영인과학
YOUNG IN Scientific

2023 최신분석기술 온라인 세미나 시리즈

자동차 내장재 및 타이어 분석을 위한 Pyrolysis-GC/MS 솔루션

2023. 03. 30 (목)
영인과학

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Products for Automobile Applications

The automotive industry is constantly evolving due to government regulations, changing consumer demands, and improvements in technology.

The industry faces many challenges including lowering greenhouse gas emissions, boosting aerodynamics, increasing fuel economy, delivering the optimum strength-to-weight ratio, and ensuring safety.

The industry is also in the midst of a revolution with the global surge in electric vehicle production and demand as well as the rise in semi- and fully-autonomous (self driving) vehicle technologies.

This constant evolution creates a landscape of continuous challenges and opportunities for improvements through advanced materials and innovative design.

Polymer products for automotive applications

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High Performance Polymers for Automobile Industry

- After packaging, building, and construction, the automotive industry is the third largest consumer of polymers.
- Polymers deliver the characteristics of high-impact resistance, reduced noise and vibration, structural integrity design flexibility, low density, and high durability. Each feature is vital to the industry for use in automobiles, over-the-road trucks, and off-highway equipment.
- Within the market, some typical applications include air conditioning, braking, safety, steering, suspension, shock absorption, thermal management, and fuel systems.
- Additionally, the automotive sector uses polymer products for drivetrain and transmissions, electronic control units (ECU), clutches, torque converters and differentials, interior and exterior components, panel, and so much more.

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High Performance Polymers for Automobile Industry

Here is a sample of the many products manufactured using high-performance polymer products for the automotive industry;

- Oxygen sensor grommets
- PTFE seals
- O-Rings
- Bearings and thrust bearings
- Low-drag mudflaps
- Suspension cylinder seals
- Bushings
- Diaphragms
- Sensor covers
- Rubber-to-metal bonded seals
- Wiring hardness and housing
- Battery sealing for pressure relief valves
- Buffer rings and back-up rings
- Rotary seals
- Friction and wear-resistant components
- Custom-made gaskets
- Custom-molded parts

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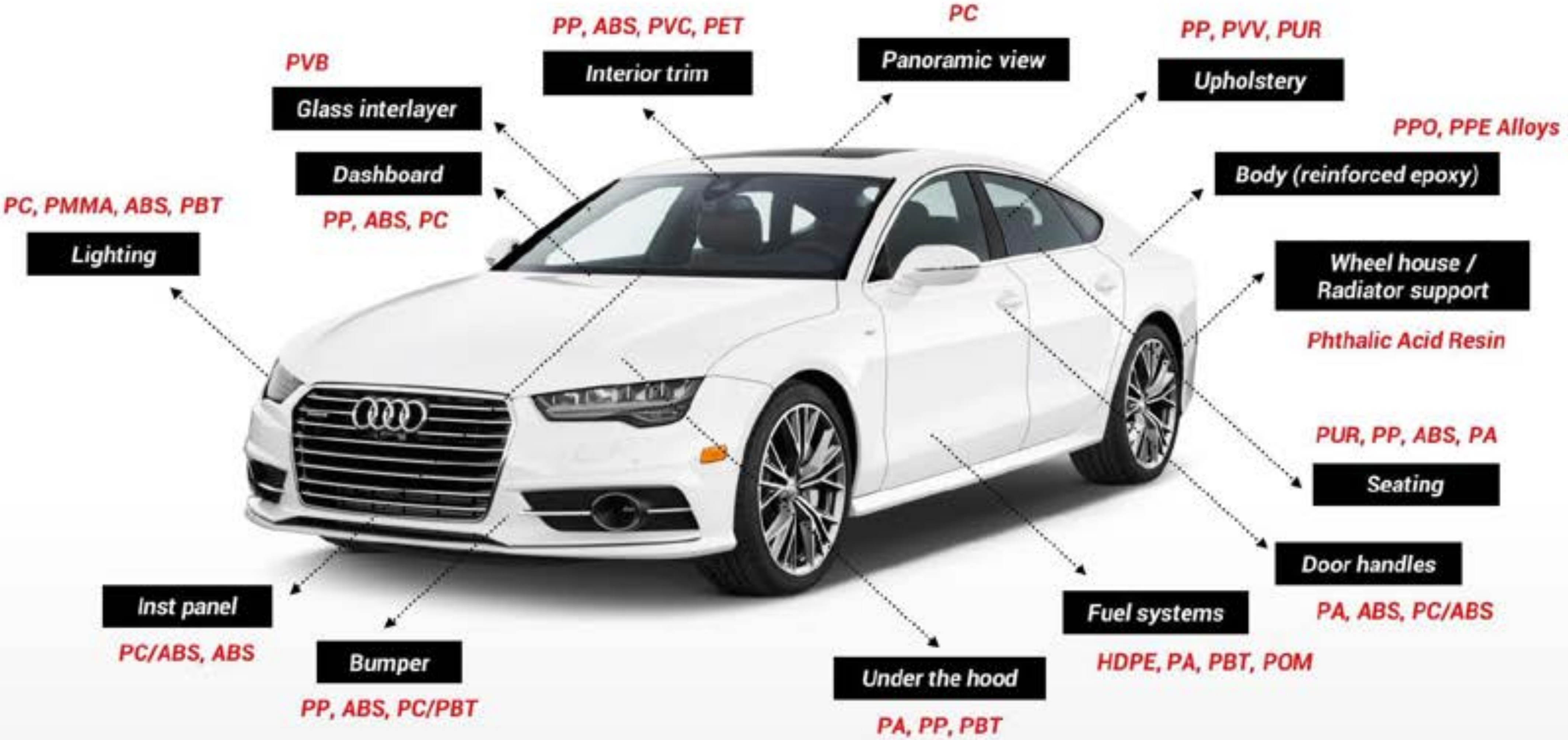
Plastics Applications in Automotive Parts



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High Performance Polymers for Automobile Industry

The average vehicle uses about 150 – 300 kg of plastics and plastic composites versus 1,163 kg of iron and steel – currently it is moving around 15 – 20% of total weight of the car, over 2,000 parts and components of all shapes and sizes.

Although up to 13 different polymers may be used in a single car model(see Table 1), just three types of plastics make up to about 66% of the total plastics used in a car;

- Polypropylene(PP), 32%
- Polyurethane(PU), 17%
- PVC, 16%

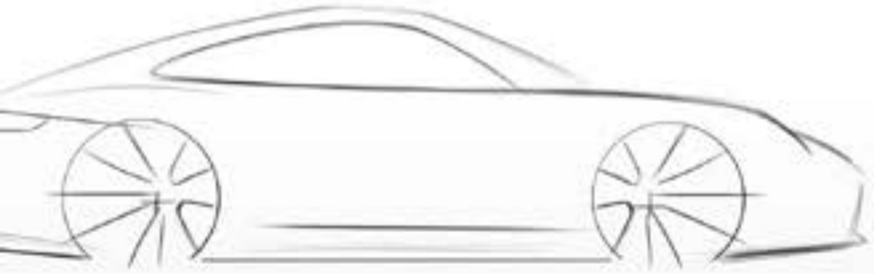

Table 1: Plastics used in a typical car

Component	Main types of plastics	Avg. weight in car (kg)
Bumpers	PS, ABS, PC/PBT	10
Seating	PUR, PP, PVC, ABS, PA	13
Dashboard	PP, ABS, SMA, PPE, PC	7
Fuel systems	HDPE, POM, PA, PP, PBT	6
Body (incl. panels)	PP, PPE, PU	6
Under-bonnet components	PA, PP, PBT	9
Interior trim	PP, ABS, PET, POM, PVC	20
Electrical components	PP, PE, PBT, PA, PVC	7
Exterior trim	ABS, PA, PBT, POM, ASA, PP	4
Lightning	PC, PBT, ABS, PMMA, PU	5
Upholstery	PVC, PUR, PP, PE	8
Liquid reservoirs	PP, PE, PA	1
Total		105

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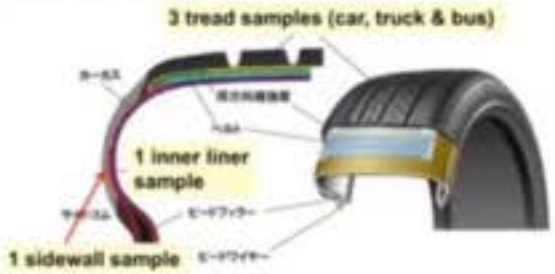
Rubber Products in Automobile







Varying the composition of rubber materials and different additives can influence the physical property and process ability.

Rubber Raw Materials + **Additives**
- Vulcanizing agent
- Vulcanization accelerator
- Accelerator activator
- Antioxidant, etc.

Compounding agent	*Compound*
Filler	Carbon black, Metal powder
Crosslinker	Polyamines, Polyols
Vulcanization accelerator	Amines, Thiazoles
Plasticizer	Phthalates
Antioxidant	Aromatic amines, Phenols
Anti-scorching agent	Aromatic acids

Characterization of these material is important (Py-GC/MS)

- Product Verification and Conformity
- Reverses Engineering
- Failure Analysis

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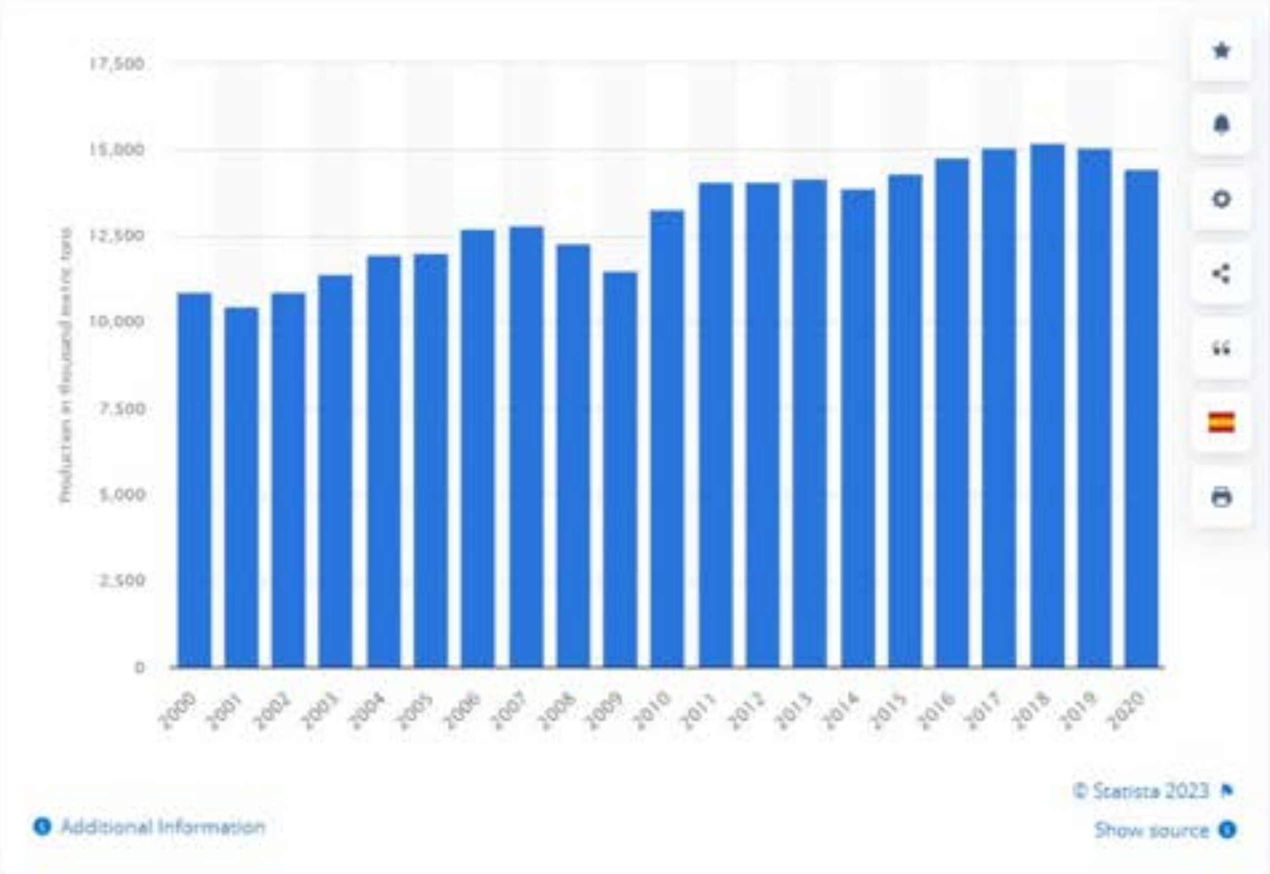
Annual Rubber Production and Usage

Synthetic rubber production worldwide from 2000 to 2020

(in 1,000 metric tons)



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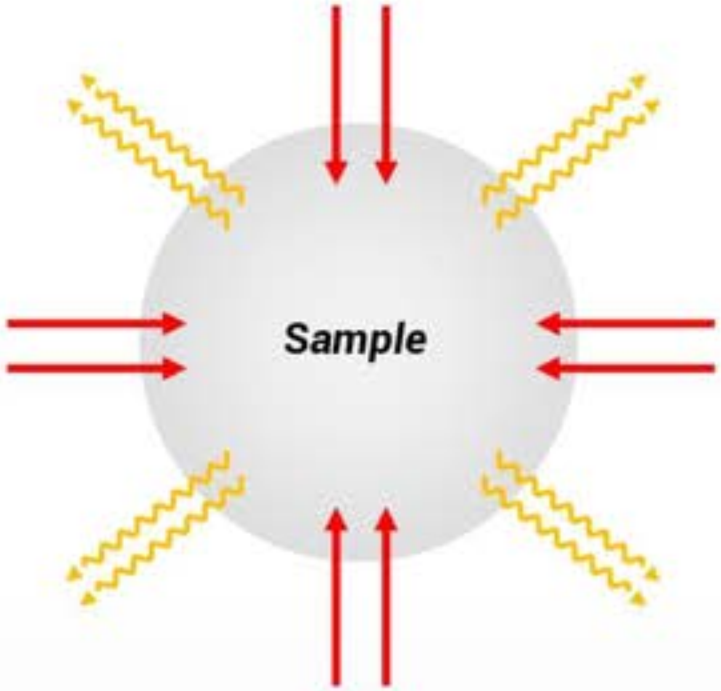
Information from Polymeric Materials by Heating



Analytical Pyrolysis Defined

- Pyrolysis is a thermochemical decomposition of organic material at elevated temperatures **without the participation of oxygen**. It involves the simultaneous change of chemical composition and physical phase, and is irreversible. The word is coined from the Greek-derived words pyr "fire" and lysis "separating".
- Think of analytical pyrolysis as breaking apart or manipulating organic molecules in a controlled and predictable manner using the precise use of heat.

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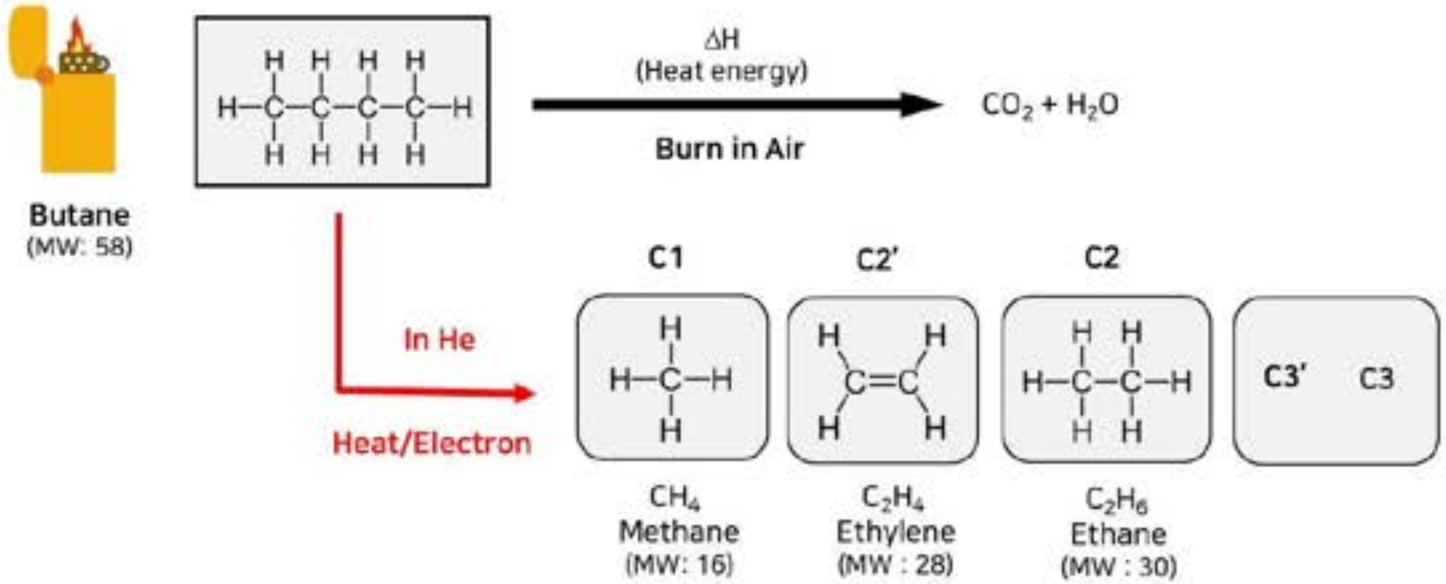
Pyrolysis of Polymeric Materials and Pyrolyzates



폴리스타이렌(PS)의 Pyolyzates

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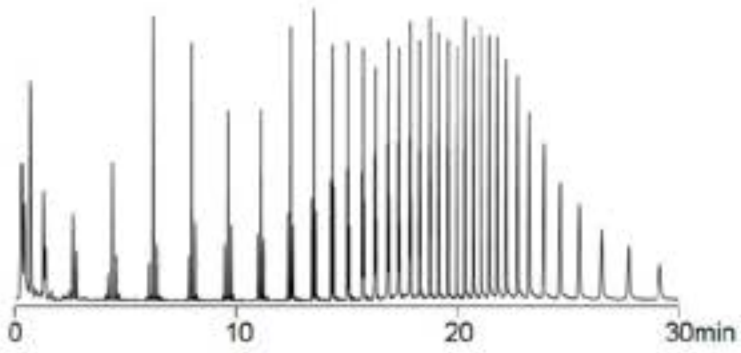
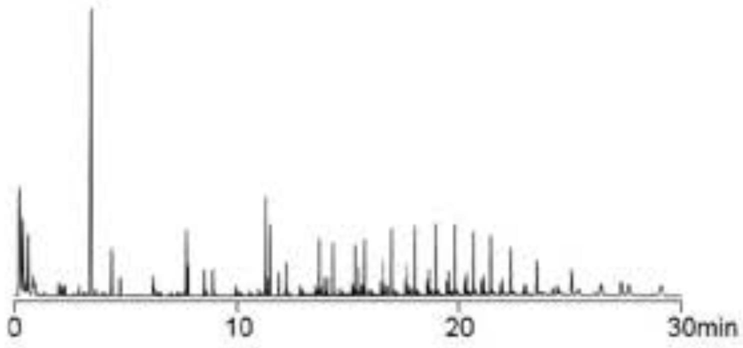
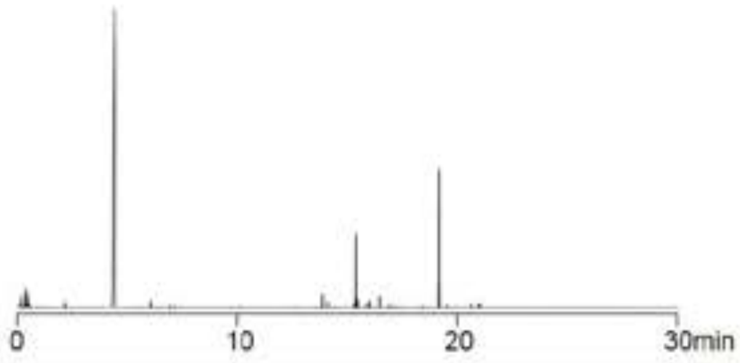
Typical Pyrograms of Different Polymers



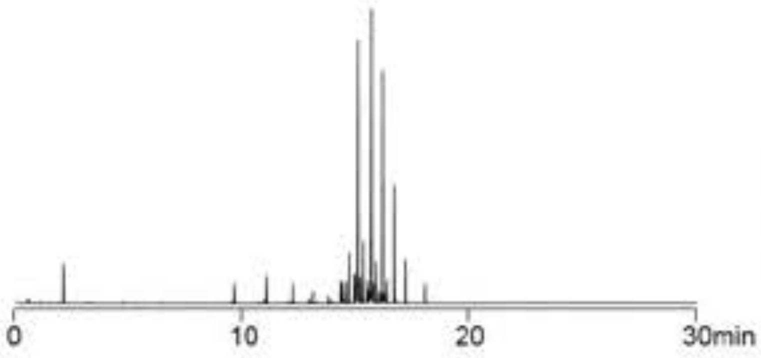
Polyethylene (PE)



Polypropylene (PP)



Polystyrene (PS)



Higher methacrylate copolymer

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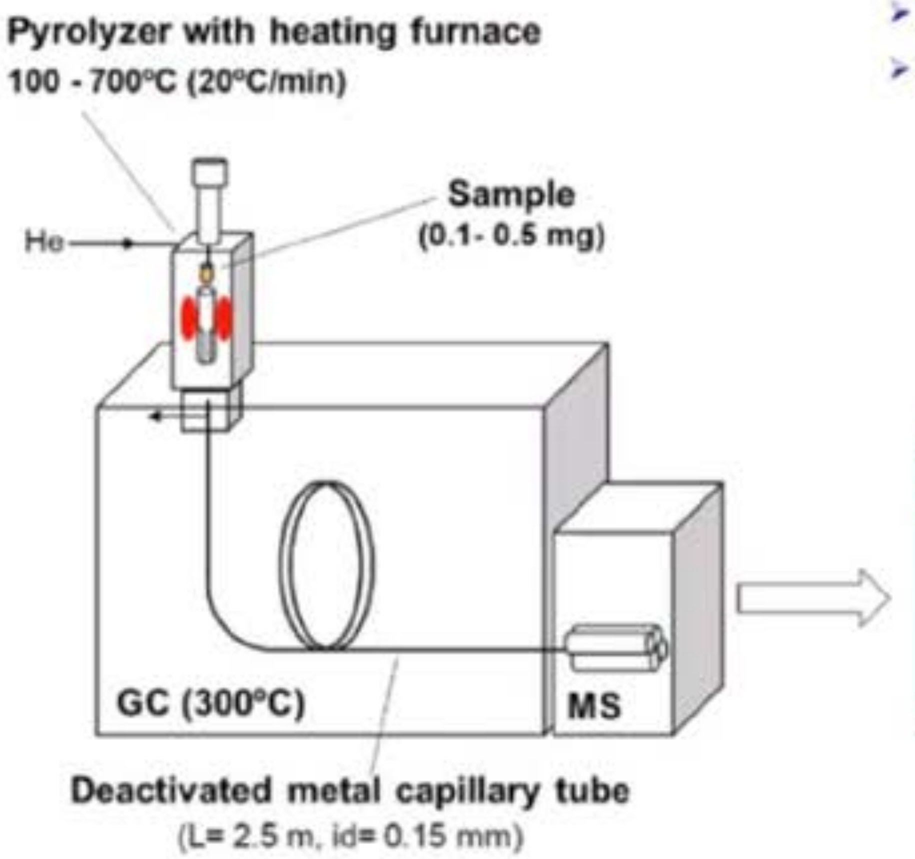
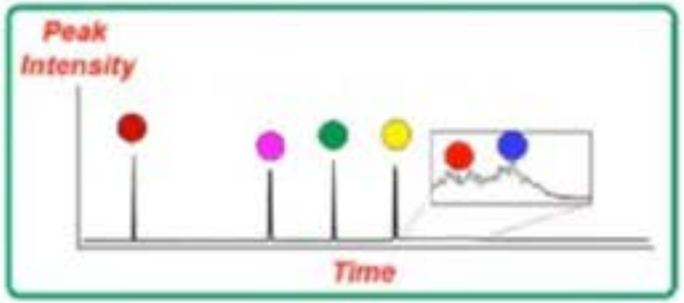
Py-GC/MS Working Principle



Key advantages:

- **Direct Sample Analysis**
- **Can operate at higher temperature**



Detection of peaks

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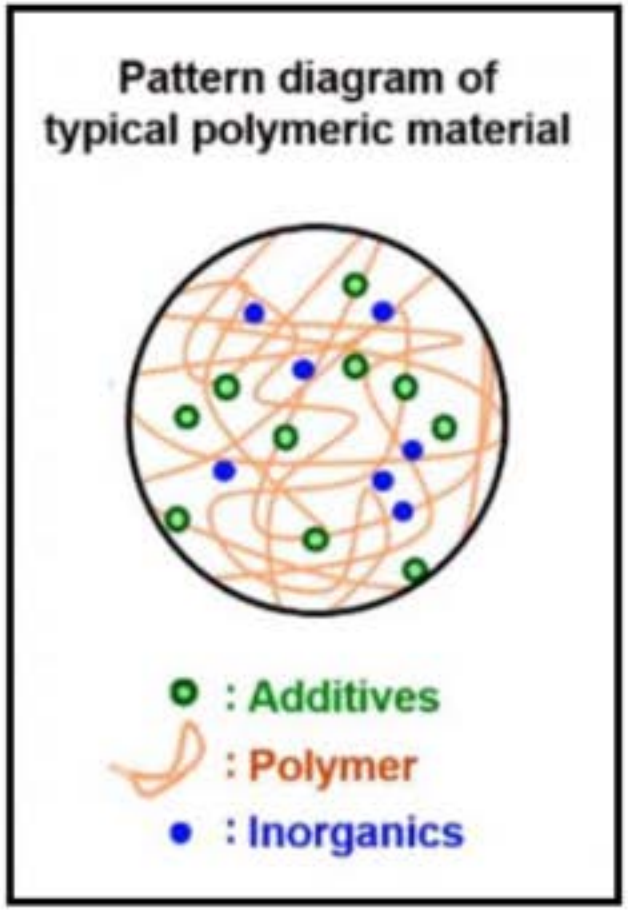
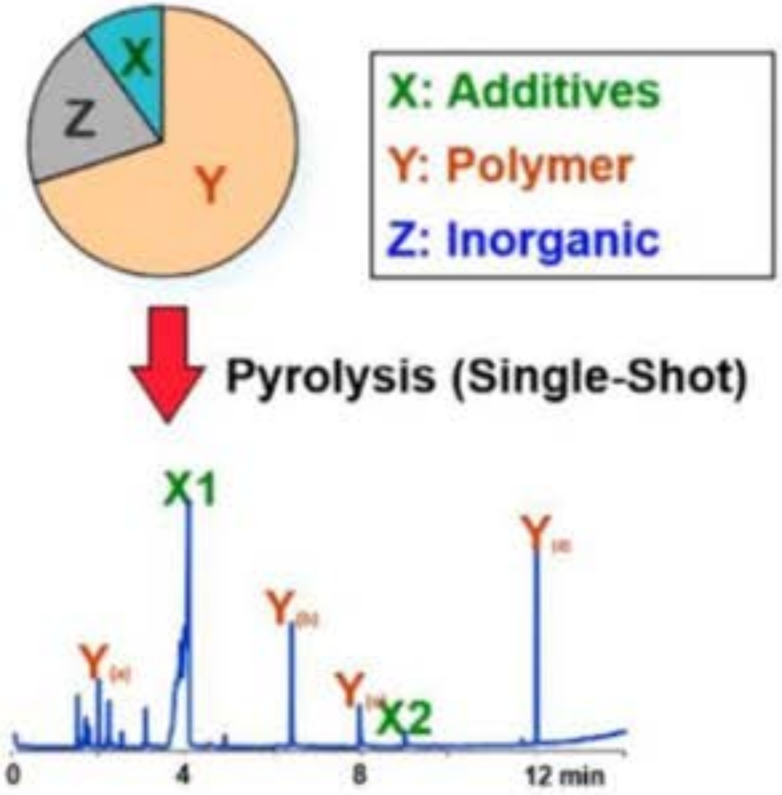
Polymeric Materials and Pyrolysis





Mixed Information of polymer and volatiles

Sometimes difficult to interpret results !!

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Py-GC/MS Working Principles

STEP 01

Sample Preparation

Solid samples
Using a cutter knife

Solid samples
Using a cryogenic mill

Film samples
Using Micro-puncher

Liquid sample
Using a micro syringe

STEP 02

Measure Weight

Sampling
Placed in a sample cup

Weighing Samples
Using a micro balance

STEP 03

Placed the Sample on to Pyrolyzer

Inject directly
Without solvent extraction

Heating sample
(Thermal desorption)

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4 Analytical Techniques & Method Mapping

1. *Evolved Gas Analysis* **(EGA-MS)**
2. *Single-Shot Analysis* **(PY, Flash Pyrolysis)**
3. *Double-Shot Analysis* **(TD/PY)**
4. *Heart-Cut/EGA-GC/MS Analysis* **(Multi-Shot Analysis)**

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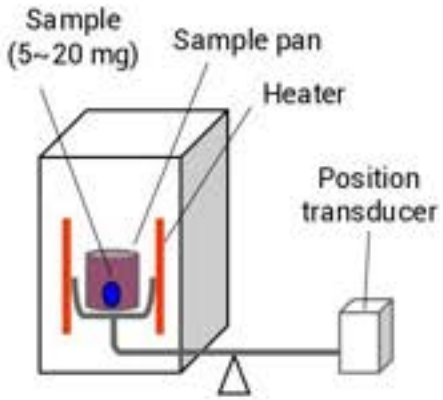
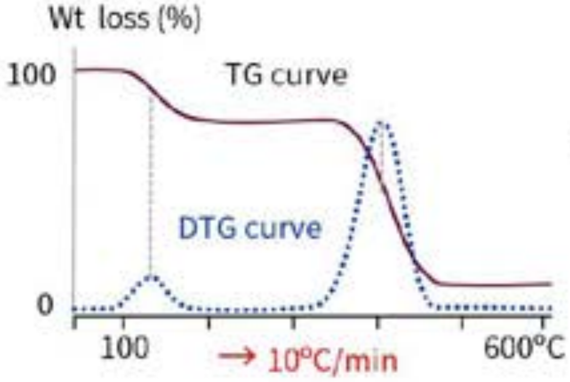
Evolved Gas Analysis (EGA-MS)

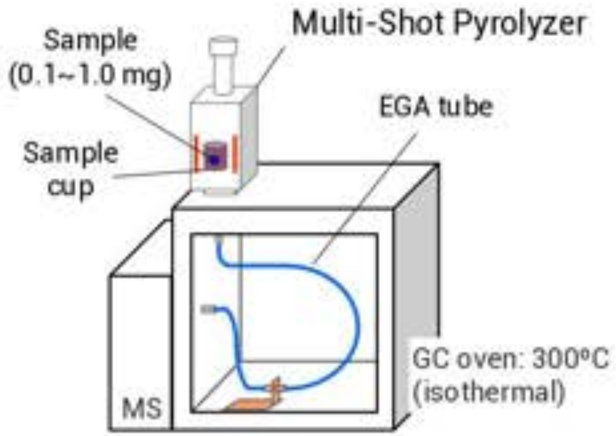
TGA
Thermogravimetric Analysis



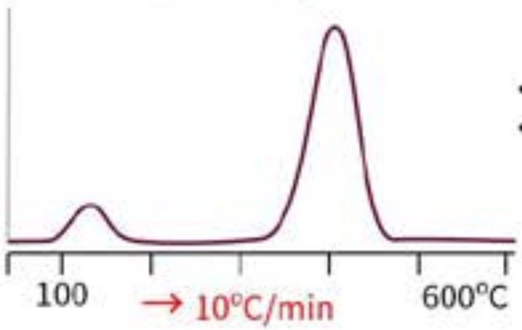


- Weight loss information

EGA
Evolved Gas Analysis



EGA thermogram



- High sensitivity
- Detailed sample information (MS spectrum)

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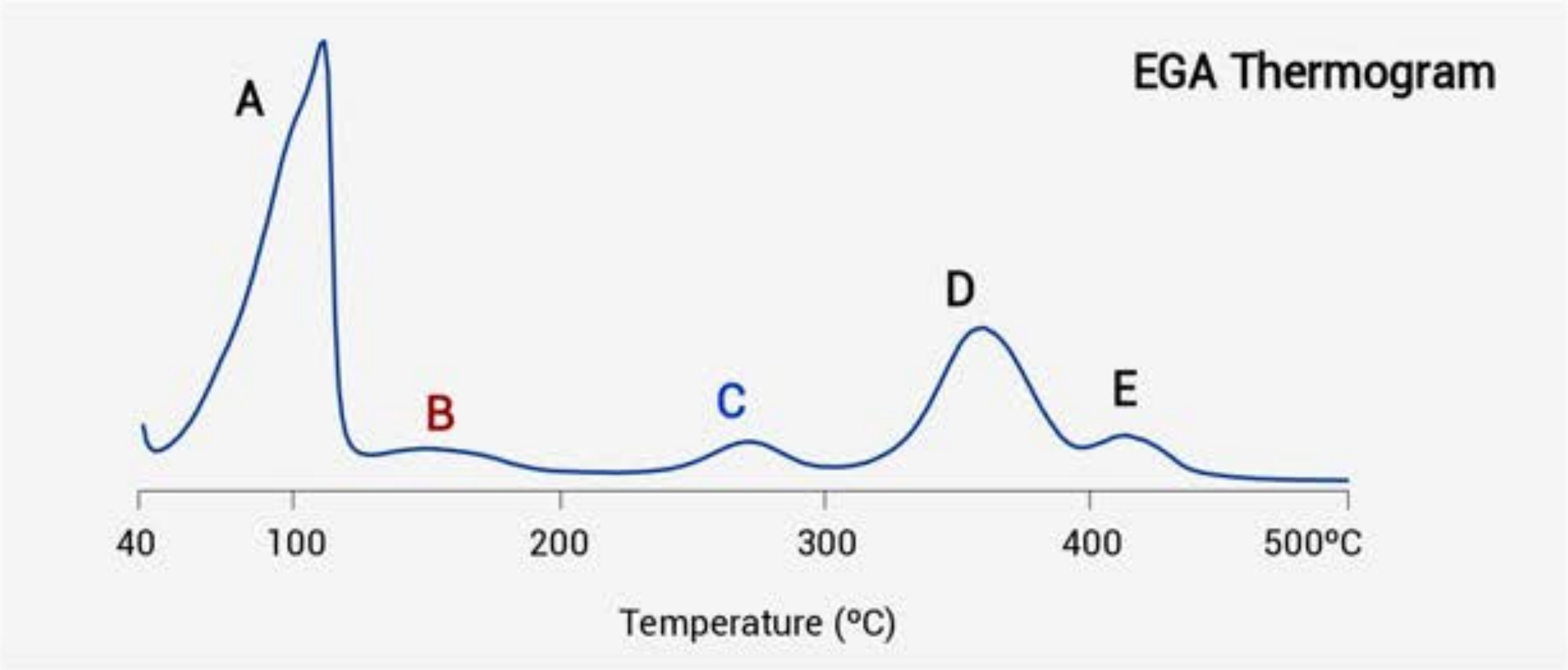
Evolved Gas Analysis (EGA-MS)



- How many peaks?
- Each temperature?

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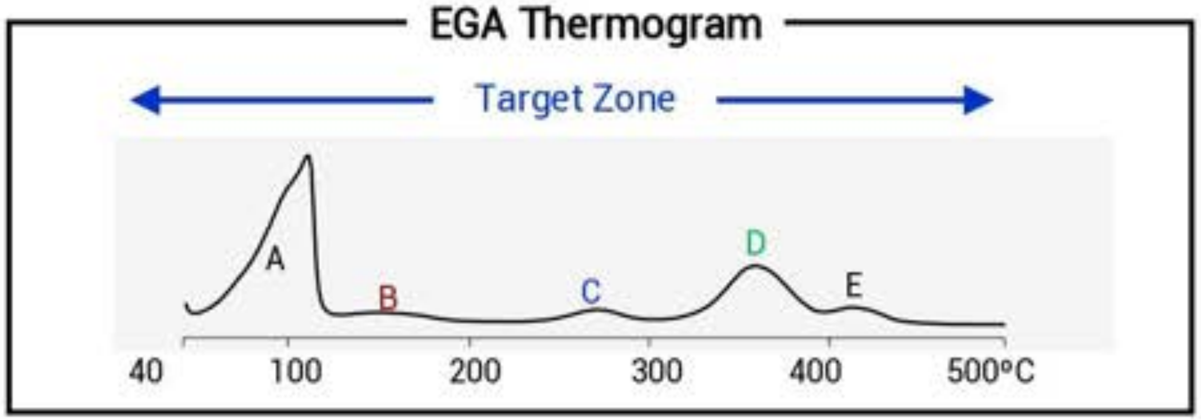
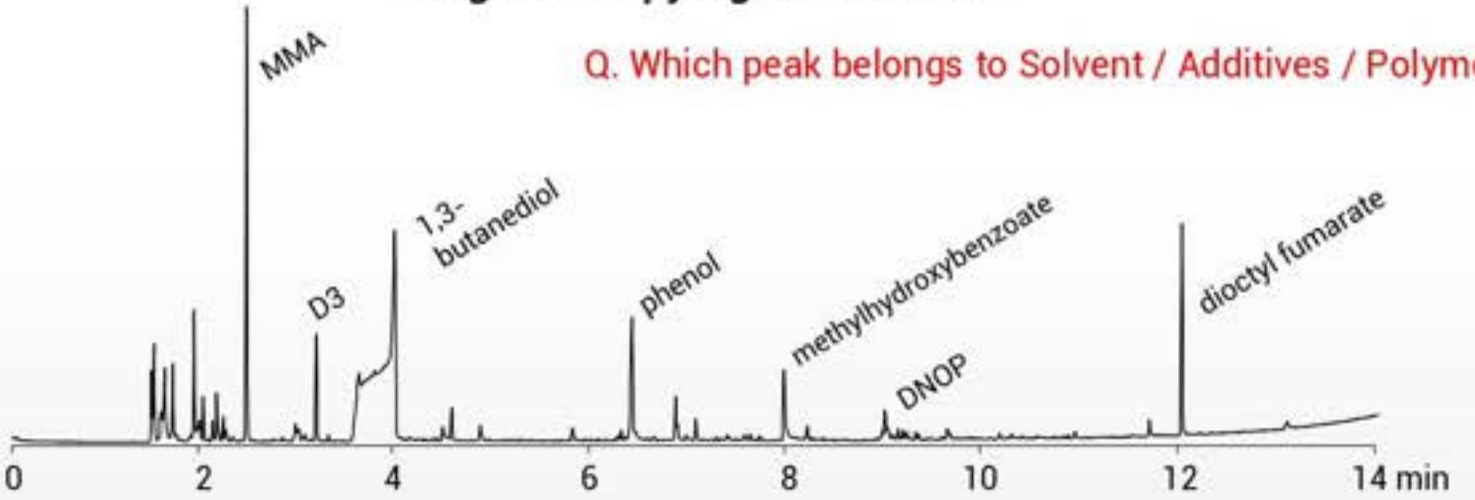
Single-Shot Analysis





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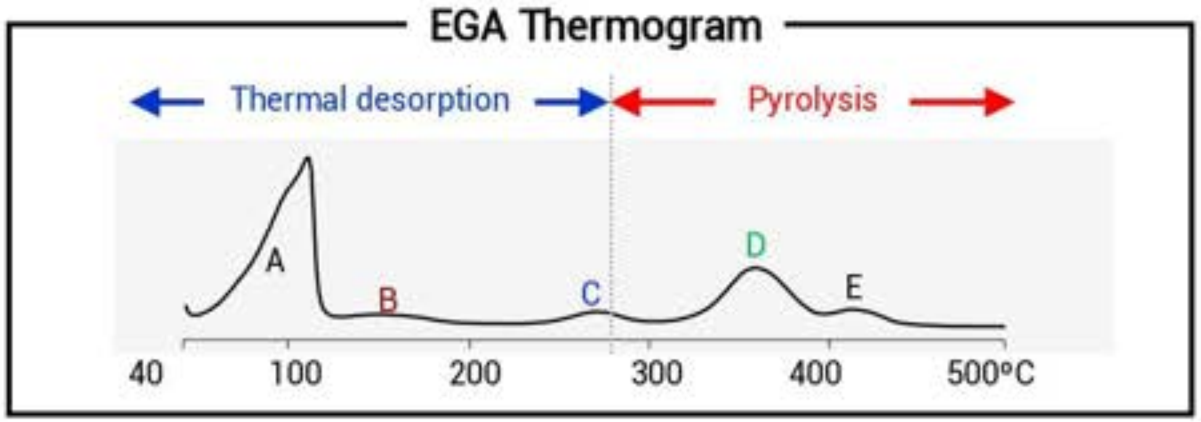
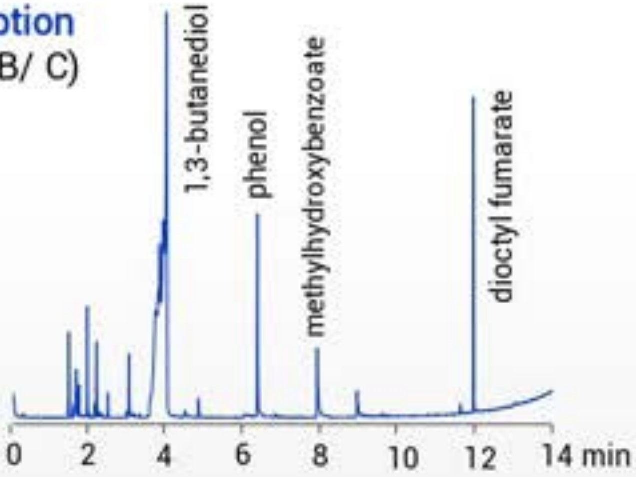
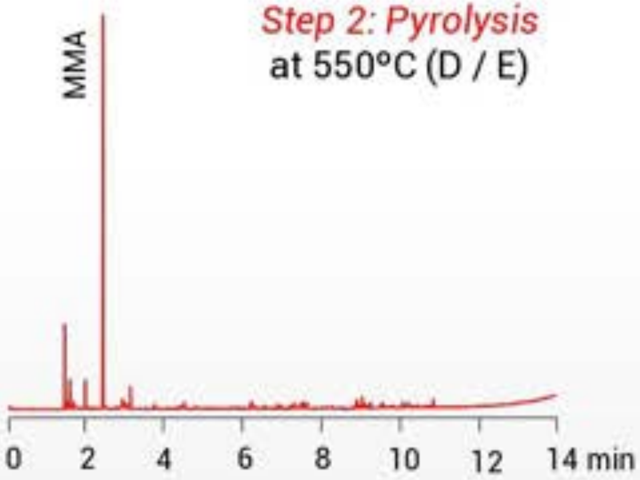
Double-Shot Analysis



Step1: Thermal desorption
from 40 to 310°C (A/ B/ C)



Step 2: Pyrolysis
at 550°C (D / E)



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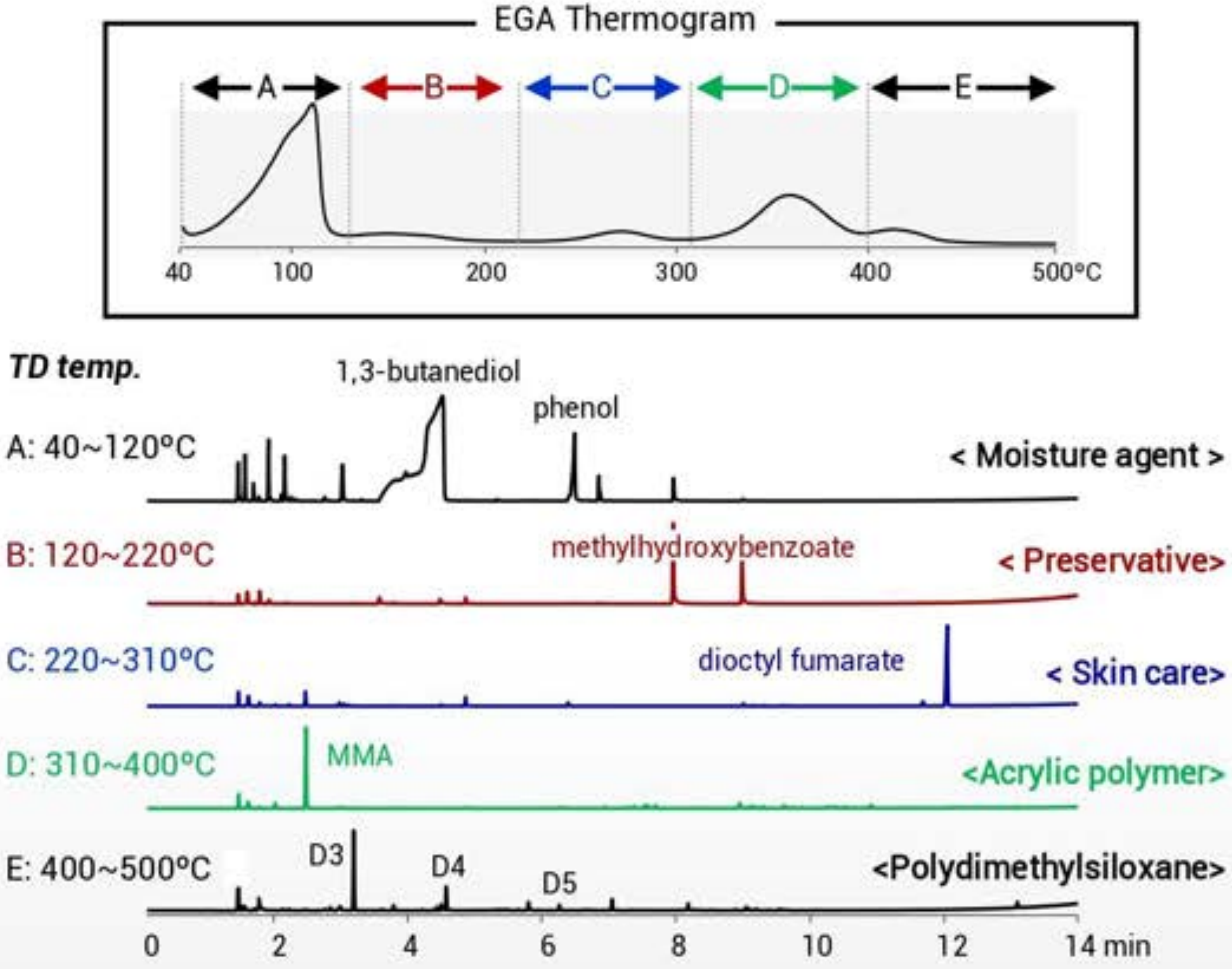
Heart Cutting EGA-GC/MS Analysis



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Py-GC/MS Applications for Automotive Market

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Analytical Problems and Frontier-Based Solutions

- A. Polymer Processing
- B. Additives
- C. Paints & Coating
- D. Rubbers
- E. Adhesives
- F. Weatherability Tests

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Analytical Problems and Frontier-Based Solutions

A. Polymer Processing

PMMA(Acrylic) is a transparent thermoplastic; Applications: Windows, displays, screens

Analysis of Polymerization Reagents Incorporated into Poly (Methyl Methacrylate) Chains

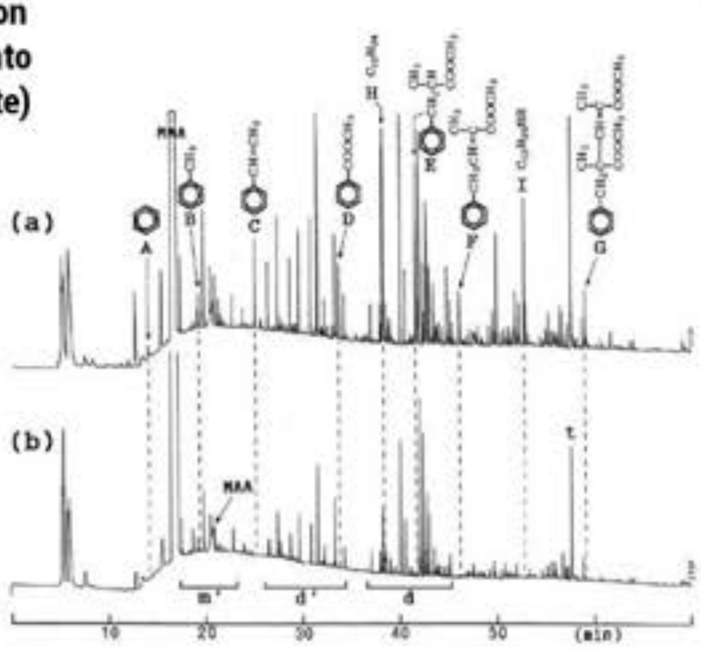

Fig. 1 Pyrograms of poly (methyl methacrylate): prepared in toluene with 0.3% of benzoyl peroxide and 1.5% of dodecanethiol; and thermally polymerized in bulk without any polymerization reagent.

Analysis of the End Groups in Radically Polymerized Poly (Methyl Methacrylate)

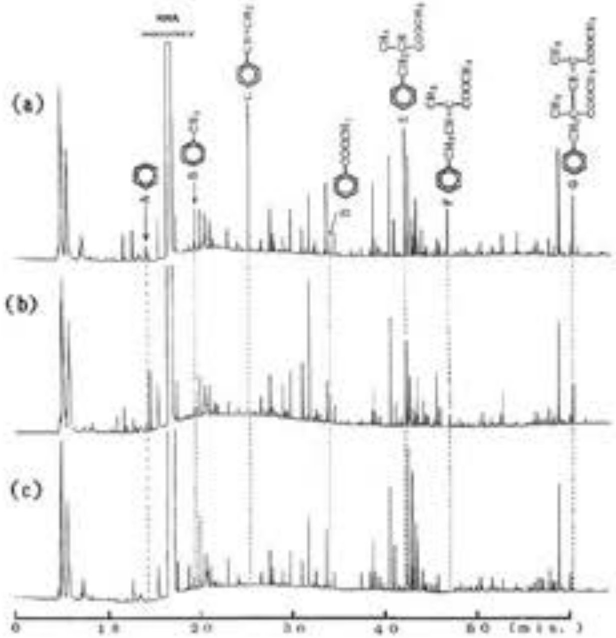

Fig. 1 Pyrograms of PMMA samples obtained at 460°C
(a) polymerized in toluene,
(b) polymerized in benzene, and
(c) polymerized without any initiator.

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Analytical Problems and Frontier-Based Solutions

A. Polymer Processing

Polybutylene Terephthalate(PBT) has good chemical resistance and electrical properties, hard and tough material with water absorption, very good resistance to dynamic stress, thermal and dimensional stability.
Applications: Fog lamp housings and bezels, sun-roof front parts, locking system housings, door handles, bumpers, carburetor components, etc.

Analysis of the Constituent Monomers of Polybutylene Terephthalate (PBT)

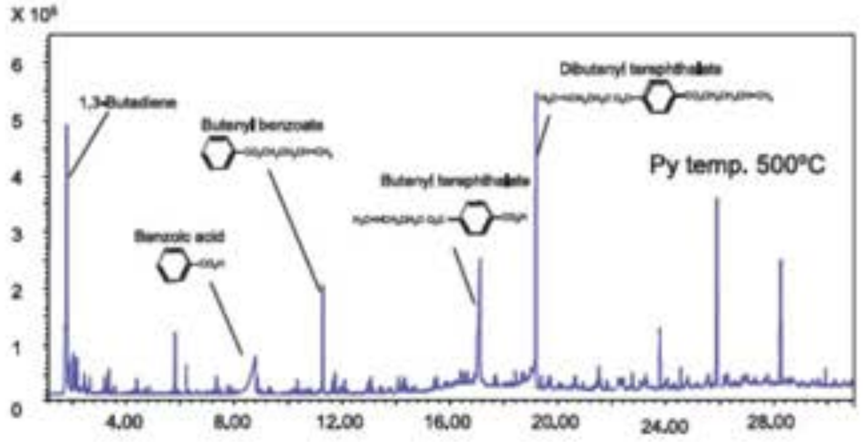

Fig. 1 Pyrogram obtained by flash pyrolysis of PBT

Flash pyrolysis technique gave products arising from decomposition and decarboxylation of ester group, but no monomer. On the other hand, reactive pyrolysis gave PBT constituent monomer of dimethyl derivatives of terephthalic acid and mono and dimethyl derivatives of 1,4-butanediol.

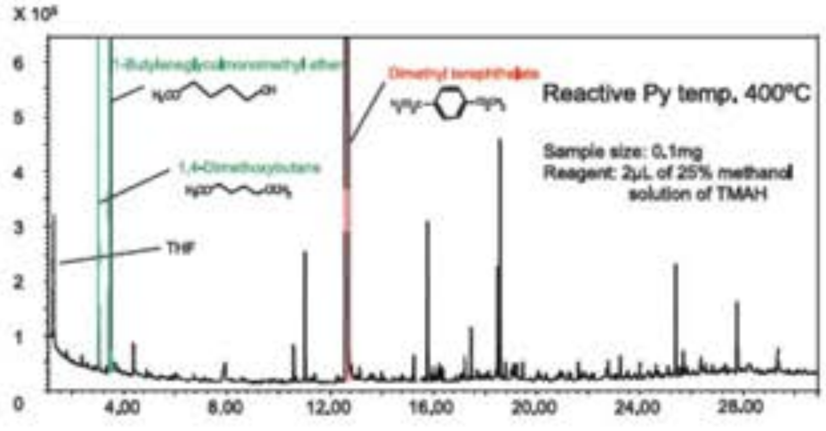

Fig. 2 Pyrogram obtained by reactive pyrolysis of PBT
Carrier gas: He, Injection port pressure: 103kPa, Split ratio: 1/60, Separation column: Ultra ALLOY+-5 (5% diphenyldimethylpolysiloxane) L=30m, Id=0.25mm, df=0.25μm, GC oven temp: 38°C~300°C (20°C /min)

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Analytical Problems and Frontier-Based Solutions

B. Additives

Analysis of Ceramic Composite Materials

Fig. 1a Library Search Result for Peak C

Name	Qual
1. Poly(n-butyl methacrylate) (PBMA)	**: 72**
2. Poly(2-hydroxyethyl methacrylate) ;	: 4
3. Higher methacrylate copolymer	: 2

Fig. 1b Library Search Result for Peak D

Name	Qual
1. Polystyrene (PS)	**: 90**
2. Styrene-ethylene-butadiene-styrene-block copolymer	: 78
3. Modified poly(phenylene oxide)	: 64

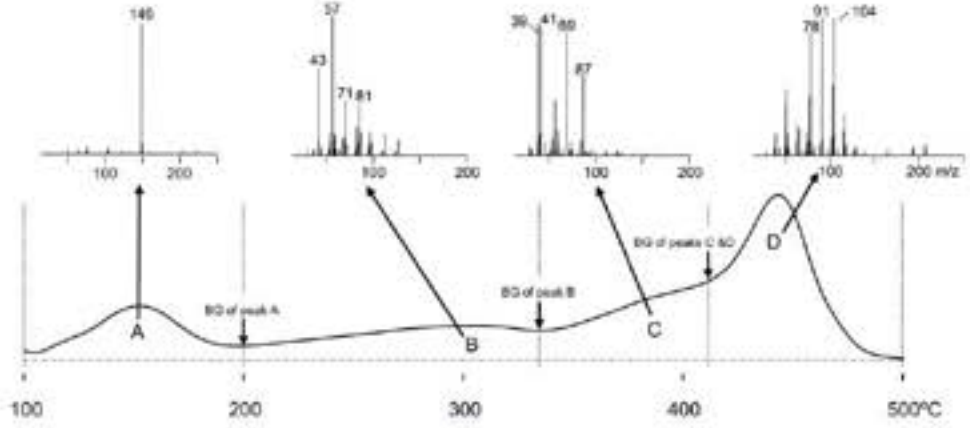

Fig. 1 EGA Curve of Ceramic Composite Material (Injection molding)
Pyrolysis furnace temp : 100°C~500°C (20C/min), Carrier gas : He 50kPa, Split ratio : ca. 1/50
EGA capillary tube : 0.15mm id, length 2.5m (UADTM-2.5N), GC oven temp : 300°C
Injection port temp : 320°C, Amount of sample : ca. 0.5mg, Detector : MS (m/z=29-400, 0.1 scan/sec)
PY-GC interface temp : 320°C (AUTO mode)

Analysis of Butylhydroxytoluene (BHT) in PE

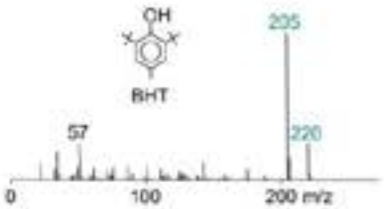

Fig. 1 Chemical structure of BHT and its mass spectrum

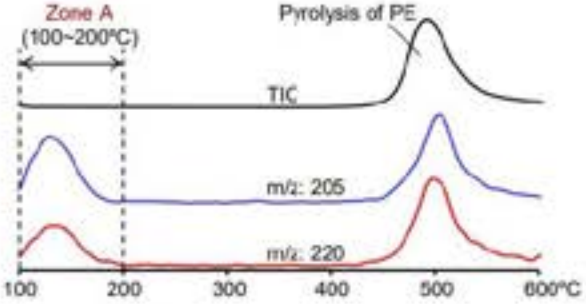

Fig. 2 Thermograms of a PE Sample
Furnace temp. : [illegible]°C, (20°C/min), split ratio : 1/50
[illegible]'s size : about 0.5mg, detector : MS

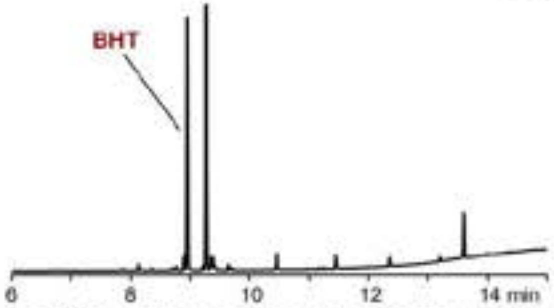

Fig. 3 Chromatogram of thermally desorbed components from a PE sample

Furnace temp.; 100-200°C (20°C/min, 3min hold), flow rate : 1 mL/min, split ratio : 1/50, GC oven temp.: 40-320°C (20°C/min), sample size : about 3mg, detector : FID, separation column : Ultra ALLOY-5 (5%-diphenyl 95%-dimethyl polysiloxane, L=30m, id=0.25mm, df=0.25μm)

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Analytical Problems and Frontier-Based Solutions

C. Paints & Coating

Organic pigments are widely used in the automotive manufacturing. The analysis and structure elucidation of organic pigments is challenging because they are not only insoluble in organic solvents but also many of them have similar structures.

Characterization of 35 Organic Pigments

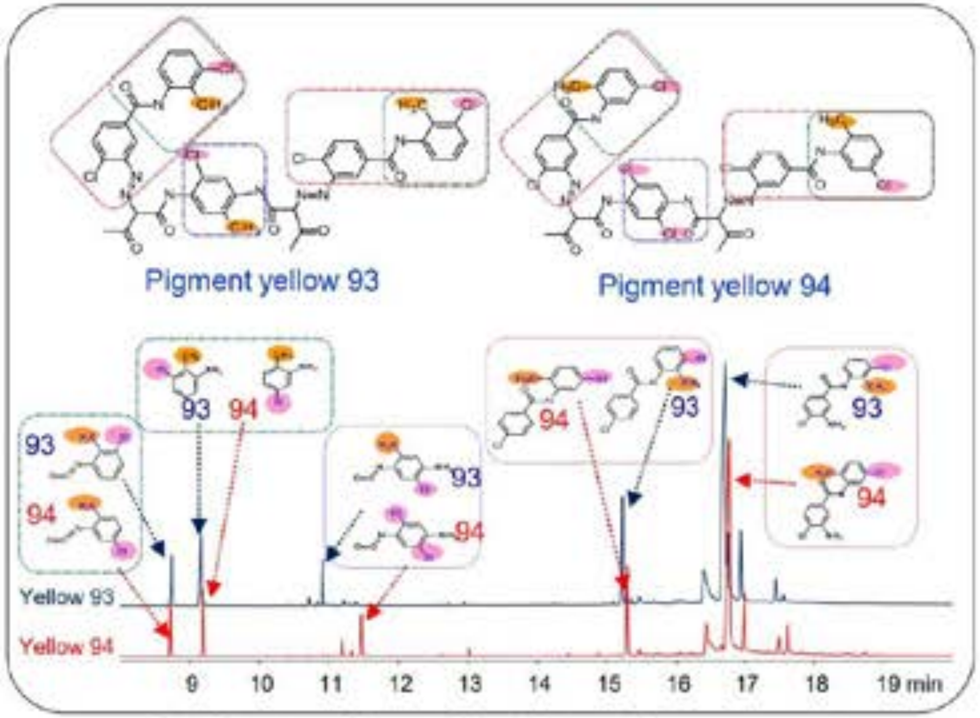

Fig. 1 Structure of Pigment 93 and Pigment 94, pyrograms, and identification of major peaks

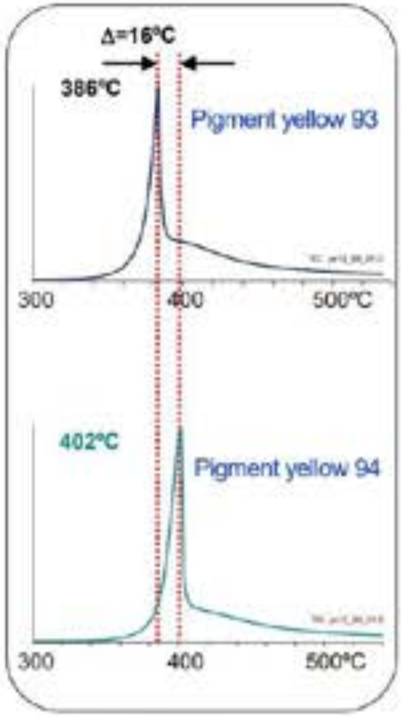

Fig. 2 EGA Thermogram of Pigments 93 and 94

Pyrolysis temperature: 600°C, GC oven temperature: 40 - 320°C (20°C/min)
Separation column: Ultra ALLOY+-5 (5% diphenyl 95% dimethylpolysiloxane), L=30 m, i.d.=0.25 mm, df=0.25 μm, split ratio: 1/30, Sample wt.: approx.70 μg

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Analytical Problems and Frontier-Based Solutions

C. Paints & Coating

The EGA thermogram of the film is presented in Fig 1. Each zone is analyzed separately using a Heart-Cutting EGA-GC/MS technique. The results of the analyses are shown in Fig. 2. The data indicates that a number of additives and pyrolyzates of the polymer back bone are present in each EGA zone.

Analysis of Toxic Gases Released from Polyvinylidene Chloride (PVDC) Film

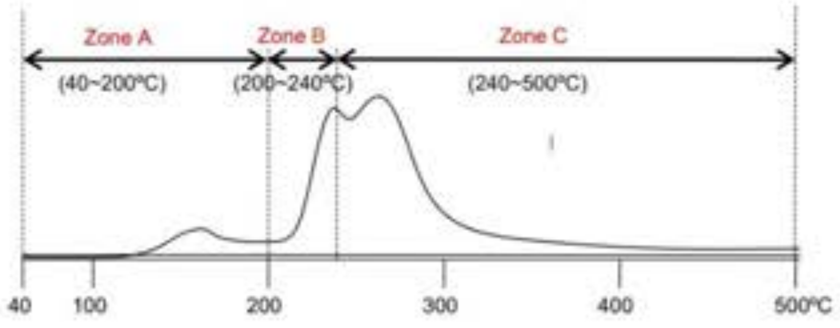

Fig. 1 EGA Profile of Polyvinylidene Chloride

Pyrolysis temp: 40~600°C (30°C/min), carrier gas: He
Interface: deactivated metal capillary column (length: 2.5m, id: 0.15mm)
Injection port pressure: 50kPa

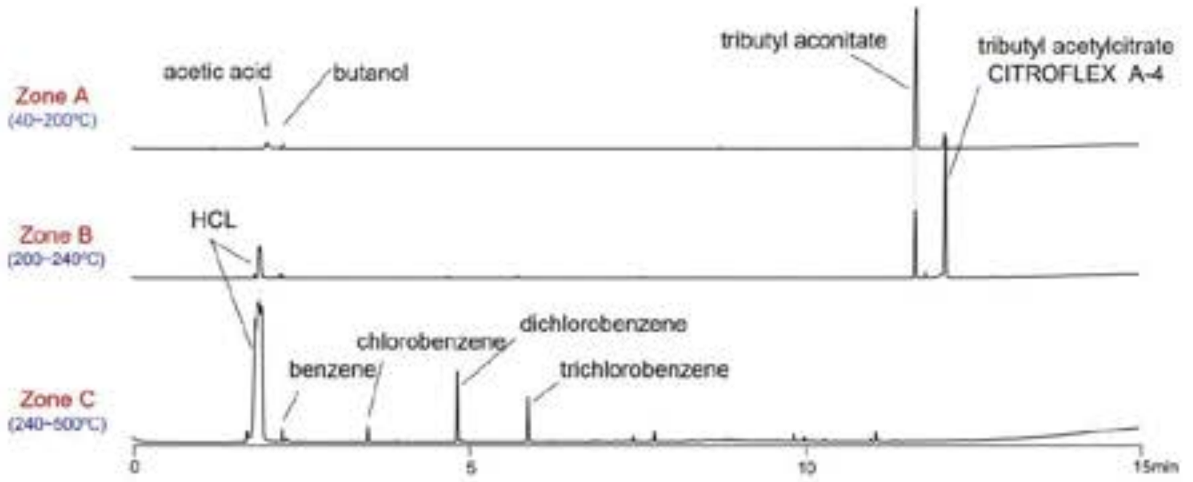

Fig. 2 Analysis Results of Zones A, B, and C of Polyvinylidene Chloride

Carrier gas: He, column flow rate: 1ml/min, Split injection, separation column: Ultra ALLOY-5 (5% diphenyl dimethyl polysiloxane), length: 30m, id: 0.25mm, film thickness: 0.25μm, GC oven temp: 40°C (1min hold) ~ 320°C (20°C/min), injection port temp: 320°C, Cryo trap temp: -196°C, sample: 0.25cm²

Reference: Hosaka et al., 49th Japan Analytical Society Meeting (2000)

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Analytical Problems and Frontier-Based Solutions

D. Rubbers

Rubber Materials: Tires, Seal, O-rings

Analysis of Compounded Rubber

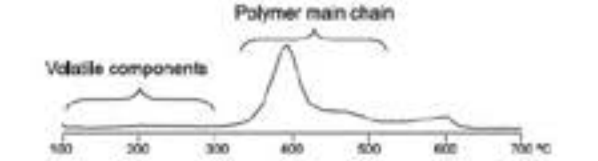

Fig. 1 Evolved gas curve of a compounded rubber
Pyrolysis temp.: 100–700°C (20°C/min), Carrier gas : He 50kPa, Split ratio : ca. 1/20 EGA capillary tube : 0.15mm id, 2.5m (UADTM-2.5N), GC oven temp.: 300°C Injection temp.: 320°C, Sample : ca. 5g, Detector : MS (m/z=29-400)

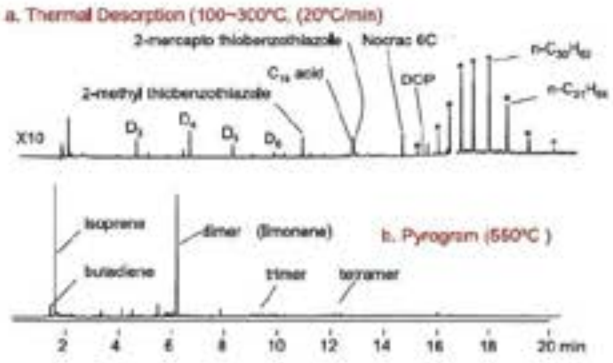

Fig. 2 GC/MS analysis of compounded rubber by double-shot technique
Column flow rate : 1ml/min (fixed flow rate), Split ratio: 1/20 Separation column: Ultra ALLOY+-5 (5% diphenyl polysiloxane), 30m, 0.25mm id, Df: 0.25m GC oven temp.: 40–300°C (20°C/min), Sample : 5g, Detector: MS (m/z=29-400, 2 scans/sec)

Identification of an Unknown Antidegradant in Rubber

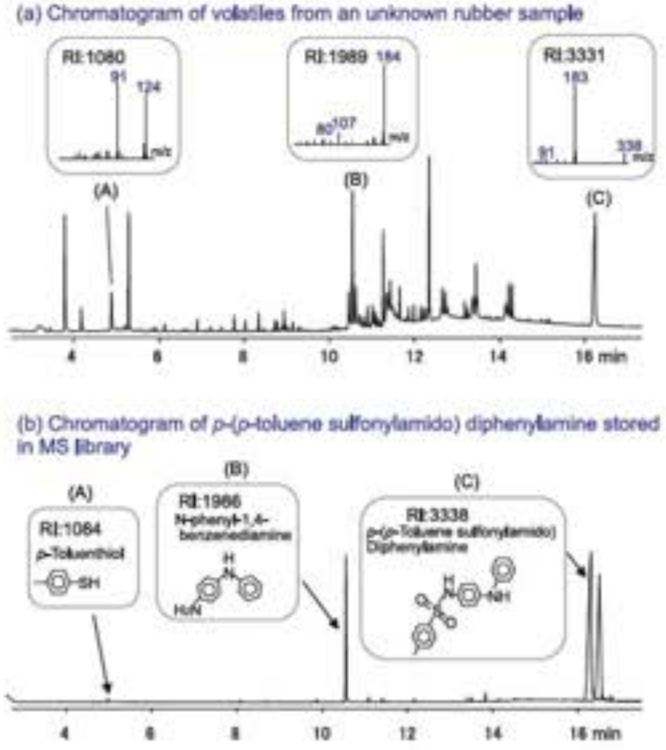

Fig. 1 Chromatogram obtained by (TD)-GC/MS technique

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Analytical Problems and Frontier-Based Solutions

D. Rubbers

Curing process of epoxy resins has been often studied by IR, FT-IR, or NMR by looking at the spectral changes of chemical species formed during the course of curing process. DSC has also been used to study the curing reactions by evaluating the heat of reaction. On the other hand, high resolution Py-GC is another technique that can be applied for studying systems with insoluble species and various additives.

Results showed that the yields of the pyrolyzates with epoxide groups decreased with increase of the degree of cure. While those of various phenols, characteristic of prepolymer skeleton increased. The results observed corresponded well to the those deduced from Tg measurements by DSC.

Studies on Curing Process of Epoxy Resins by Py-GC
- Cured with 1-Benzyl-2-Methyl Imidazole (1B2MZ) -n

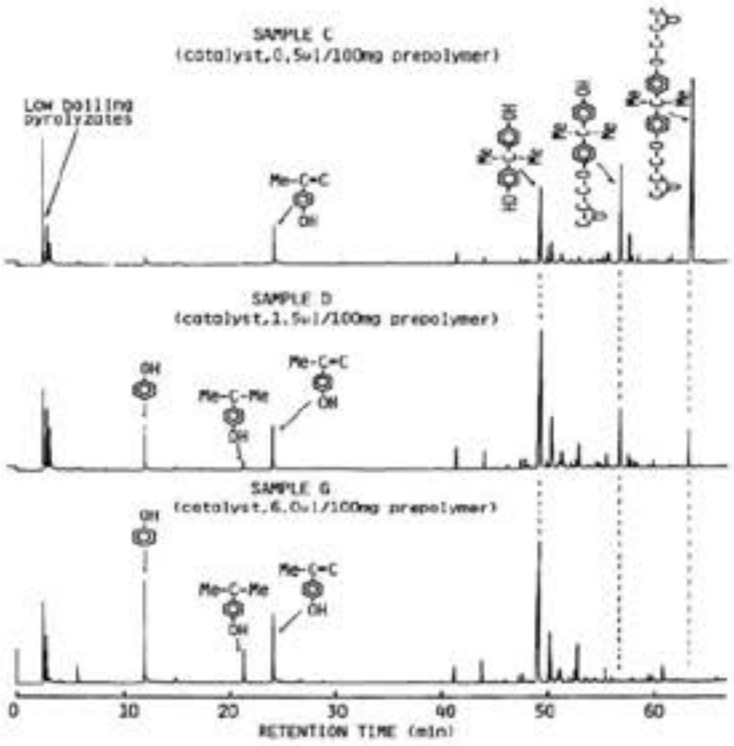

Figure 1. High-resolution pyrograms of epoxy resins cured with various amounts of imidazole catalyst at 180˚C for 3h.

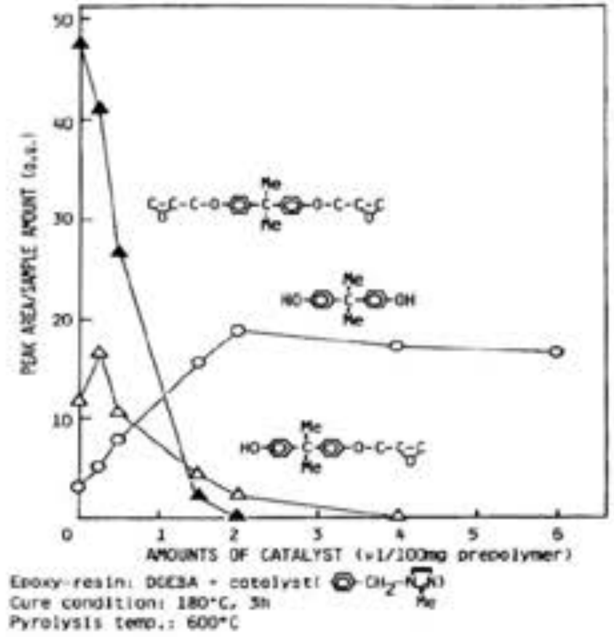

Figure 2. Changes of characteristic products from epoxy resins as a function of catalyst amount.

*Contents excerpted from H. Nakagawa, S. Wakatsuka, S. Tsuge, T. Koyama, *Polymer. J.* No. 1, pp 9-16 1992

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Analytical Problems and Frontier-Based Solutions

F. Weatherability Tests

UV curable resins are used in a wide spectrum of applications including microelectronics packaging adhesives in electronics and optical parts, etc. The curing reaction generates volatile compounds from the resin, which corrode metal surfaces and deteriorate product quality; therefore, there is a need for qualitative and quantitative analysis of such volatiles.

Analysis of Volatiles Released from a UV Curable Resin

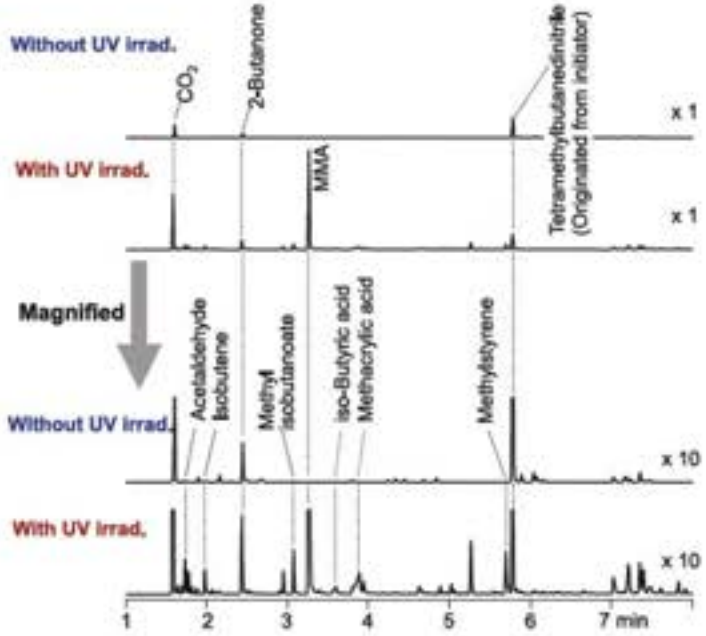

Fig. 1 Analysis of volatiles released from UV curable acrylic dry film

Micro UV irradiator: UV-1047Xe, separation column: Ultra ALLOY+-1 (dimetylpolysiloxane), L=30 m, id=0.25 mm, df=0.5 µm, atmosphere gas: He, Column flow rate: 1 ml/min, split ratio: 1/10, sample size: 350 g (3 mm diameter disc), GC oven temp: 40 ~ 300 °C (20 °C/min)

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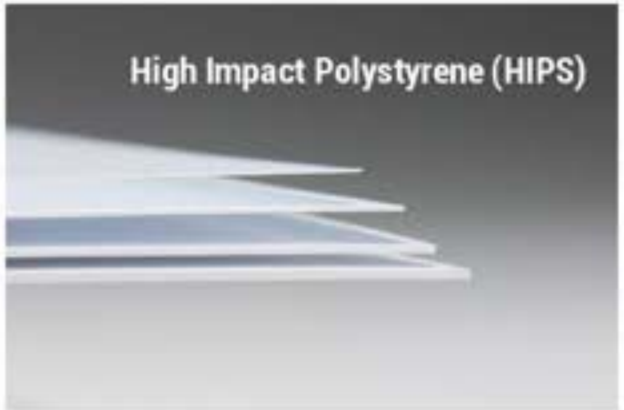
Analytical Problems and Frontier-Based Solutions

F. Weatherability Tests

The chromatograms of the volatile degradation products from HIPS with and without UV irradiation. Benzaldehyde, acetophenone, and benzoic acid are the PS degradation products formed during the irradiation. 2-propenal is also observed. It is the volatile degradation product of butadiene present in HIPS.

Analysis of the Photo/Thermal/Oxidative Degradation Products of High Impact Polystyrene (HIPS)



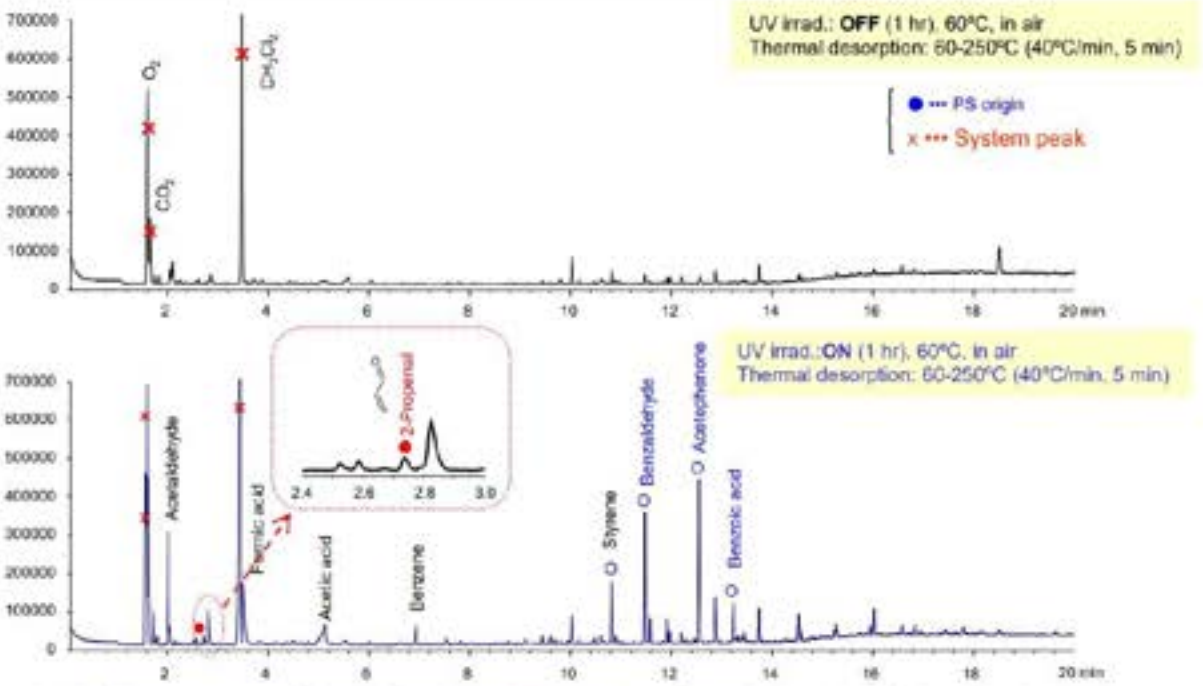


Fig 1. Chromatograms of the volatile degradation products formed when HIPS is irradiated and not irradiated.

<UV irradiation> Micro UV irradiator : UV-1047Xe, irradiation: 1 hr, furnace temp.: 60°C, atmosphere gas: 10 mL/min Air, split ratio: 1/10
<GC/MS> Separation column: Ultra ALLOY⁺-1 (polydimethylsiloxane, L=30 m, i.d.=0.25 mm, df=0.5 μm), GC oven temp.: 40°C(5 min)-240°C(20°C/min), GC injection temp.: 250°C, carrier gas: 50 ml/min He, split ratio: 1/50

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Py-GC/MS Application for Tire Rubber

Additive

Rubber

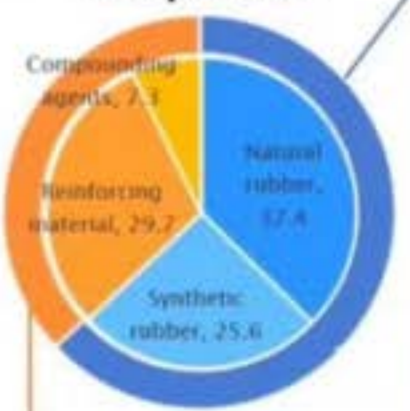
[1]

Mixing

Tire rubber

[2]

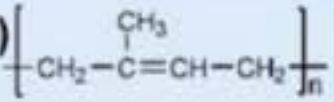
[3] Tire rubber composition



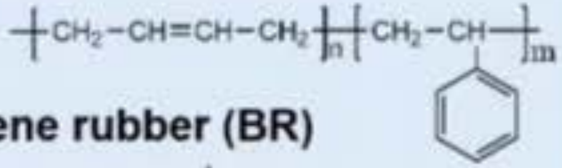
[4]

Rubber material

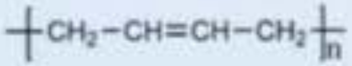
Natural rubber (NR)



Typical synthetic rubbers:
Styrene butadiene rubber (SBR)



Butadiene rubber (BR)



[5]

Additives

Reinforcing material	: Carbon black, silica, etc.
Compounding agents	
Vulcanizer	: Increases the elasticity of rubber
Vulcanization accelerator	: Shortens vulcanization time
Nucleating agent	: Improves crystallization temperature
Anti-aging agent	: Inhibits aging and degradation **Prevents surface cracking**
Antioxidant	: Prevents oxidation

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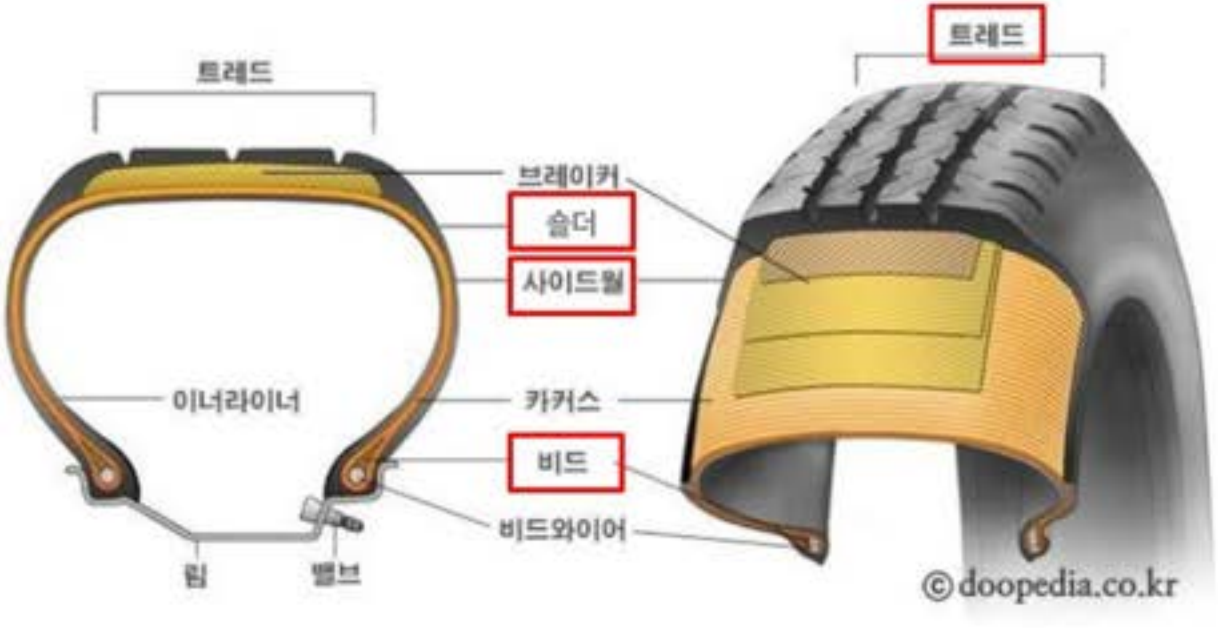
Background and Goal

Cross section



Roles differ depending on parts

- Tread: Protects the inside from impact
- Shoulder: Dissipates heat during driving
- Sidewall: Protects the inside and prevents stretching
- Bead: Fix the tire to the wheel

Tire rubber composition varies depending on each of the part.

Our Goal : *Analysis of rubber components and additives contained in each part of tire by pyrolysis*

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Collecting Samples

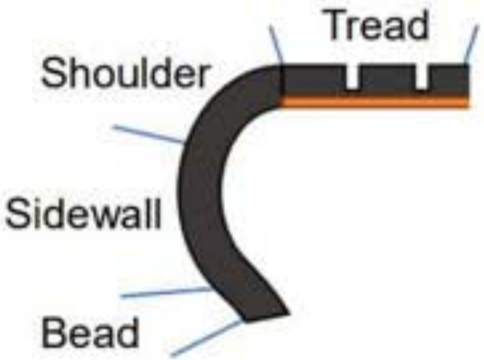
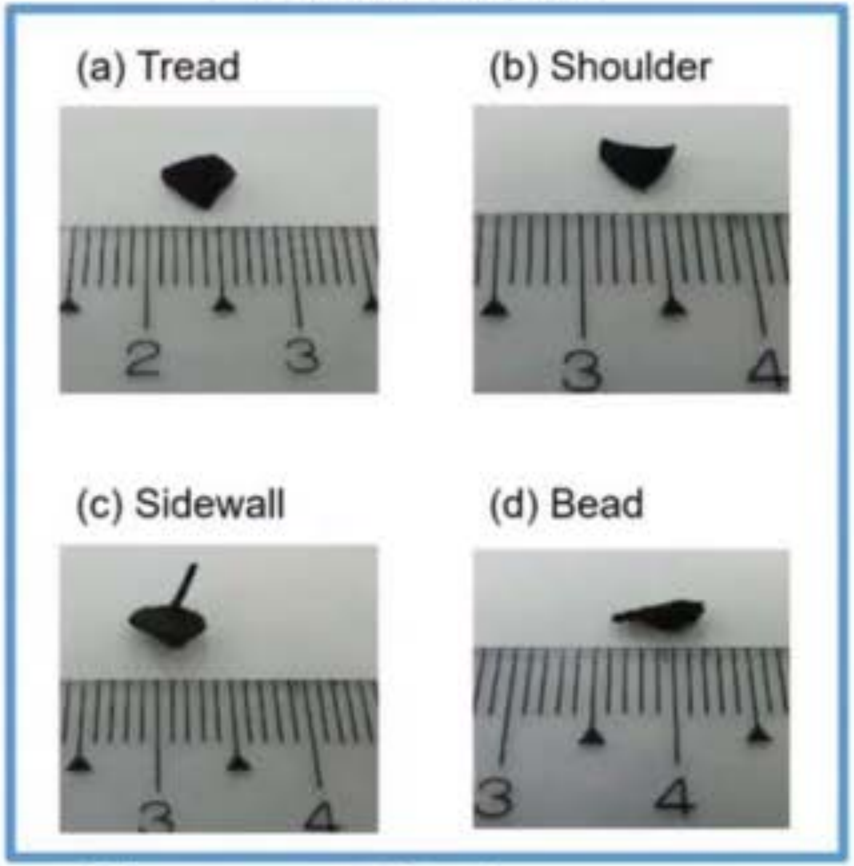


Fig. 1 Cross section of tire

Sampling

Photos of samples



* These were cut into 1 mm squares.

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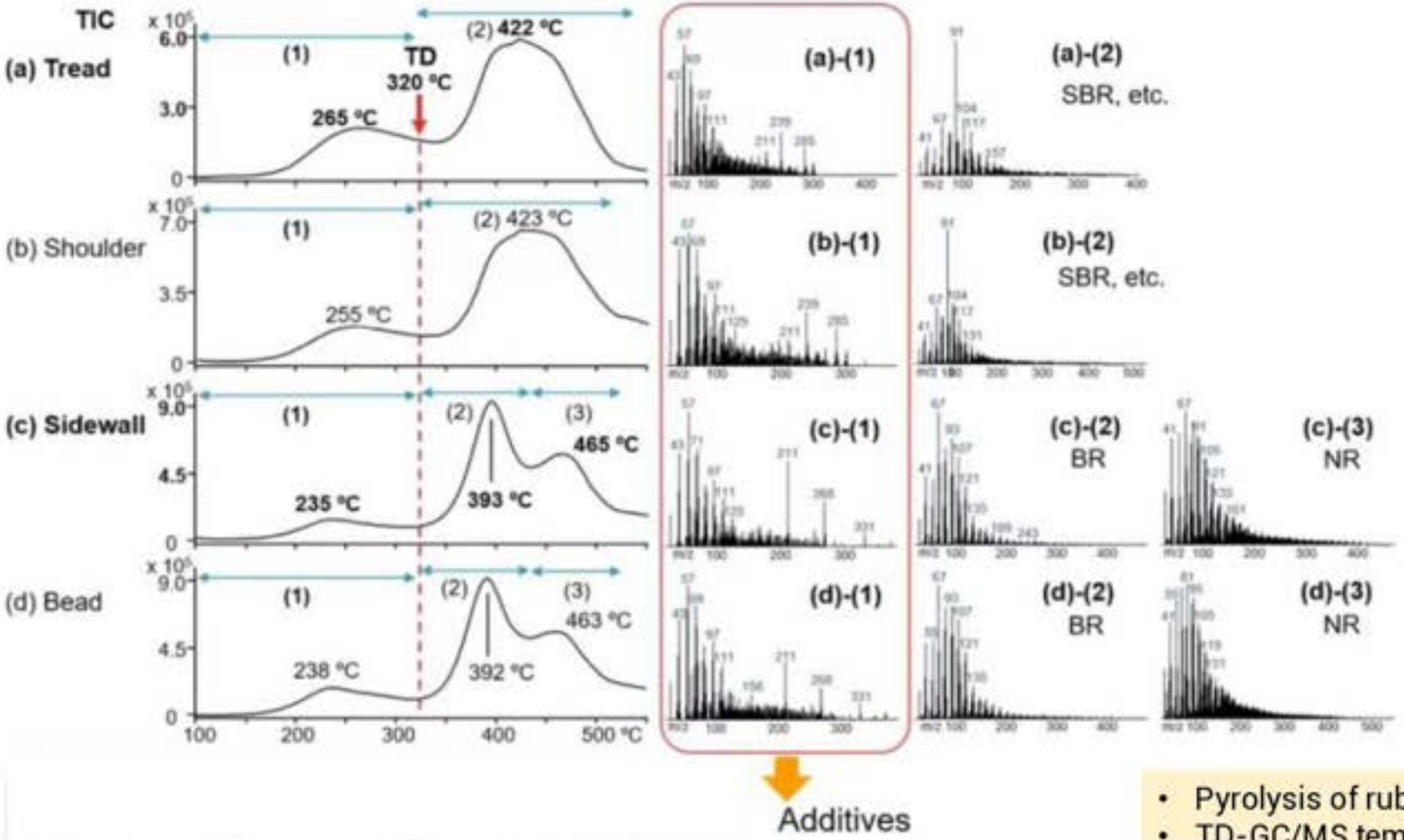
EGA Thermogram and Averaged Mass Spectrum of Tire Rubber



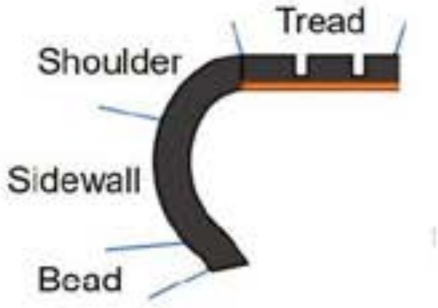


Fig. 1 Cross section of tire

- Pyrolysis of rubber starts at 320℃
- TD-GC/MS temperature set as 100 to 320℃

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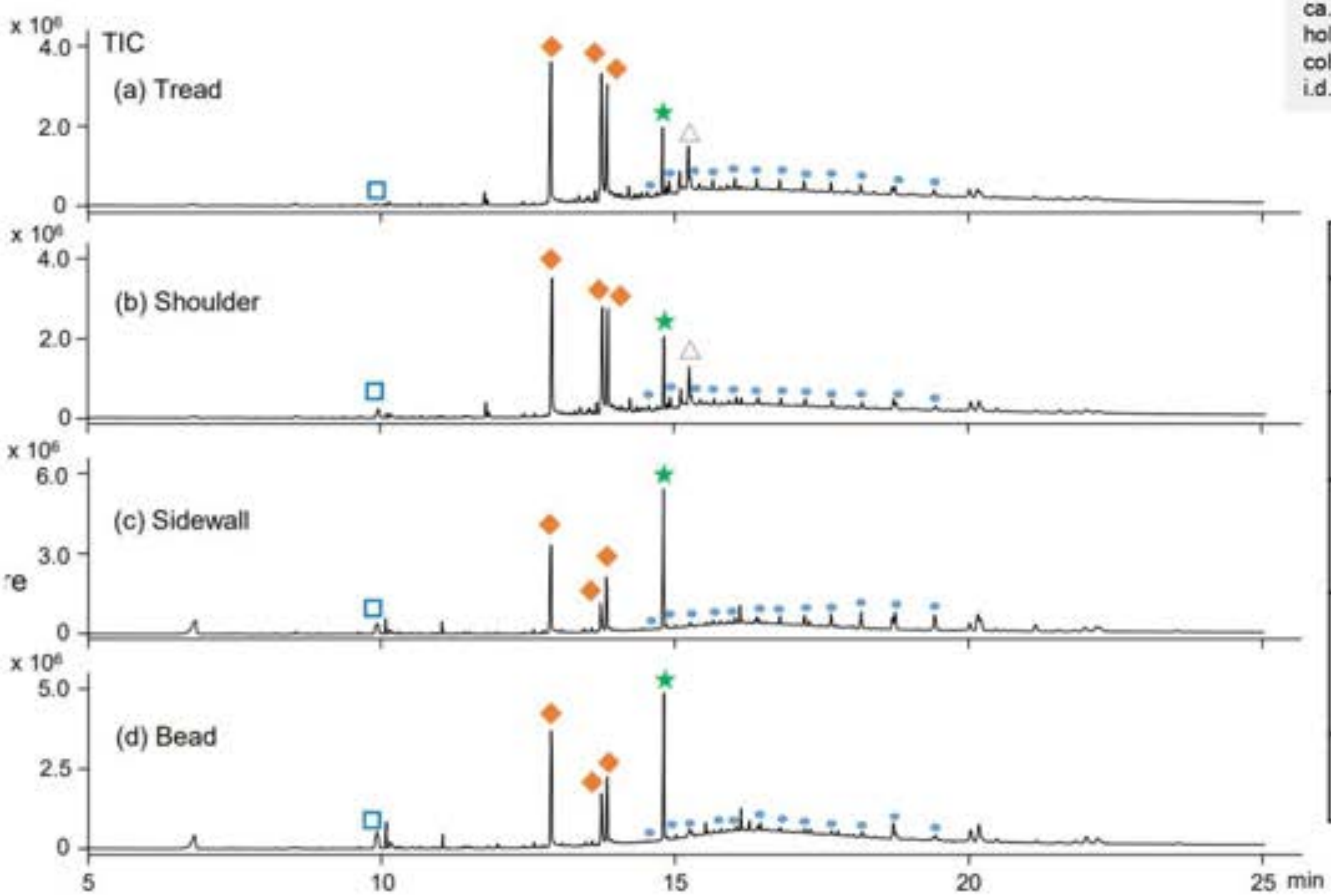
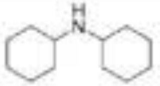
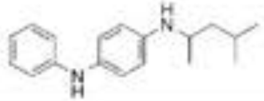
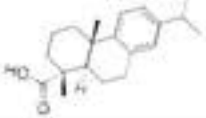
Additives Analysis of Tire Rubber by TD-GC/MS



Thermal desorption temp.: 100 - 320 °C (20 °C/min, 1 min hold), Sample amount: ca.0.2 mg, MS scan range: m/z 29 – 600, Split ratio: 1/20, GC oven: 40 °C (2 min hold) - 320 °C (20 °C/min, 14 min hold), Column flow rate: 1 mL/min, Separation column: Ultra ALLOY+-5 (5 % diphenyl-95 % dimethylpolysiloxane), L=30 m, i.d.=0.25 mm, df=0.25 μm

Mark	Chemical	Role	Structure
□	DCHA	Vulcanization accelerator	
◆	PLA	Fatty acids	
★	6PPD	Antiaging agent	
△	DHA	Nucleating agent	
●	Wax		C23 - C34

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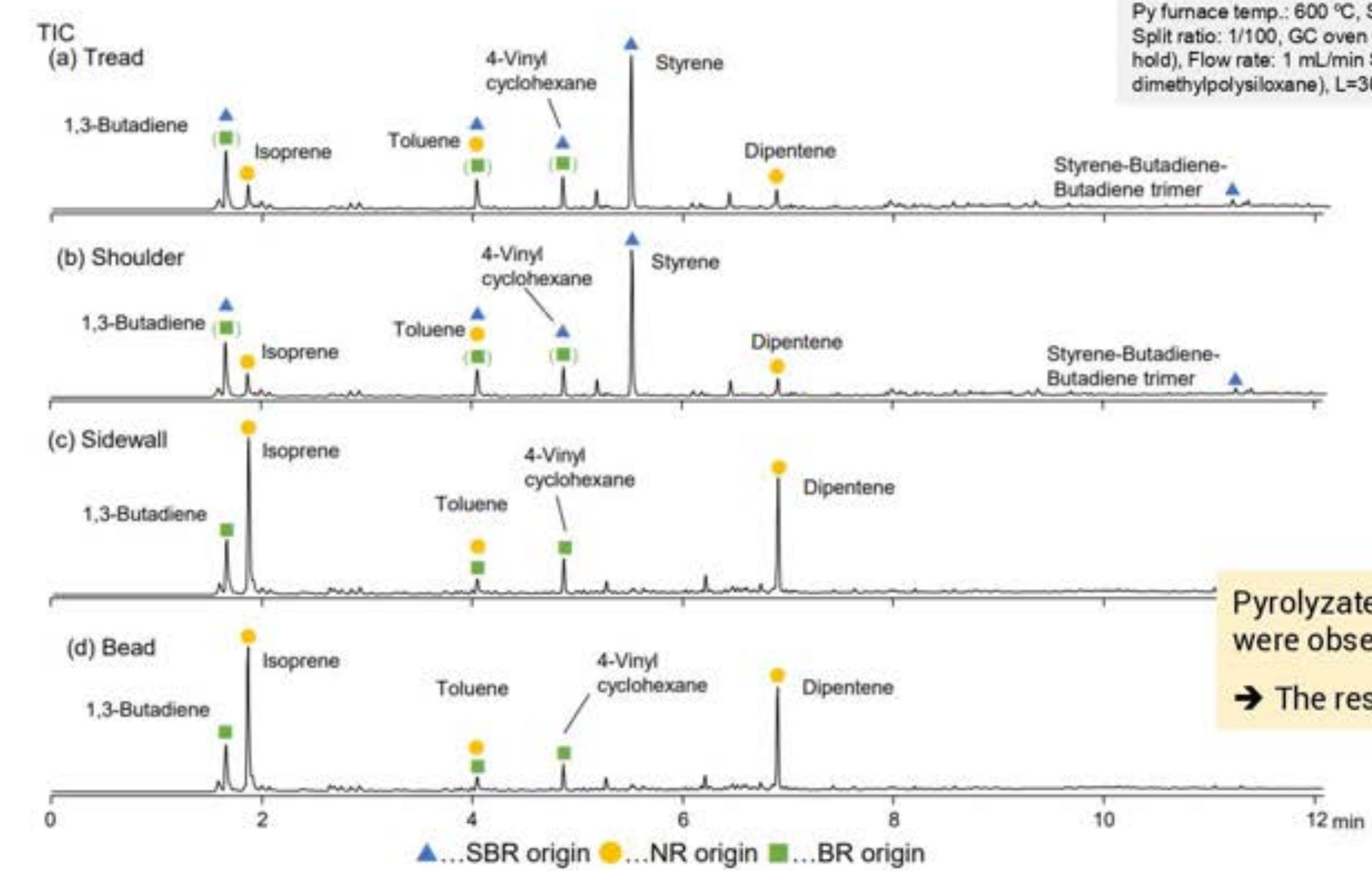
Pyrograms of Tire Rubber

Py furnace temp.: 600 °C, Sample amount: ca. 0.2 mg, MS scan rate: m/z 29 - 600 Split ratio: 1/100, GC oven temp.: 40 °C (2 min hold) - 320 °C (20 °C/min, 14 min hold), Flow rate: 1 mL/min Separation column: Ultra ALLOY+-5 (5 % diphenyl 95 % dimethylpolysiloxane), L=30 m, i.d.=0.25 mm, df=0.25 μm



Pyrolyzates derived from each of rubber parts were observed.

➔ The results agree with EGA results.

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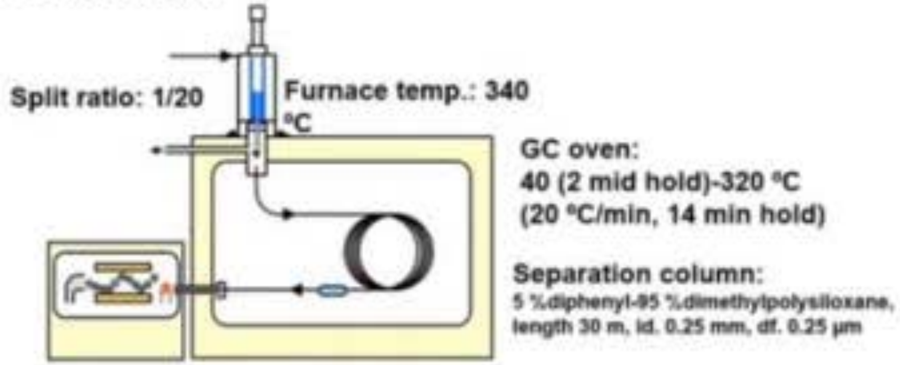
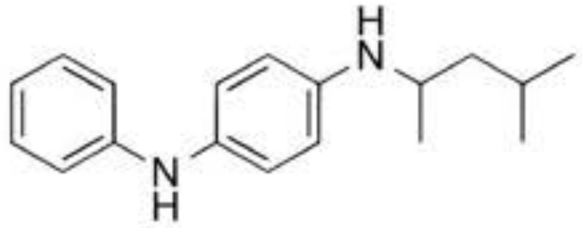
Quantitative Analysis of Additives in Tire Rubber

Target analyte: Anti-aging agent ★: *N*-phenyl-*N'*-(1,3-dimethylbutyl)-*p*-phenylenediamine (6PPD)

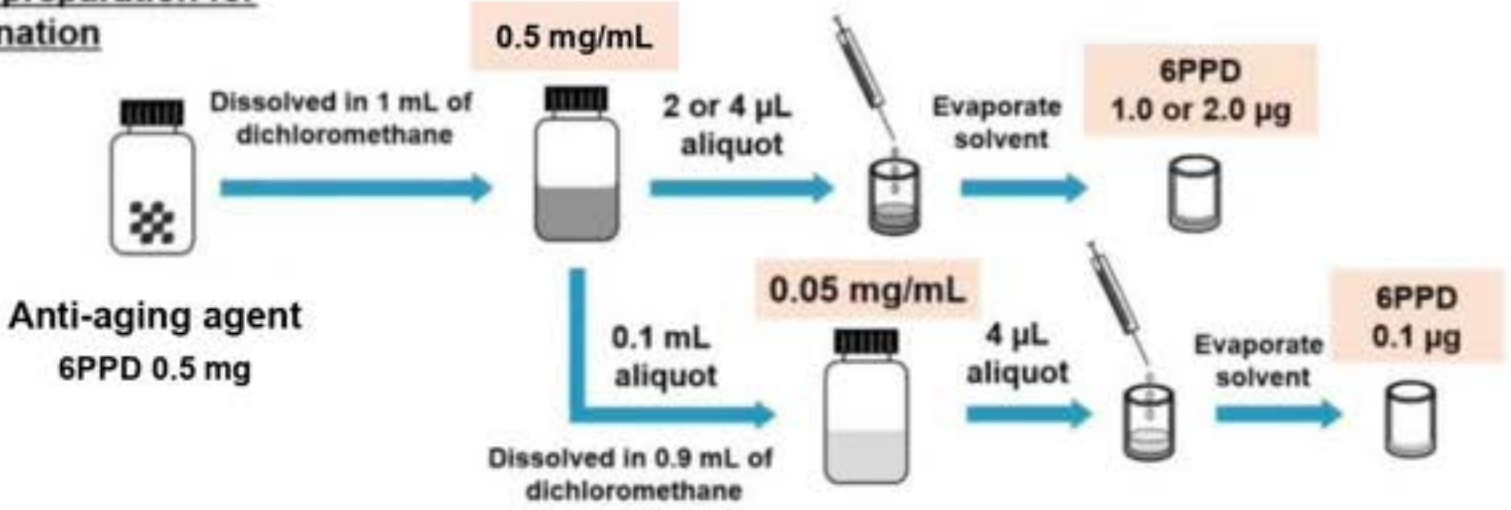
Analysis conditions



Molecular structure of 6PPD



Sample preparation for determination



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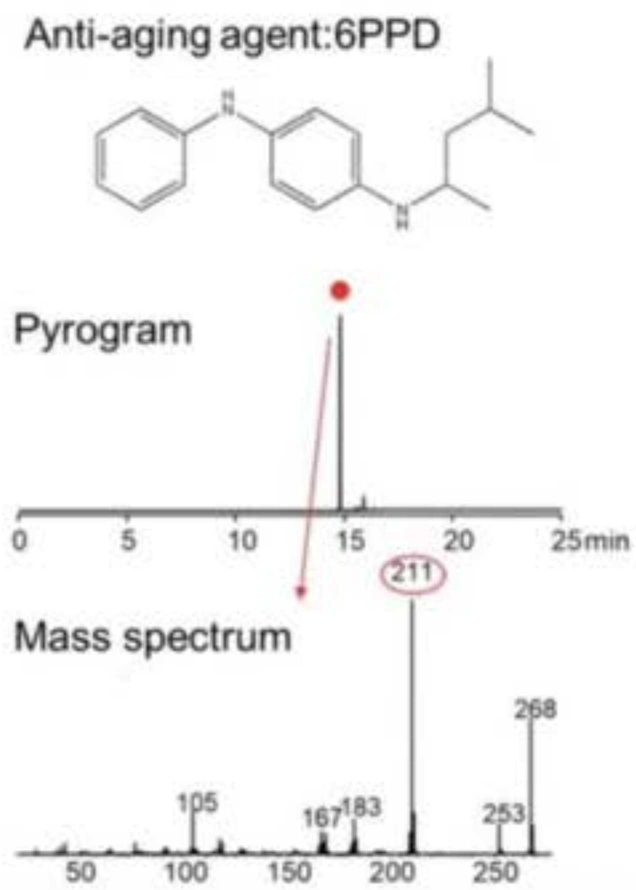
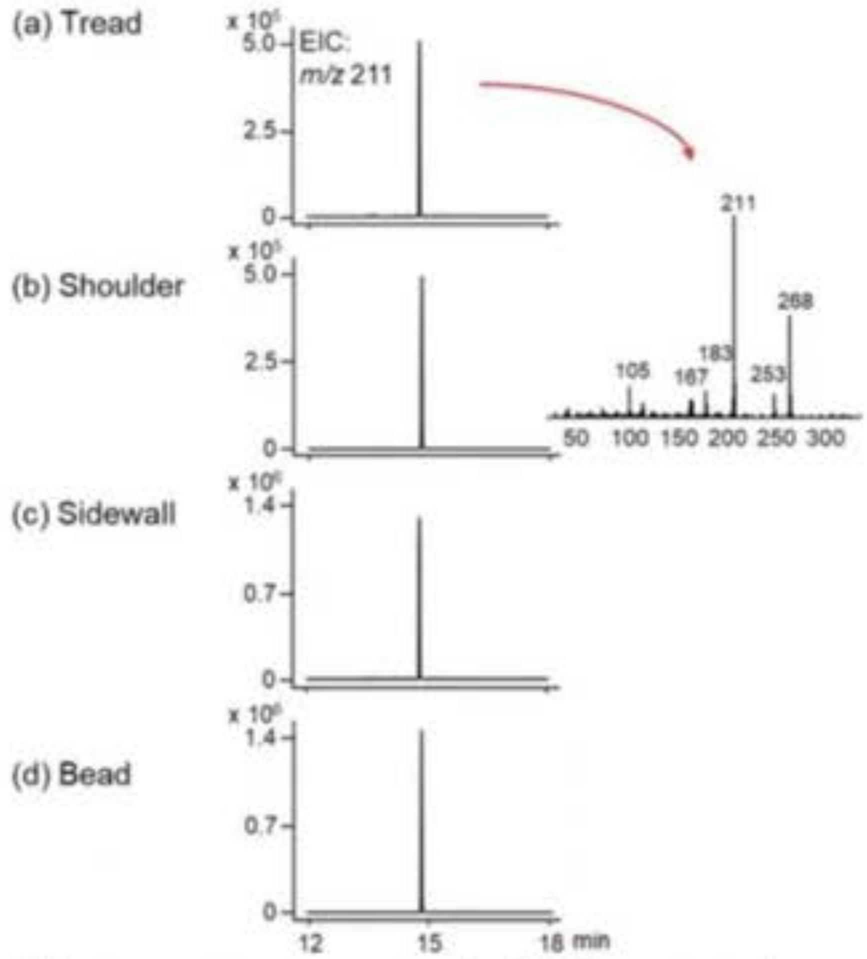
EIC of 6PPD in Tire Rubber



EICs with m/z 211 were obtained from TD chromatograms of tire rubber parts.



·The average areas were calculated by measuring three times each.

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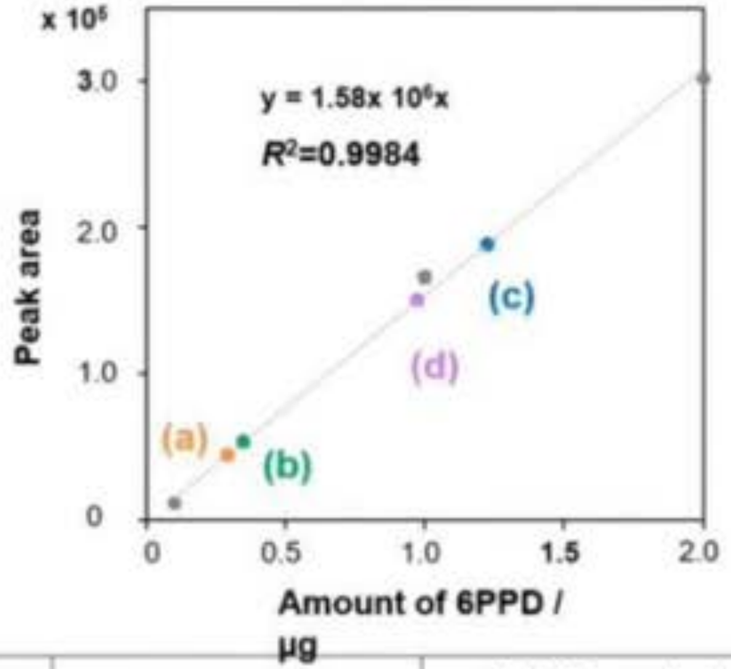
Quantitative Results and Reproducibility

Calibration Curve

6PPD [μg]	Average area (*n*=3)	RSD [%]
0.1	128,534	0.25
1.0	1,661,627	2.29
2.0	3,017,483	0.53



Samples

	Average area (*n*=3) (/0.2 mg of tire sample)	RSD [%]	6PPD [μg] (/0.2 mg of tire sample)	6PPD content [ppm]
(a) Tread	446,716	0.58	0.29	1,452
(b) Shoulder	536,792	4.75	0.35	1,744
(c) Sidewall	1,883,990	1.04	1.22	6,122
(d) Bead	1,498,021	1.51	0.97	4,868

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Summary

- Rubbers and additives were found to be different depending on parts of the tire.

	Rubber		Additive
Tread	SBR	NR	Vulcanization accelerator, fatty acid, anti-aging agent, and **nucleating agent**
Shoulder	SBR	NR	Vulcanization accelerator, fatty acid, anti-aging agent, and **nucleating agent**
Sidewall	BR	NR	Vulcanization accelerator, fatty acid, and anti-aging agent
Bead	BR	NR	Vulcanization accelerator, fatty acid, and anti-aging agent

- The amount of anti-aging agent (6PPD) was elucidated for each part of the tire.

Quantification result	6PPD content (ppm)
Tread	1,452
Shoulder	1,744
Sidewall	6,122
Bead	4,868

영인과학 2023 최신 분석기기 세미나

상반기 세미나 일정 (예정)

일 자	장 소	주 제	응 용
2023-02-23	On-line	Pyrolysis-GC/MS를 이용한 플라스틱 및 고무의 열분해 특성 연구	Plastic, Rubber
2023-03-30	On-line	자동차 내장재 및 타이어 분석을 위한 Py-GC/MS 활용 가이드	Automobile
2023-04-19	Off-line	대체 단백질 식품 향 분석을 위한 GERSTEL 전처리 솔루션	Food, Flavor
2023-04-19	Off-line	Py-GC/MS를 이용한 미세플라스틱 분석 솔루션	Microplastics
2023-04-20	Off-line	미량 수분 분석을 위한 새로운 GC 검출기 LUMA	Water, Pharma
2023-04-20	Off-line	바이오 이미징용 전자현미경(SEM) 소개	Biology
2023-05-25	On-line	탄소중립을 위한 그린 에너지, 수소 분석 토탈솔루션	Energy, Battery
2023-06-29	On-line	대기 악취 채취부터 GC/MS 분석까지! Entech 대기 분석 토탈 솔루션	Ambient Air, VOCs

ICPI WEEK 2023

2023 KOREA LAB

제17회 국제연구·실험 및 첨단분석장비전

2023.4.18 화 ~ 21 금

KINTEX 1

영인과학 전시 품목

- **GERSTEL** 다목적 시료 전처리 시스템(DHS, SPME, TDU, ODP(관능 검출기) 외)
- **AC** 황 검출기
- **Frontier Lab** 미세플라스틱 전처리 솔루션(동결 시료 분쇄기, MP 여과 시스템 외)
- **Entech Instruments** 대기/악취 분석 솔루션(캐니스터, 캐니스터 오토 샘플러 외)
- **VUV Analytics** GC용 UV 검출기(VGA, LUMA)
- **모듈싸이** 주사 전자 현미경(SEM)

영인과학 신제품·우수제품 소개 세미나

4/19. WED. 11:00 AM	대체 단백질 식품향 분석을 위한 GERSTEL 전처리 솔루션
4/19. WED. 15:00 PM	Py-GC/MS를 이용한 미세플라스틱 분석 솔루션
4/20, THU. 14:00 PM	미량 수분 분석을 위한 새로운 GC 검출기 LUMA
4/20. THU. 15:00 PM	바이오 이미징용 전자현미경(SEM) 소개

최신 첨단분석솔루션을 직접 체험하세요!

영인과학 솔루션 분석 기기실

열분해 질량 분석기

다목적 시료 전처리 자동화 시스템

황 화학발광 검출기 (SCD)

GC-VUV 검출기

대기/악취 분석 자동화 시스템

휴대용 질량 분석기

주사 전자 현미경 (SEM)

데모체험 신청서

THANK YOU

Q & A

파이롤라이저 관련 문의
마케팅팀 이 혜 민 과장
02-519-7494, hyemin@youngin.com

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Scientific