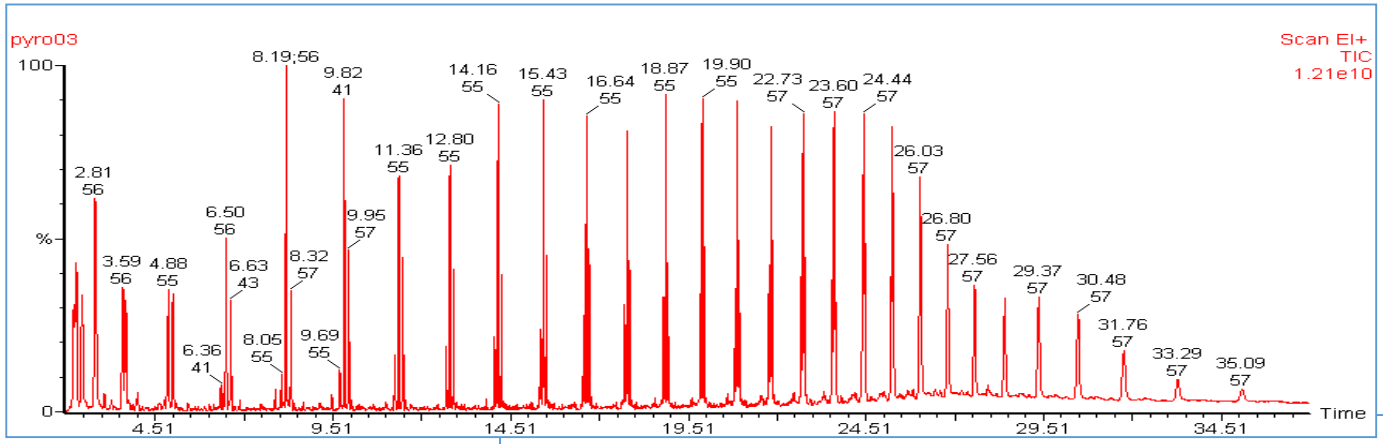
Multiple Function_Reactive Thermolysis

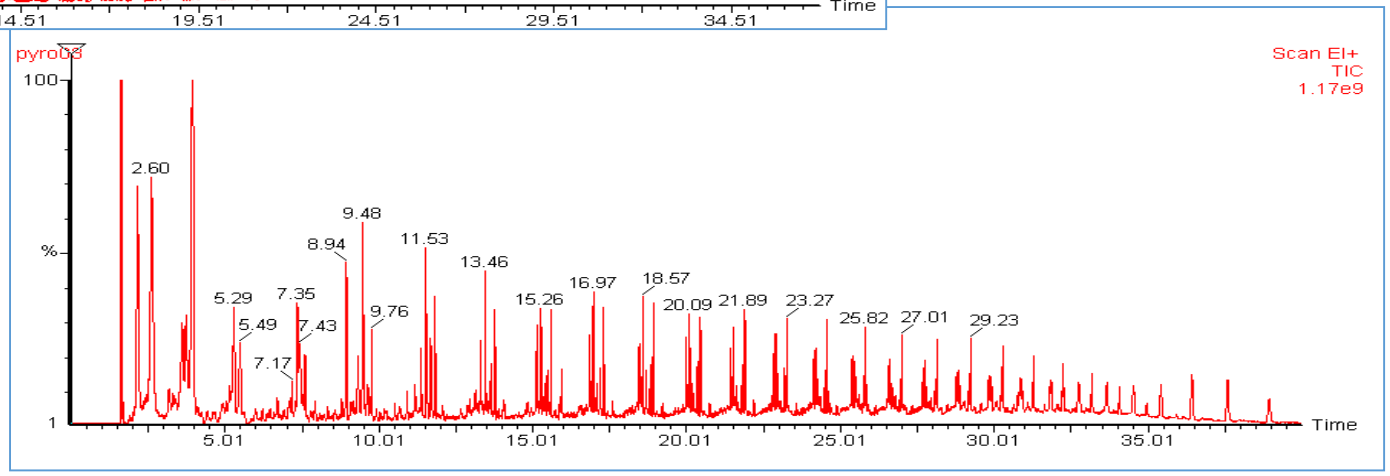
This is a pyrogram of denim fabric containing Indigo dye. A small peak for the dye can be seen at about 31 minutes. However, when the dye is treated with TMAH, methylated indigo is seen as a sharp, dominant peak in the chromatogram.



Multiple Function_Reactant Gas Chemistry

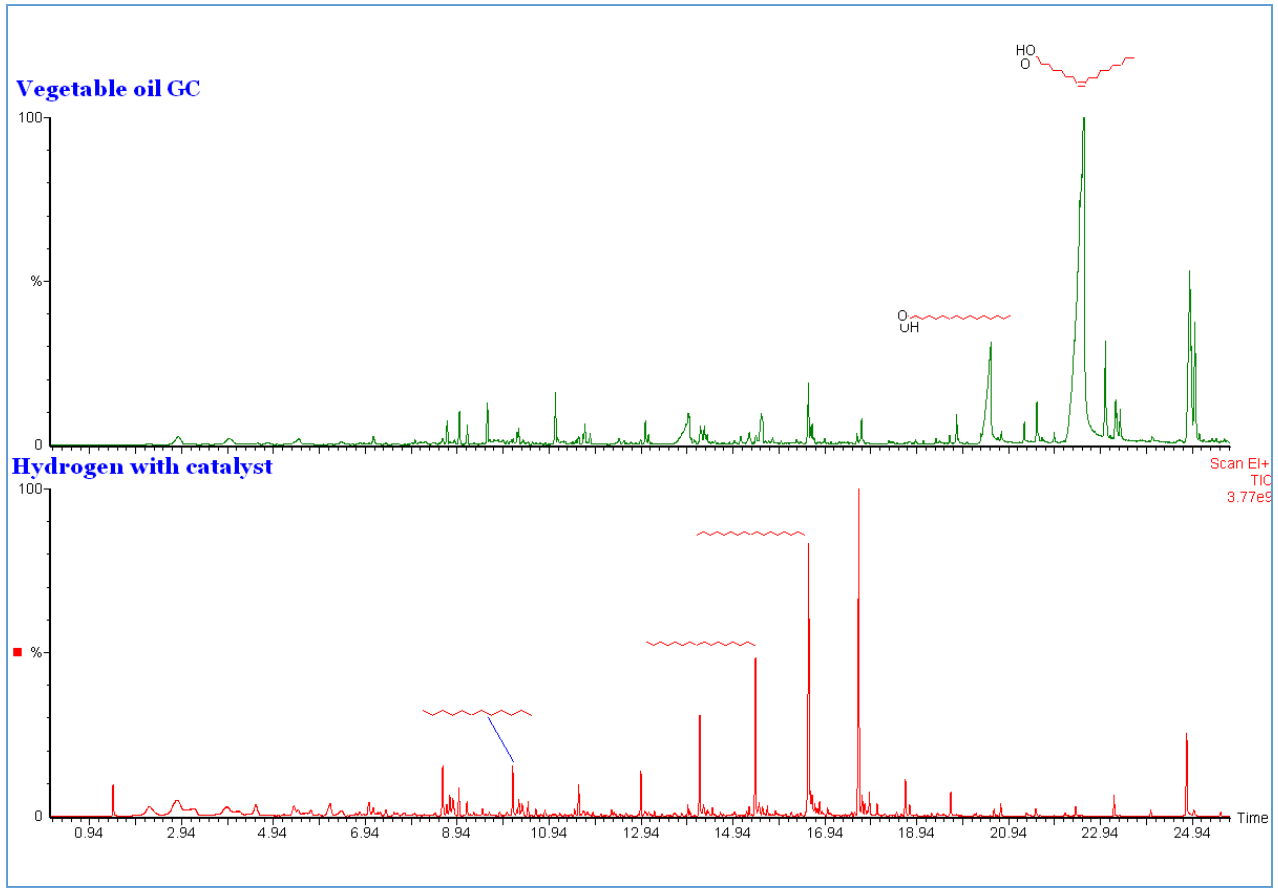
- Oxidation Process, Hydrolysis Process





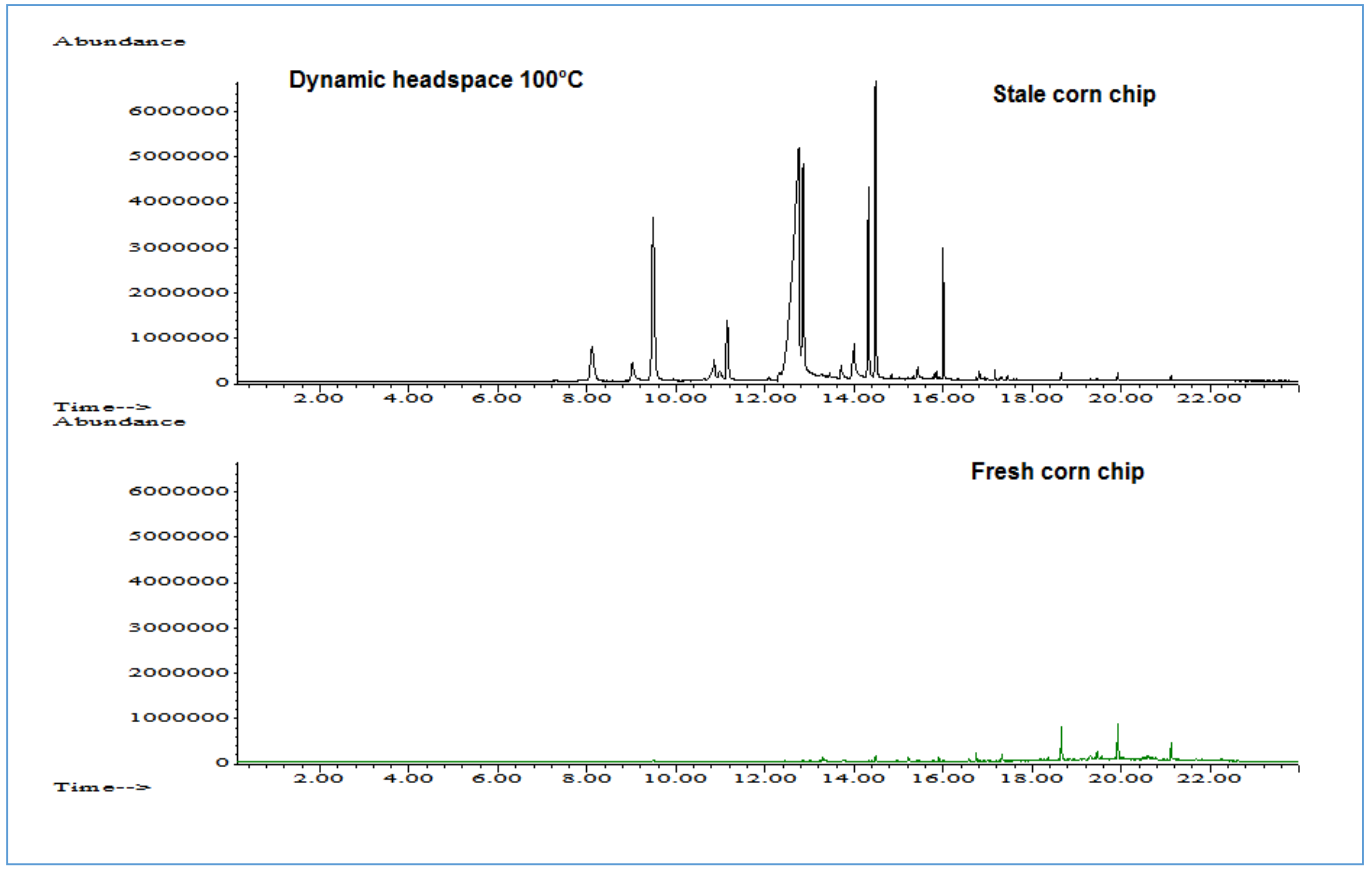
Multiple Function_Catalysis Chemistry

- High Pressure Catalysis (600°C in Hydrogen, with Pt catalyst)



Multiple Function_Dynamic Headspace

- Dynamic Headspace module (25 ml test tube adapter)



Multiple Function_Air Sampling TD with Tube

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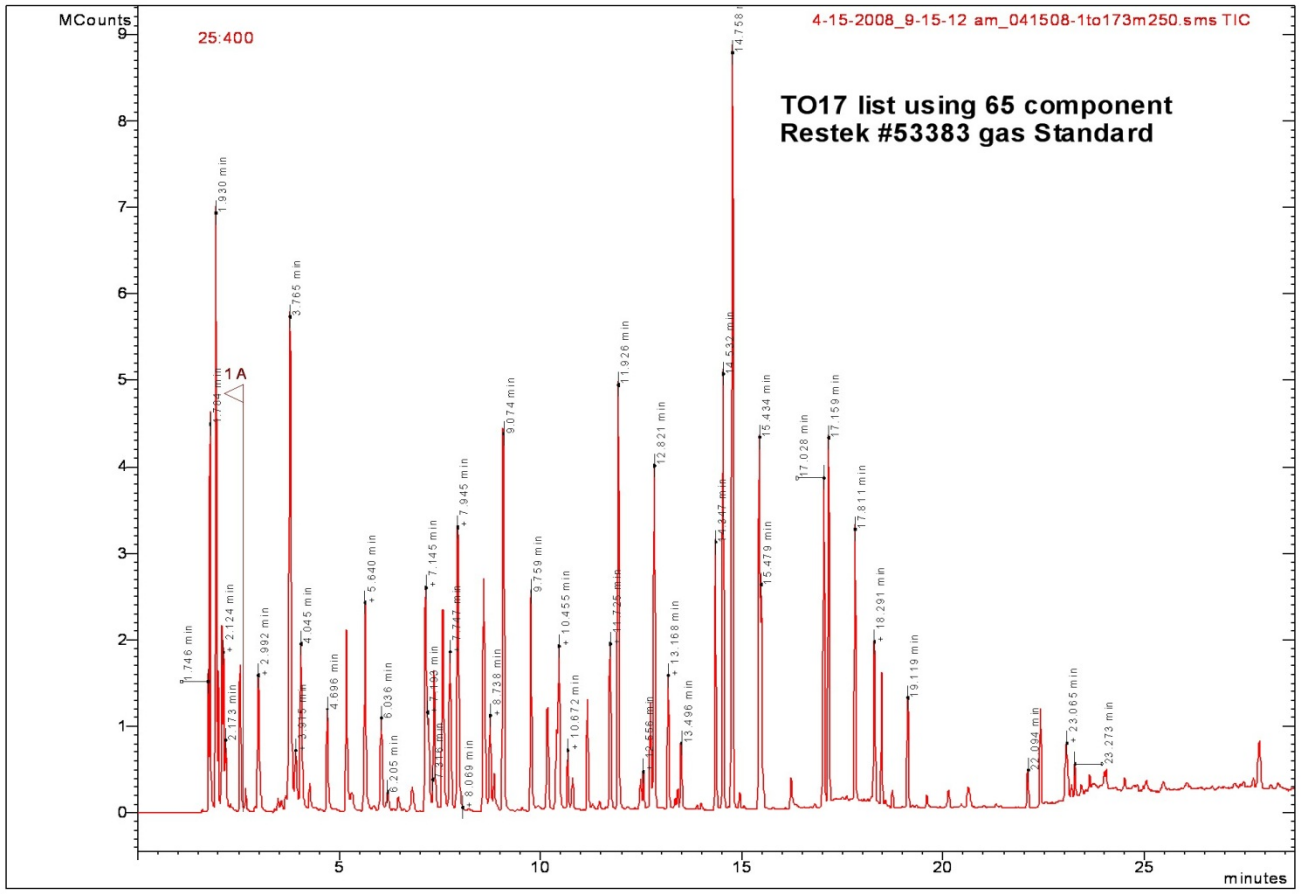
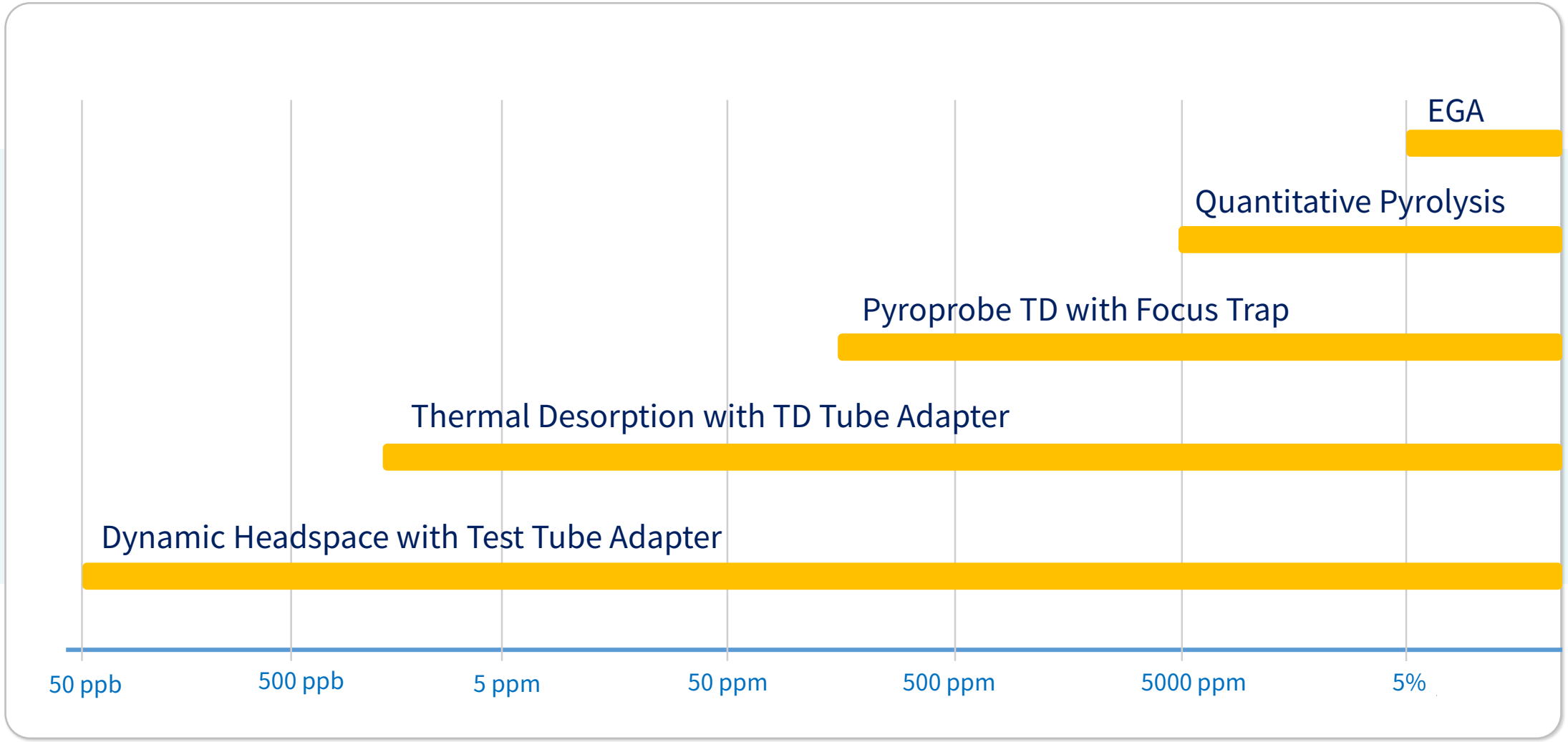
- TO-17 with Thermal Desorption Tube Adapter (3.5” & 4.5”)



03 Multiple Function_Sensitivity (Working Range)



04

Instrument Features

Instrument Features_Overview

- Consistent Heating Algorithm from past CDS Pyroprobe’s
- Easy Sample Loading
- Enhanced Reproducibility
- Improved User Interface
- Modular Design
- Leak Checking

CDS 6000 Series

04 Instrument Features_Resistive Heating

- CDS launched the first commercial analytical pyrolyzer in 1969
- Proprietary Energy Reservoir System
- Highest Pyrolysis Temperature
- Lowest Thermal Mass
- Fast Temperature Ramp Up Rate
- Reliable and repeatable Platinum filament heating system

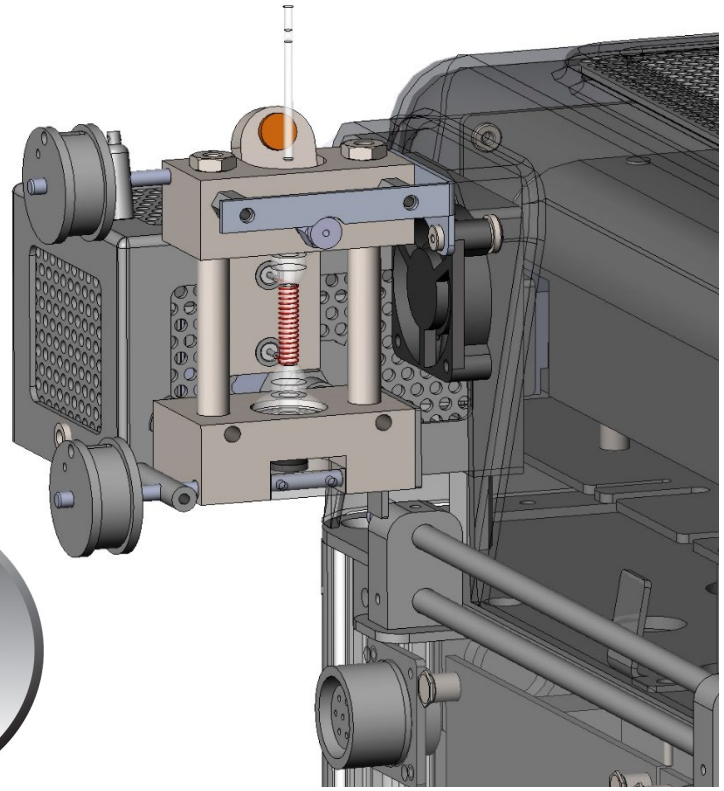
Instrument Features_Expandability

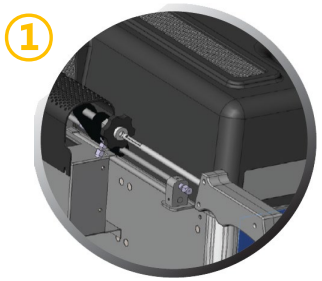
① Coil and Ribbon Manual Insertion Probe Module

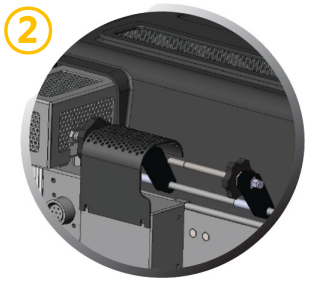
② Thermal Desorption Tube Module

③ 25 mL Test Tube Desorber Module

④ Tandem Reactor Module



① 

② 

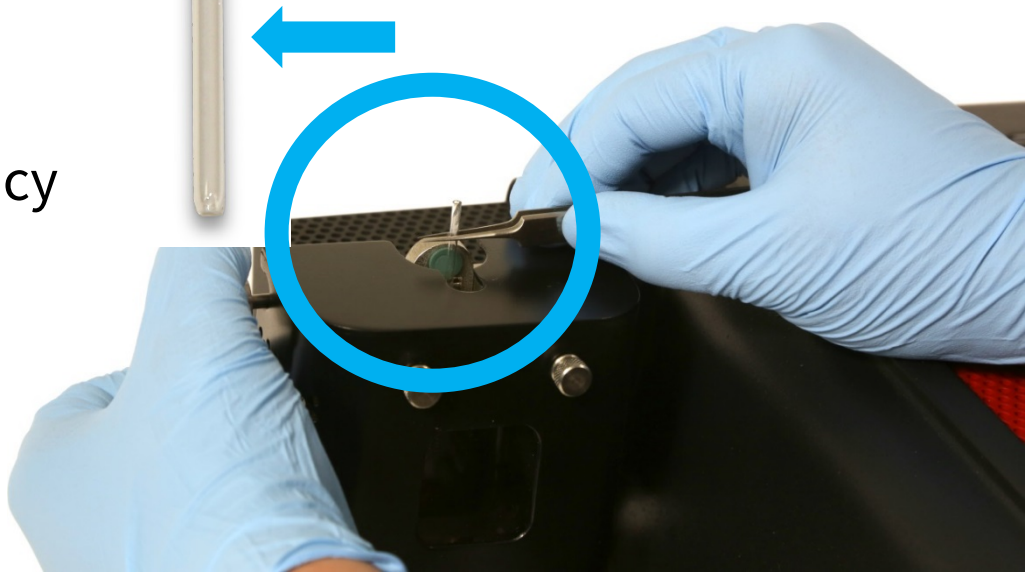
③ 

④ 

Instrument Features_Easy Sample Loading

- Easier Sample Prep
- Operator Error Reduction
- No More Quartz Wool
- Liquid Sample Compatible
- Improved Sample Positioning Accuracy

- Low Thermal Mass
- ± 0.1 mm Z Tolerance



04 Instrument Features_Enhanced Reproducibility

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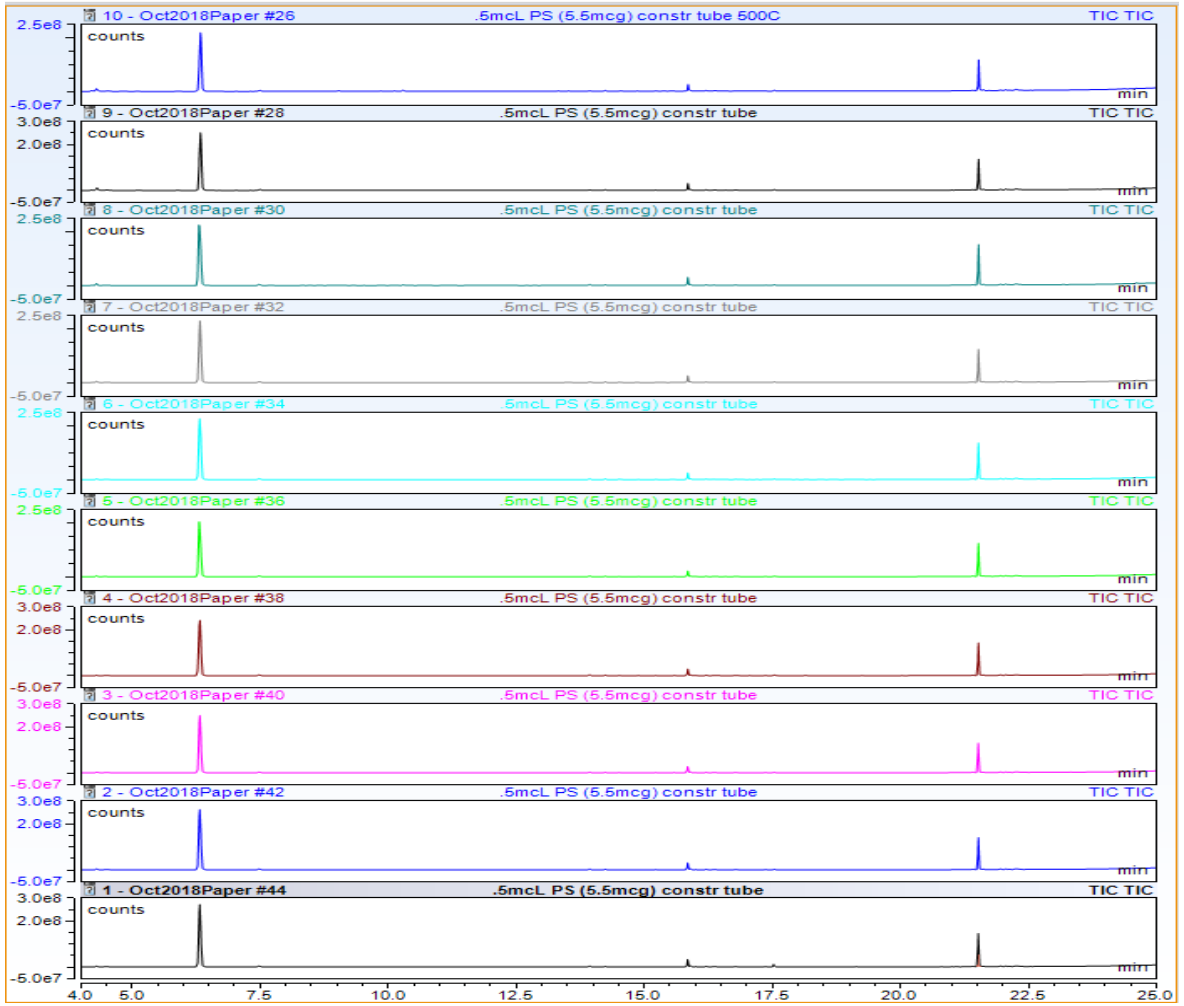
with a 1.5% RSD of Polystyrene s/sss ratio

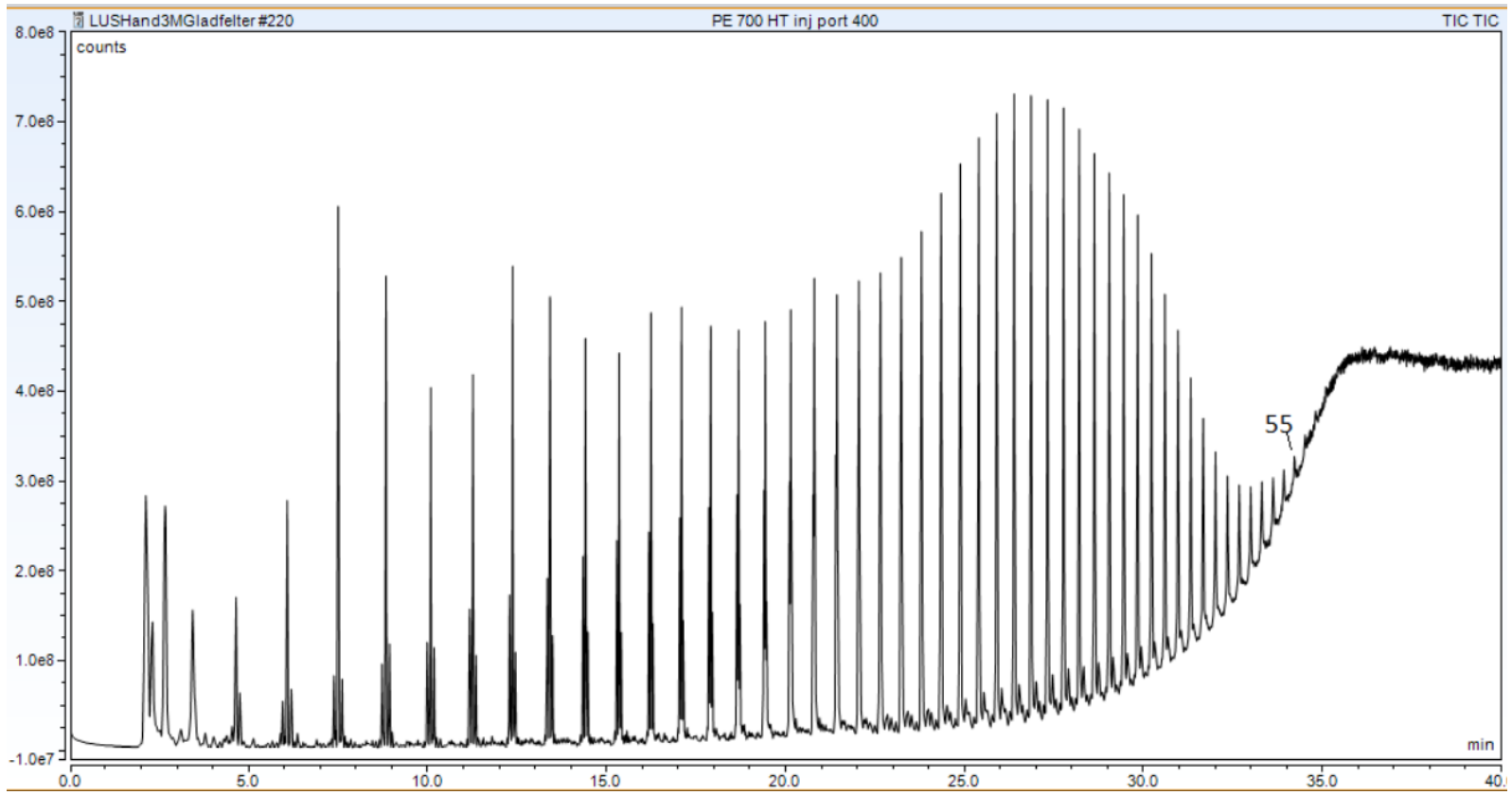
Inj #	S	SSS	S/SSS
26	10168510	2434989	4.2
28	11687222	2866628	4.1
30	13168780	3265588	4.0
32	10884334	2616078	4.2
34	11987912	2890253	4.1
36	10793113	2627532	4.1
38	12665642	3095045	4.1
40	11854108	2888729	4.1
42	12710048	3032107	4.2
44	12928970	3116431	4.1
		Avg.	4.1
		SD	0.1
		RSD	1.3

Setpoint 500C 30s
1 cord
post pyro delay 60 seconds
HT column VO 325 Xfer 375
Inj 360 60:1 split 1.25mL/min flow
DISC tubes
0.5 mcL 11mcg/mL PS in toluene (5.5mcg)
MS transfer line 320° C
Ion Source 250° C
Scan 35-600 Dwell 0.2
blank between each



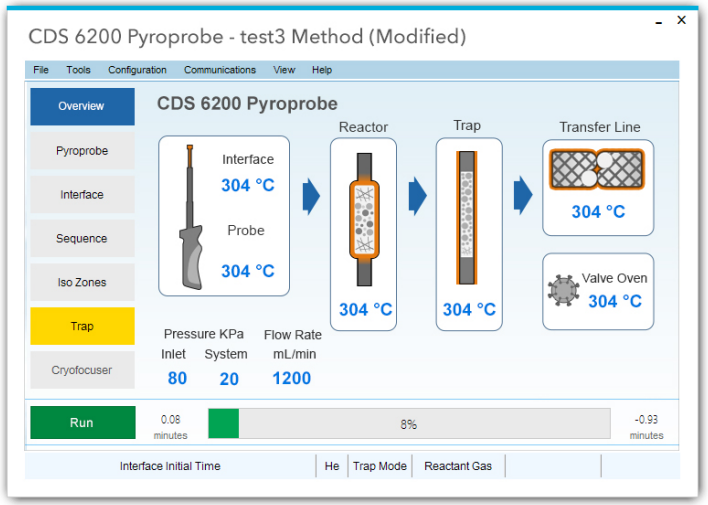
04 Instrument Features_Superior Sensitivity

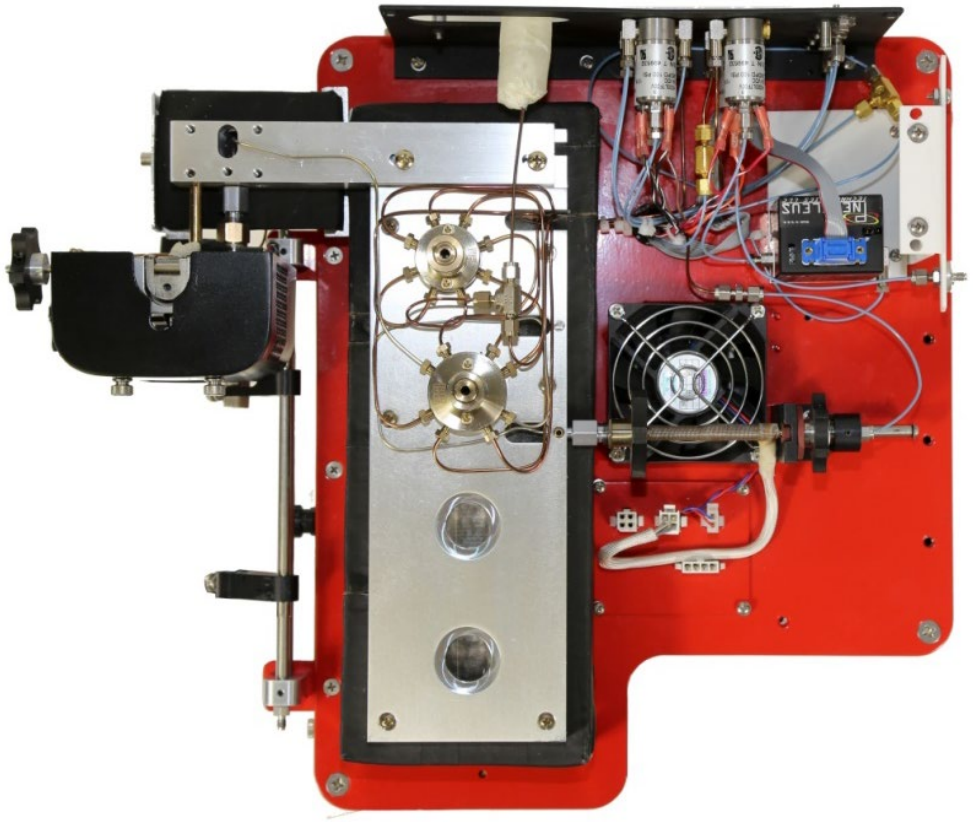
- PE Pyrolysis Data at 700 °C



04 Instrument Features_Improved User Interface

- Touch Screen
- Windows OS Compatible
- Easy Maintenance
- Dynamic Sequence Table





Instrument Features_CDS 6000 Series

	CDS 6200 Pyrolyzer	CDS 6150 Pyrolyzer
Max. Temperature	1300℃	1300℃
RSD% (Polystyrene)	1.5 %	1.5 %
Autosampler	Optional	Optional
Libarary	2MS Libraries Available	2MS Libraries Available
Leak Check	Yes	Yes
Focus Trap	Standard	N/A
CryoTrap	Optional (-198℃)	N/A
Reactant Gas	Standard	N/A
Thermal Desorption Tube Adapter	Optional	N/A
Dynamic Headspace Adapter	Optional	N/A

05

Application

Application

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Where can CDS Pyrolysis Systems help?

- Plastics – films, foams, fibers, molded parts
- Coatings – paints, artwork, varnish
- Rubber – tires, bumpers, building materials
- Criminal Forensics - paint, fiber, tapes, cosmetics, documents
- Adhesives – rubber, acrylic, urethanes
- Printing – ink, toners, coatings
- Consumer goods – cosmetics, surfactants, food, soaps, detergents
- Electronics - circuit boards, components
- Petrochemicals – resins, waxes, asphalts, oils, Biofuels Research
- Universities – Material Science, Chemistry, Chemical Engineering, Polymer Science

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Evolved Gas Analysis and Multi-step Pyrolysis of Tea Bag Using the Pyroprobe with GC/MS

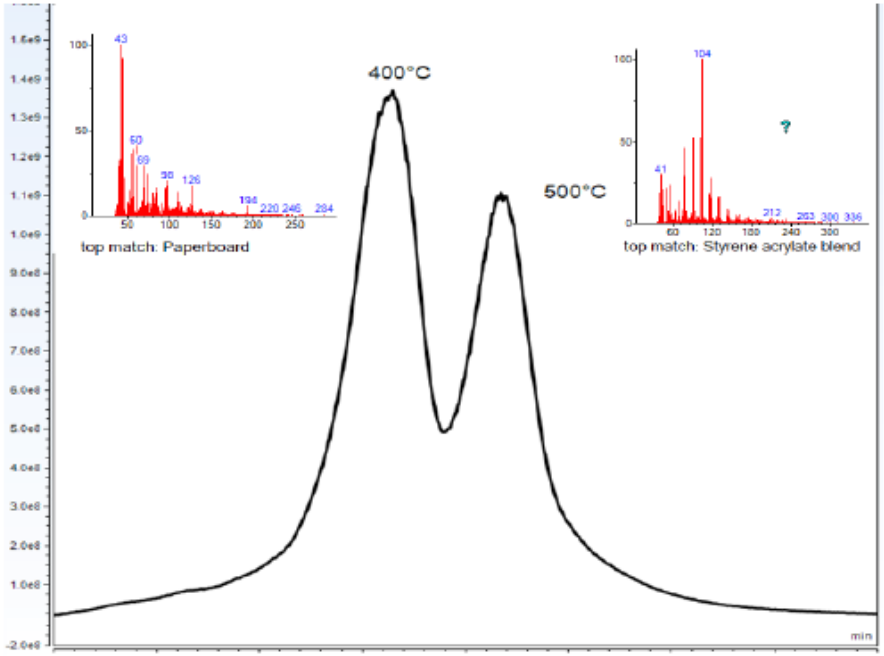

Figure 1: EGA of tea bag W from 50 °C to 800 °C at 100 °C per minute. The mass spec library top match from each peak region is shown in the figure.

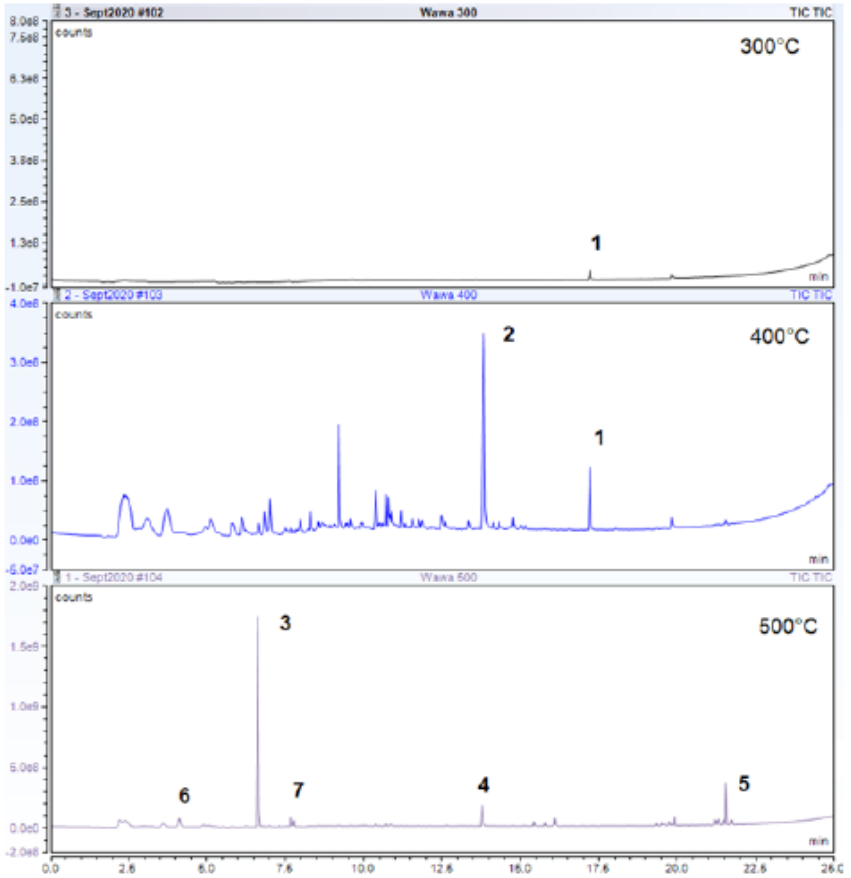

Figure 3: Multi-step pyrolysis of tea bag W at 300 °C(top), 400 °C (center) and 500 °C (bottom). Peak # Identification:

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Analysis of Tetrahydrocannabinol Vape Oils Using Pyroprobe by Thermal Extraction

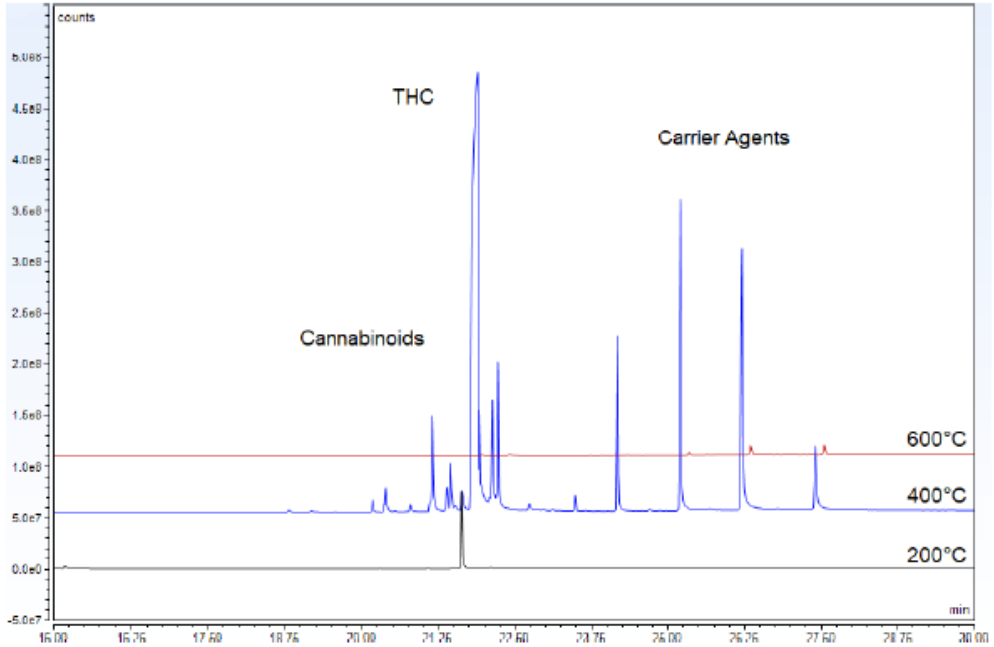

Figure 1: Time and Signal Offset Overlay of THC Vape oil externally extracted at 200°C(bottom), 400°C (middle), and 600°C (top)

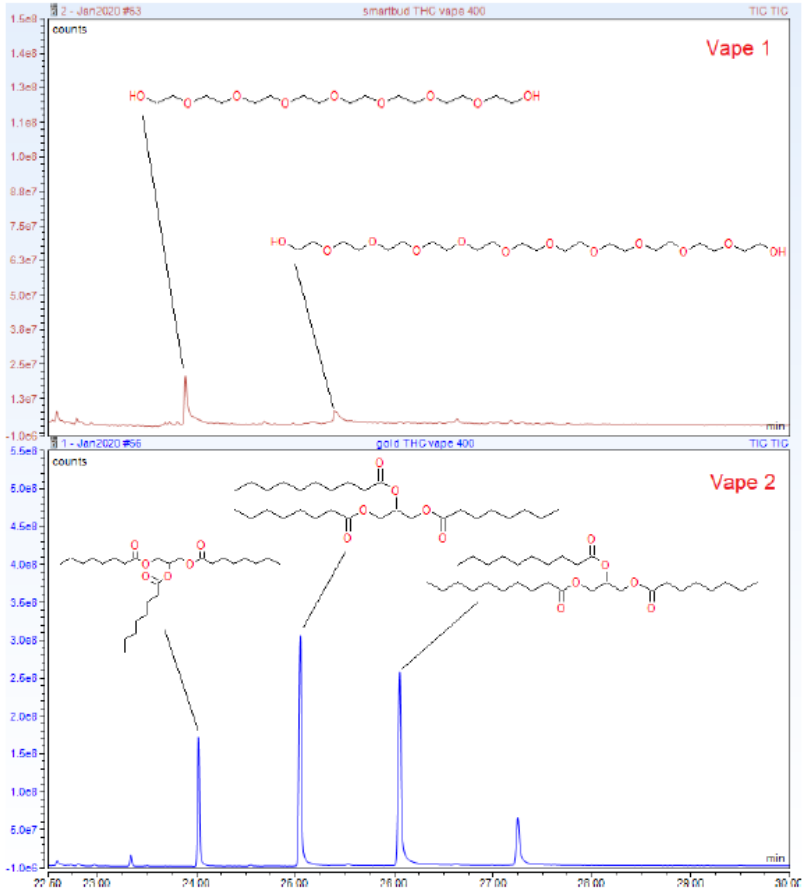

Figure 3: Magnification of two THC vape oils at 400°C

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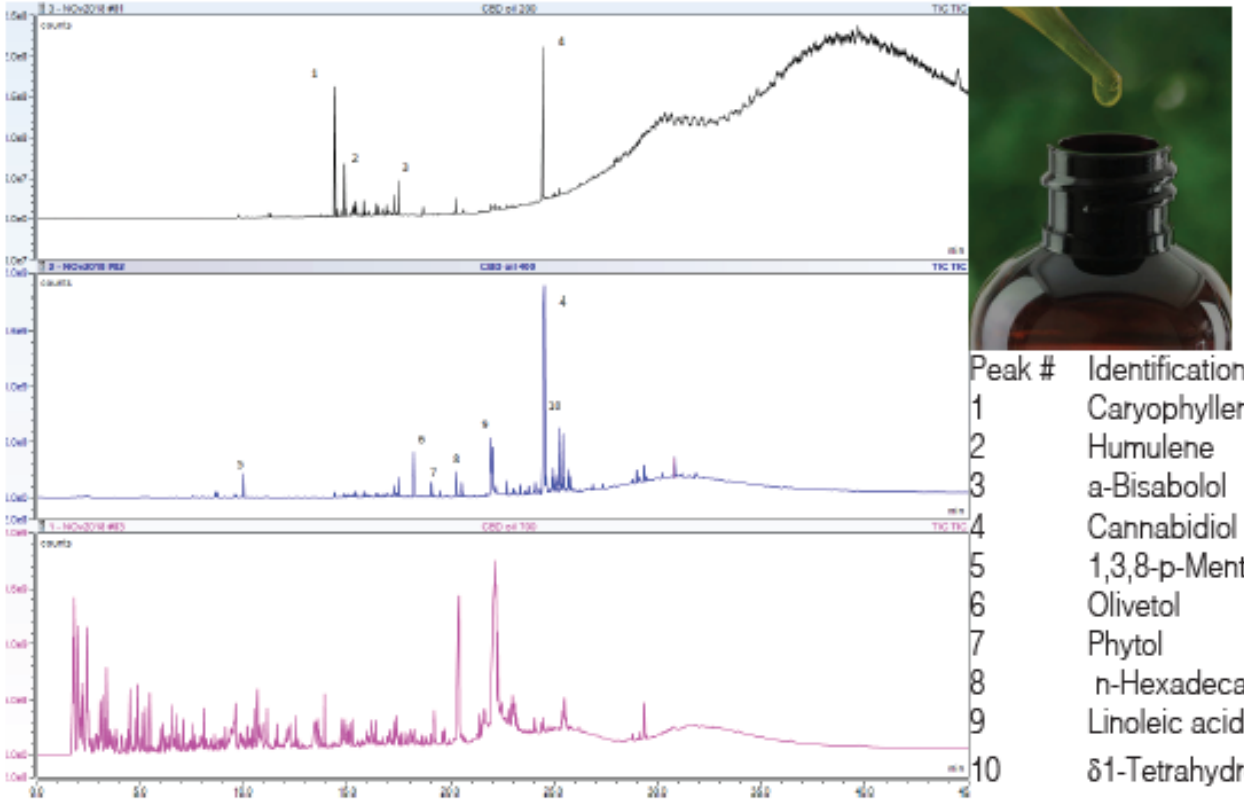
Cannabidiol Oil Analysis with the Pyroprobe



Peak #	Identification
1	Caryophyllene
2	Humulene
3	a-Bisabolol
4	Cannabidiol
5	1,3,8-p-Menthatriene
6	Olivetol
7	Phytol
8	n-Hexadecanoic acid
9	Linoleic acid
10	δ1-Tetrahydrocannabinol

Figure 1. 5% CBD oil in hemp oil, 200°C (top), 400°C, and 700°C (bottom).

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Multi-step Pyrolysis of Powdered Meteorite Using a Pyroprobe with GC/MS

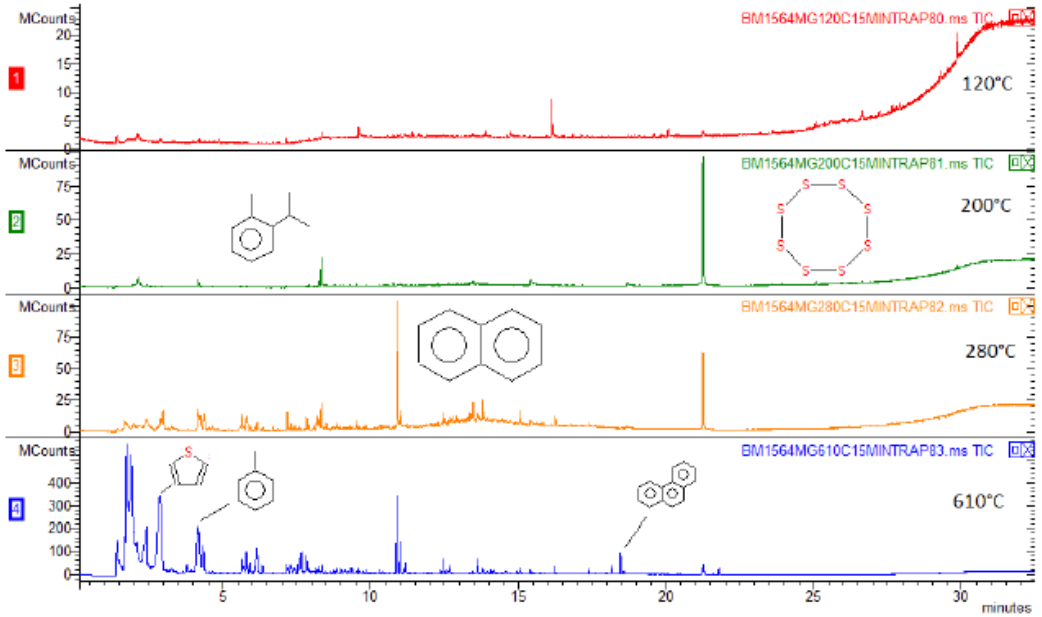

Figure 1. Meteorite, 15mg multi-step at 120°C, 200°C, 280°C and 610°C

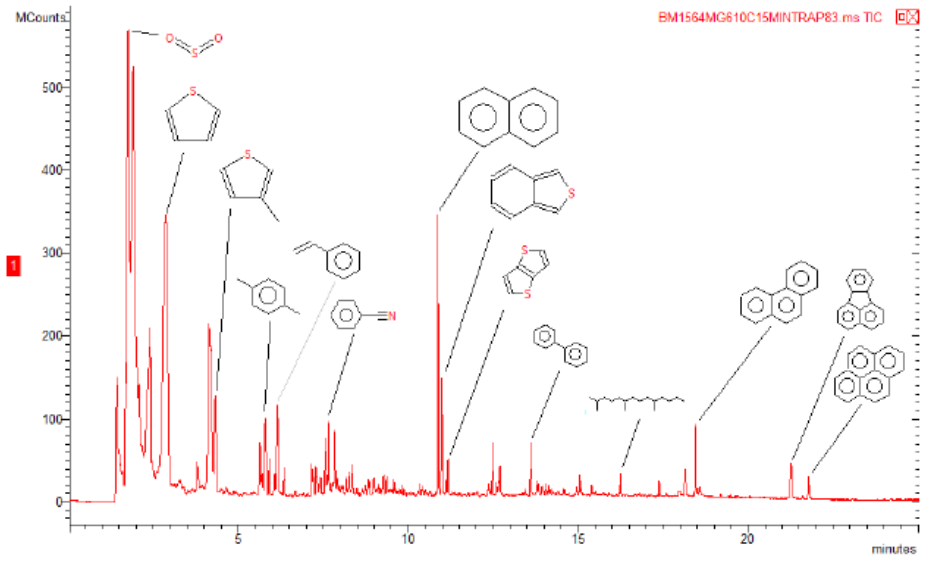

Figure 2. Powdered Meteorite, 610°C, after multi-step extraction at 120°C, 200°C, and 280°C.