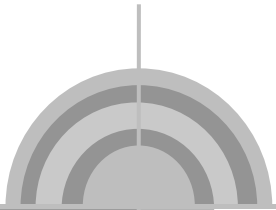


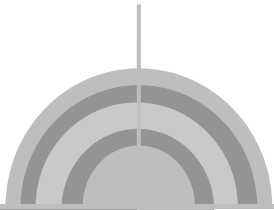
환경중 신규 오염물질과 분석동향

경기대학교 화학과
미량분석연구실(Trace Analysis Lab)
명 승 운



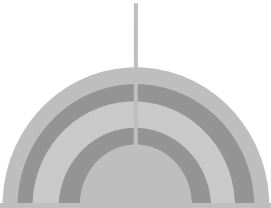
차례

- ☒ 서론
- ☒ 시료전처리
- ☒ 질량분석법
- ☒ 오염물질별 동향



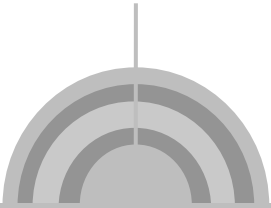
서론

- ☑ 질량분석기에 의한 검출 동향
- ☑ 샘플링과 추출 동향
- ☑ 크로마토그래피 동향
- ☑ Online 분석
- ☑ 검출한계
- ☑ 신규 오염물질



질량분석기에 의한 검출 동향-1

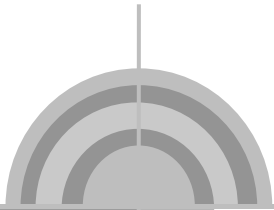
- ☑ **Time-of-flight (TOF)-mass spectrometry (MS) & quadrupole (Q)-TOF-MS**
 - 고분해능 10,000 – 12,000
 - 구조 유추와 화합물 확인
 - 의약품질, 내분비계장애물질(EDCs), 농약분해산물
 - 환경 중 변형 생성물과 구조 확인 : Q-TOF 또는 다른 고분해능 MS 사용



질량분석기에 의한 검출 동향-2

☑ Liquid chromatography (LC)/electrospray ionization (ESI) & Atmospheric pressure chemical ionization (APCI) – MS

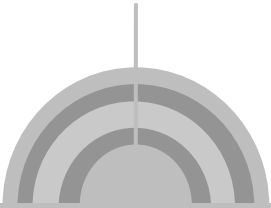
- 새로운 오염물질 분석법 개발
- MS/MS에서 Multiple reaction monitoring (MRM) 이용한 정량분석
- Chemical background를 줄임으로써 선택성, 감도 향상
- ppt (ng/L) 농도까지 유도체화 반응없이 극성 유기 오염물질 분석
- 동위원소 표준물질(deuterated 혹은 ^{13}C -labeled)을 사용한 다양한 시료 매트릭스 (폐수, 생물학적 시료)에서 정확한 정량분석



질량분석기에 의한 검출 동향-3

☑ LC / Atmospheric pressure photoionization (APPI) – MS

- 나노물질 (예, fullerenes), polybrominated diphenyl ether (PBDEs) 등 비극성화합물 분석을 위한 이온화 방법



샘플링과 추출 동향

☑ Stir bar sorptive extraction

- UV 차단제, polybrominated diphenyl ethers (PBDEs)
- Sorbent-coated stir bar 사용하여 추출 → GC/MS에 주입하여 열탈착 후 분석

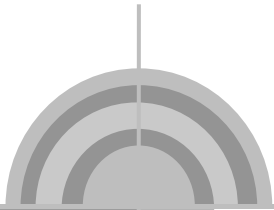
☑ Hollow-fiber microextraction

- 브롬화 난연제
- SPME와 유사
- 비극성 추출 용매가 포함된 syringe 끝에 polypropylene hollow fiber가 부착됨

☑ SPME

☑ Oasis HLB (hydrophilic-lipophilic balance) 고체상 추출

- 극성이 큰 화합물 추출 (특별히, 의약품질)



크로마토그래피 동향

☑ **Ultraperformance liquid chromatography (UPLC)**

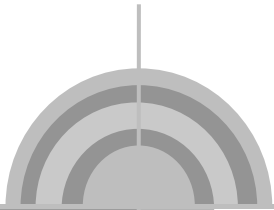
- 작은 입자($1.7\mu\text{m}$), 짧은 컬럼 $\rightarrow$ 고압 $\rightarrow$ narrow peak (5-10 s)
- Narrow peak, 향상된 크로마토그래피 분리, 짧은 분석시간 (10분 이내)

☑ **이차원 GC (GC $\times$ GC)**

- 복잡합 혼합물 분리능 향상, 동일 계열 화합물의 확인 유리
- TOF-MS 결합

☑ **Hydrophilic interaction chromatography (HILIC)**

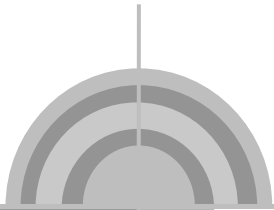
- 극성이 큰 화합물의 향상된 분리 및 검출
- Amino 기와 같은 극성 말단기를 가진 컬럼 $\rightarrow$ 컬럼의 하전된 극성 말단기와 극성 분석물질간의 친화도를 바탕으로 머무름이 생성됨



On-line 분석

☒ **On-line SPE-LC/MS/MS**

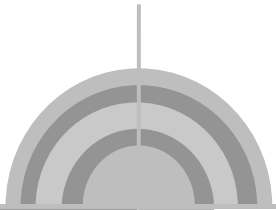
- 빠른 screening, 정밀도 향상



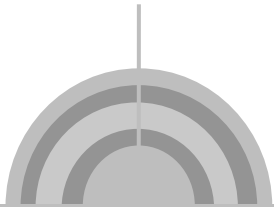
검출한계

☑ $\mu\text{g/L} \rightarrow \text{ng/L} \rightarrow \text{pg/L}$

- 분석기기와 추출기법의 향상
- 낮은 검출한계 : 화합물의 변형(transformation) 연구에 유리



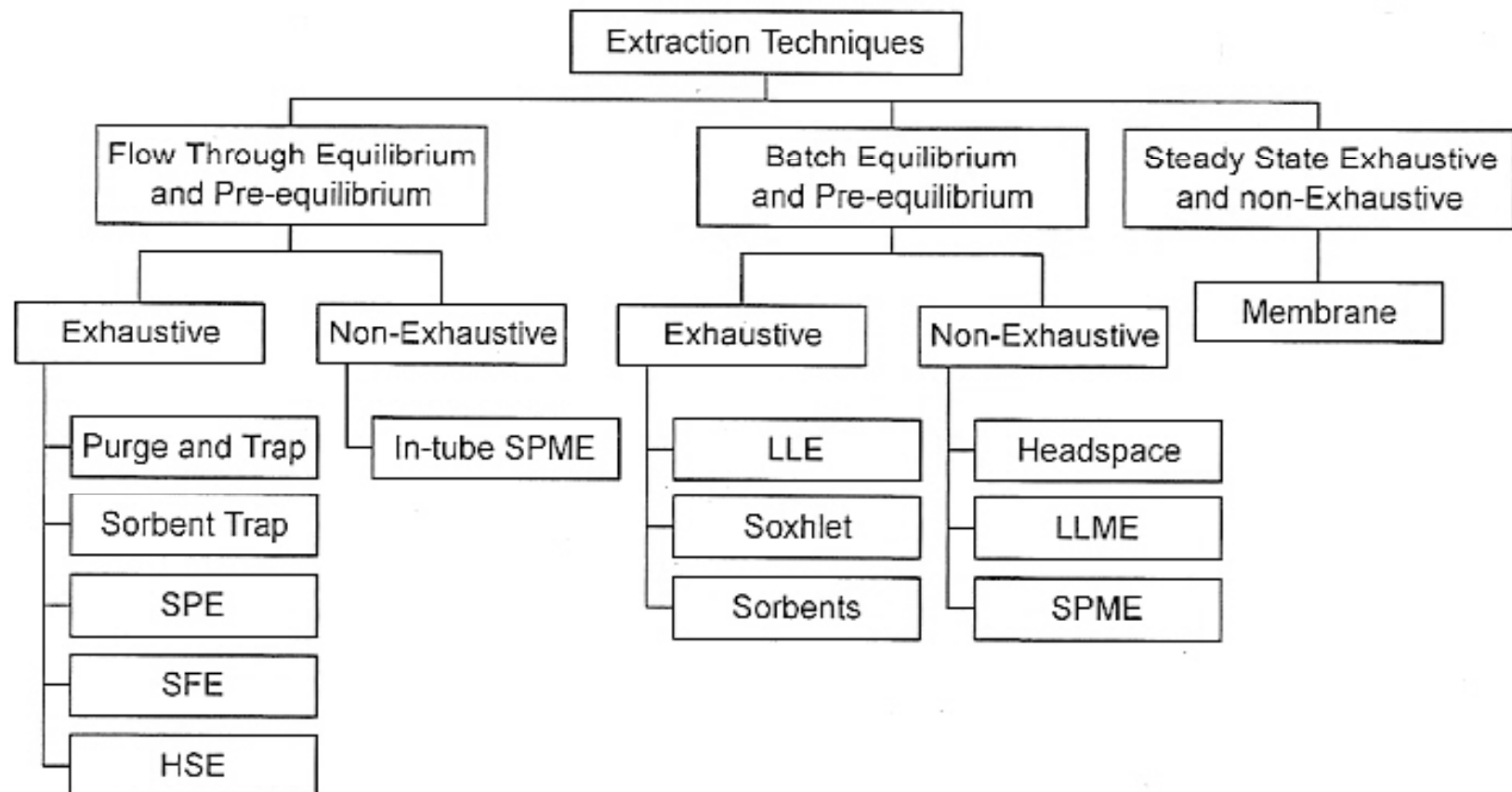
시료 전처리



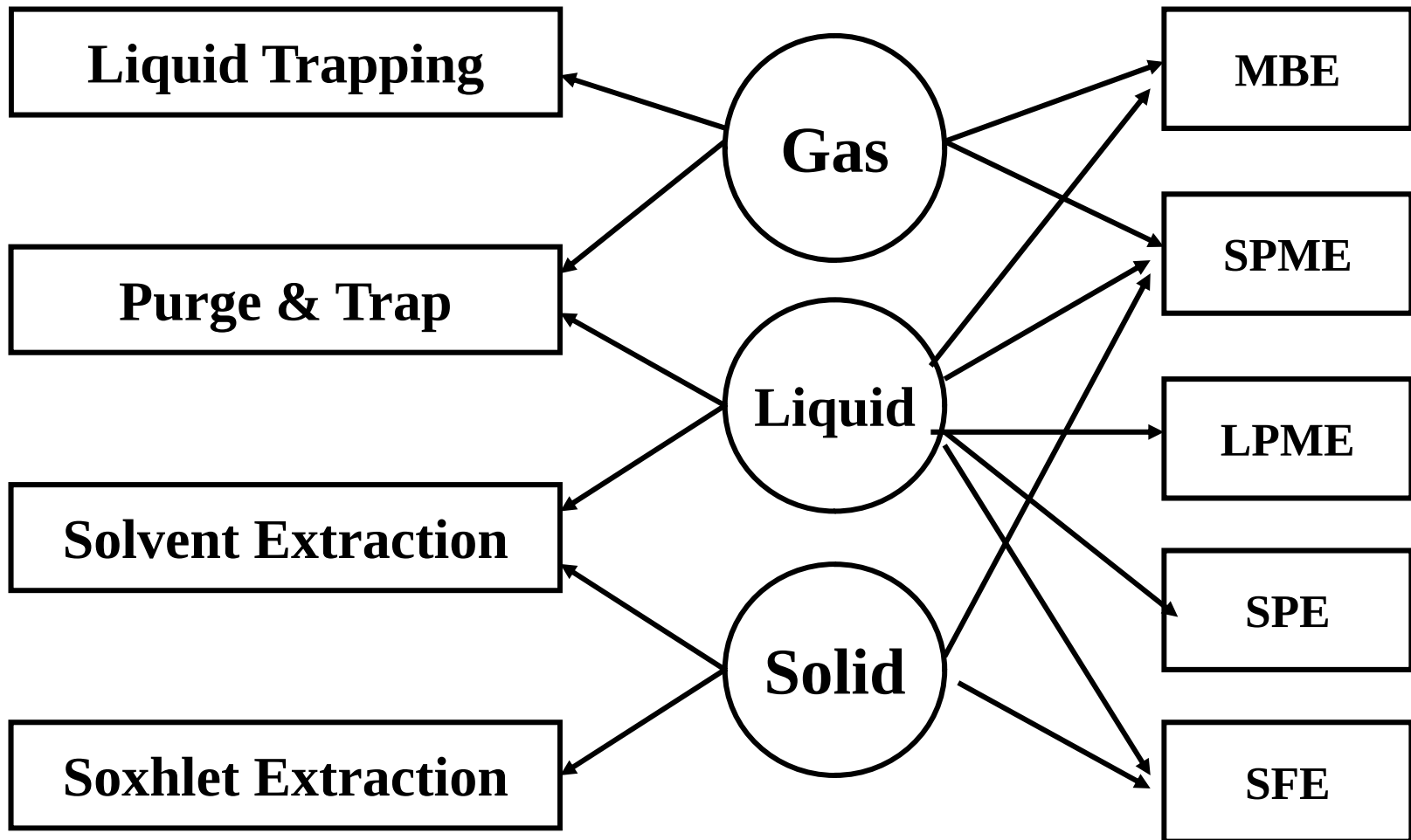
시료전처리와 기기분석

Analytes	Sample Preparation	Instrument
Organics	Extraction, concentration, clean-up, derivatization	GC, HPLC, GC/MS, LC/MS
Volatile organics	Transfer to vapor phase, concentration	GC, GC/MS
Metals	Extraction, concentration, speciation	AA, GFAA, ICP, ICP/MS
Metals	Extraction, derivatization, concentration, speciation	UV-Vis, IC
Ions	Extraction, concentration, derivatization	IC, UV-Vis
DNA/RNA	Cell lysis, extraction, PCR	Electrophoresis, UV-Vis, florescence
Amino acids, fats, carbohydrates	Extraction, Clean-up	GC, HPLC, Electrophoresis

General Classification of Extraction Techniques



추출방법



Solid Phase Microextraction (SPME)

Equilibrium partitioning of analytes between the fiber and the headspace of sample bottle.

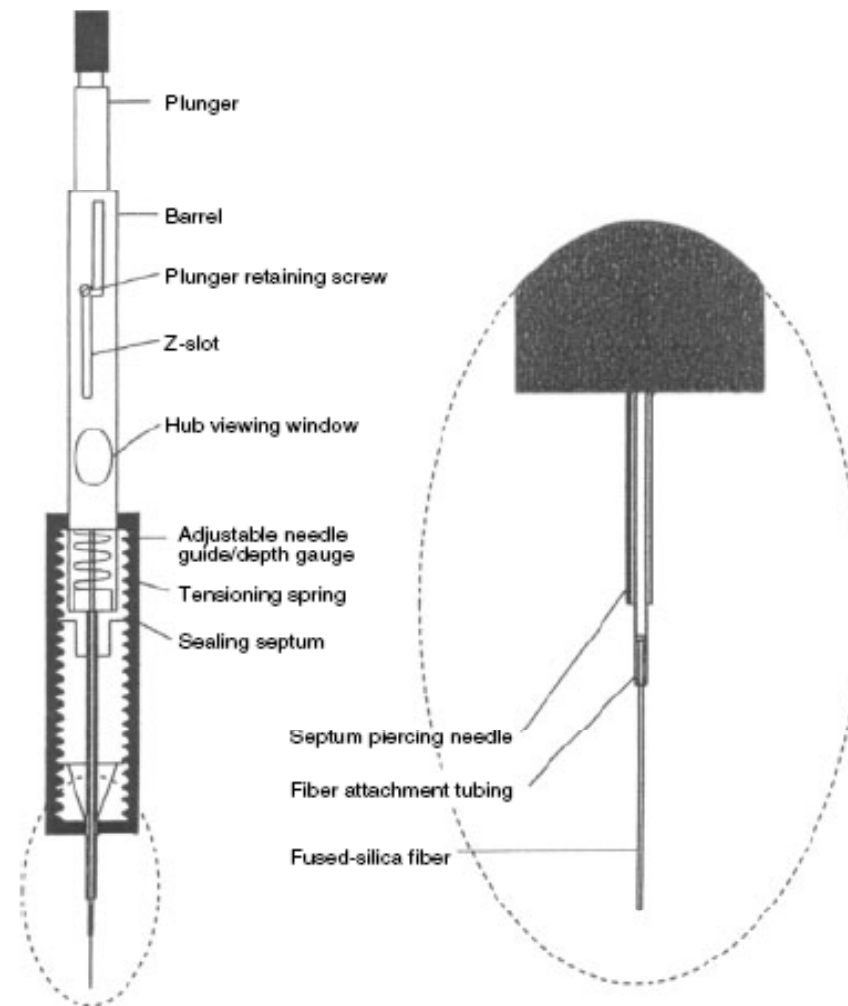
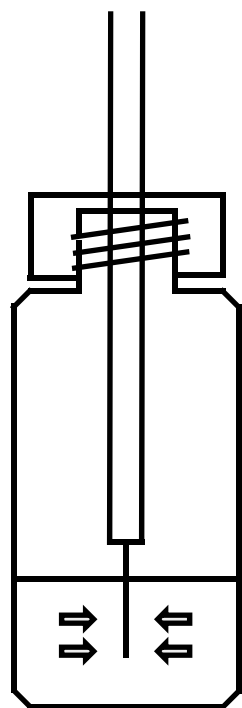
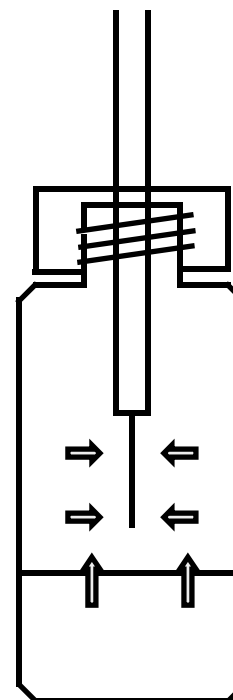


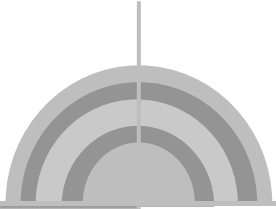
Diagram of Solid Phase Micro Extraction



Direct sampling SPME

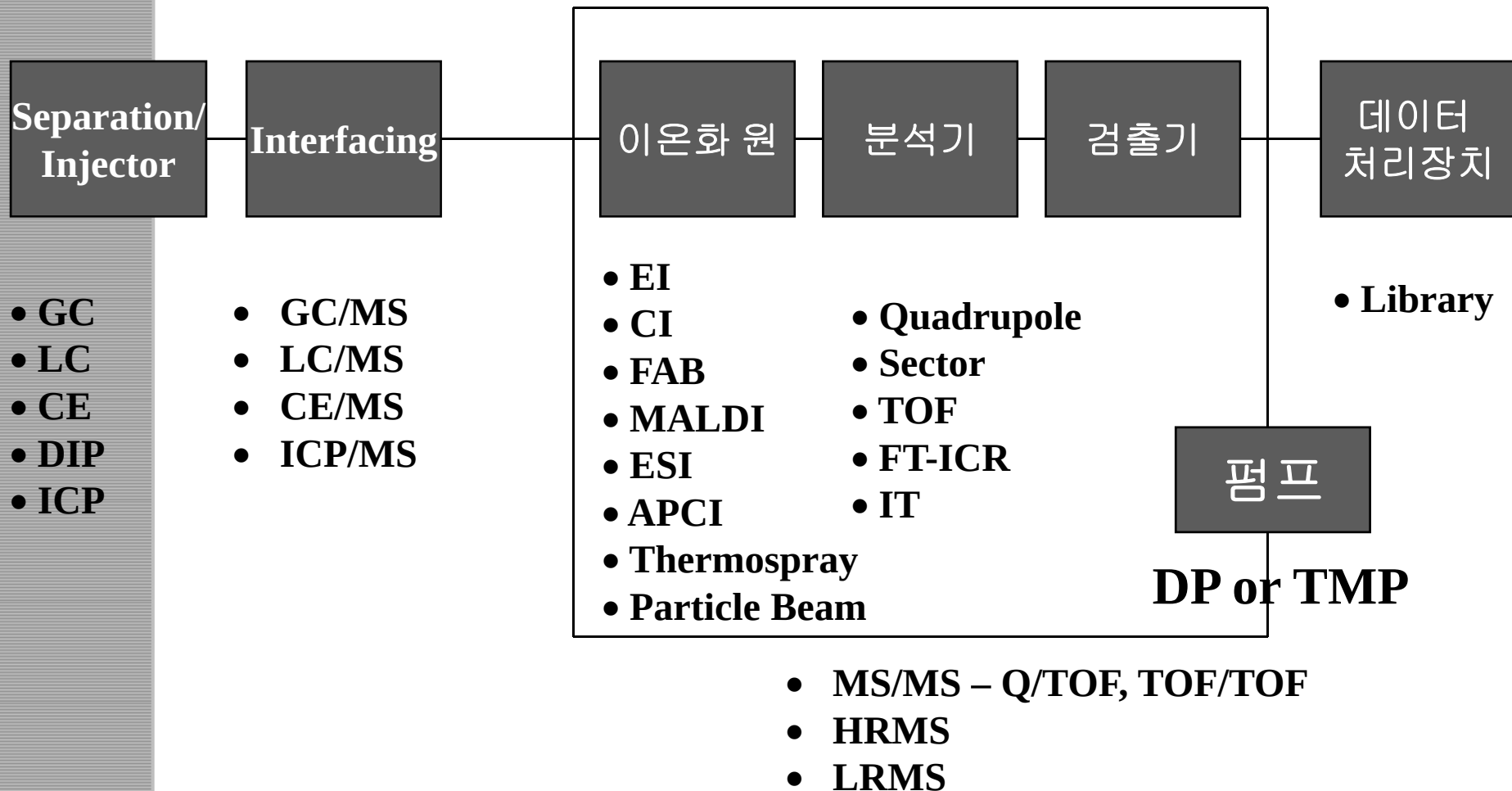


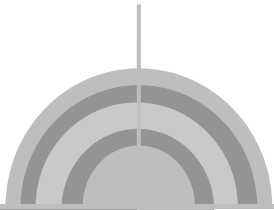
Headspace SPME



질량분석법

질량 분석계의 구성





질량분석기의 분류

이온화 방법

- ✓ EI (electron impact)
- ✓ CI (chemical ionization)
- ✓ FAB (fast atom bombardment)
- ✓ TSP (thermospray)
- ✓ MALDI (matrix assisted laser desorption ionization)
- ✓ ESI (electrospray ionization)
- ✓ APCI (atmospheric pressure chemical ionization)

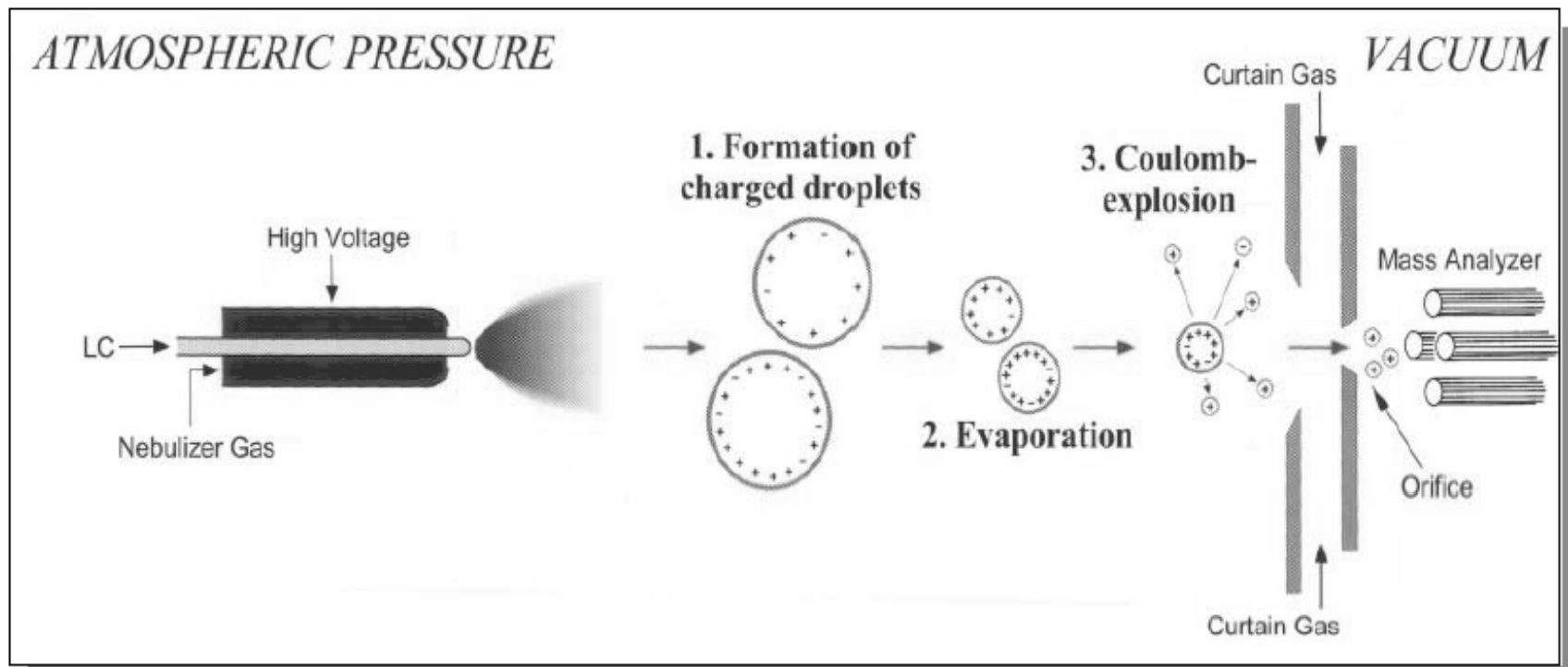
분리능

- ✓ HRMS (high resolution mass spectrometry)
- ✓ LRMS (low resolution mass spectrometry)

연결장치

- ✓ GC/MS
- ✓ LC/MS
- ✓ CE/MS
- ✓ ICP/MS (induced coupled plasma /mass spectrometry)

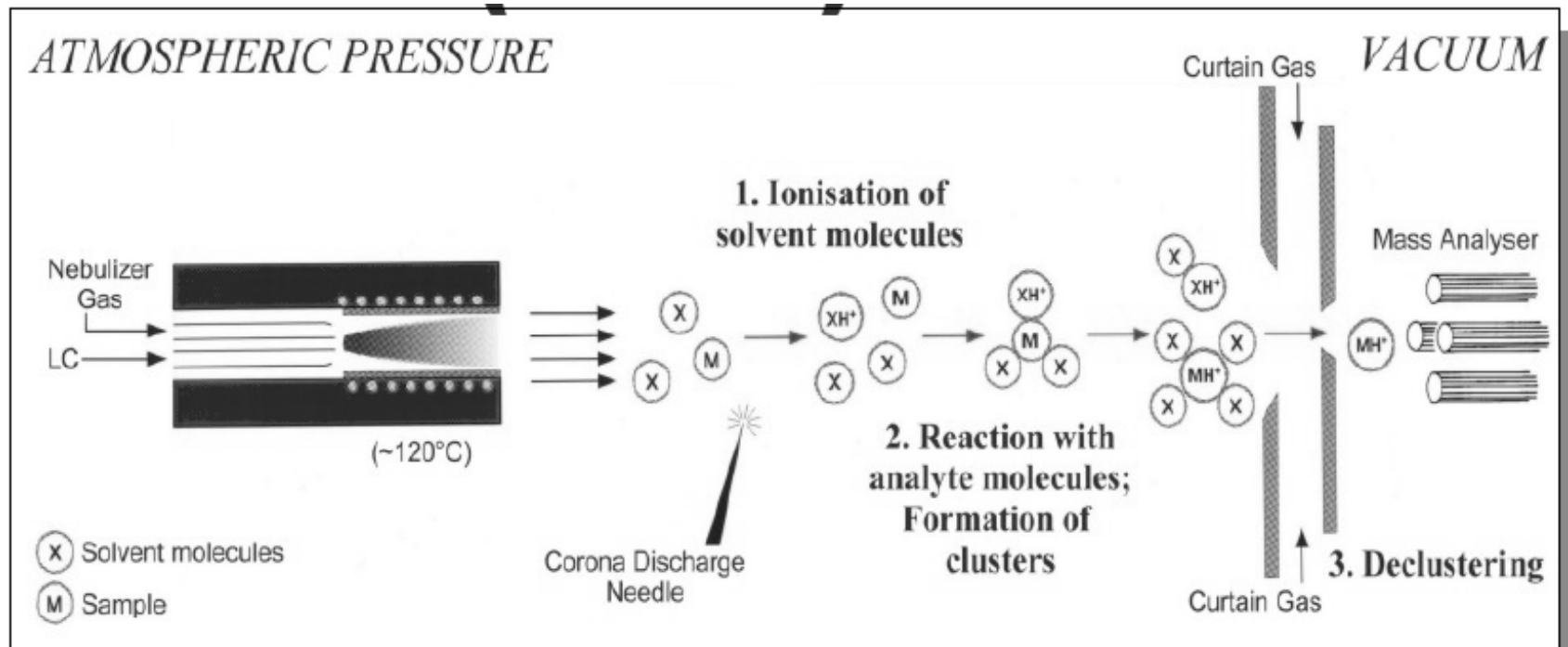
Electrospray Ionization (ESI)



-High Voltage (3-6kV) : Induce Charge Accumulation at the liquid surface

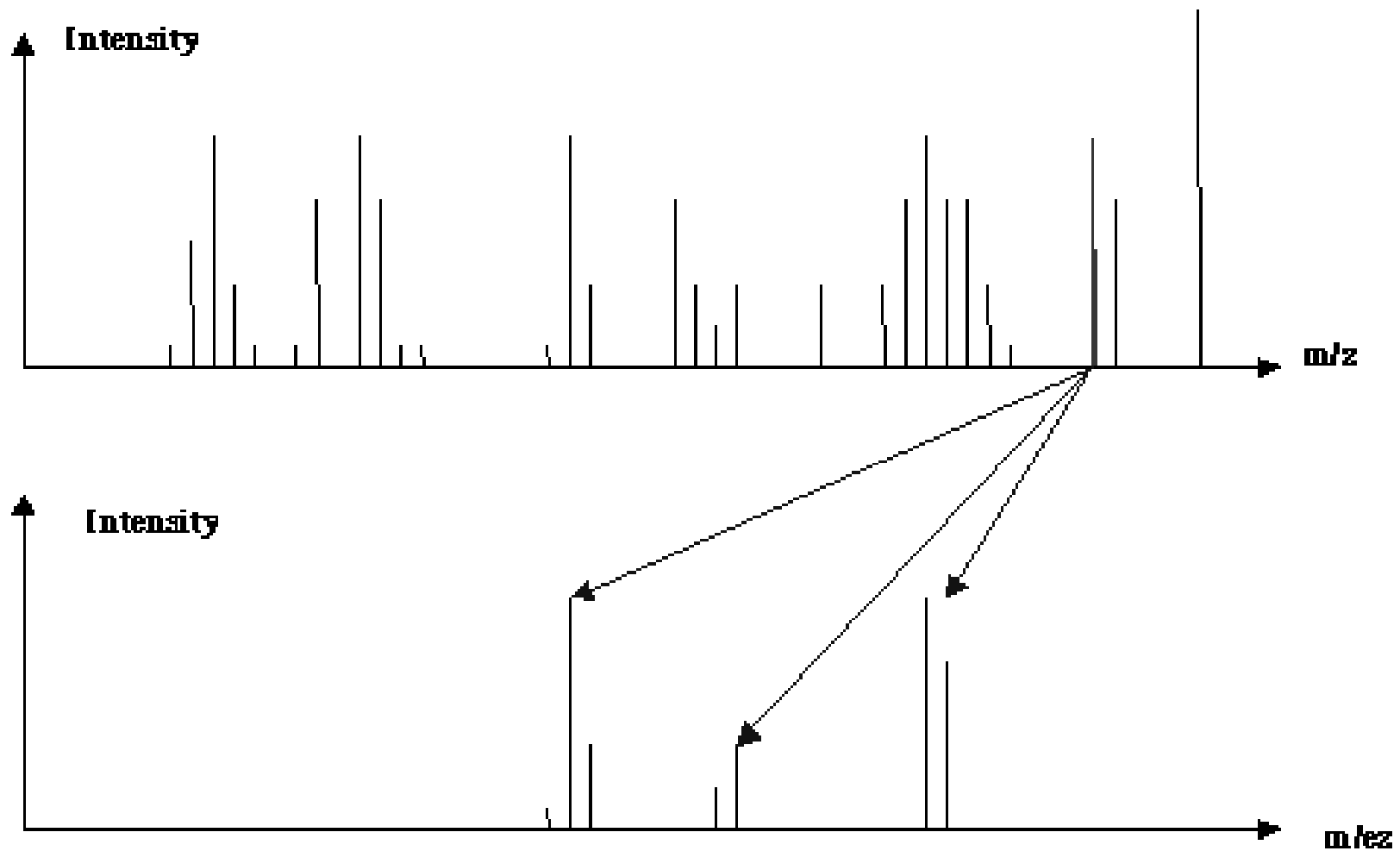
- LC/MS에서 가장 일반적인 이온화방법
- 극성이 있으며 이온화가 쉬운 화합물에 적합

APCI



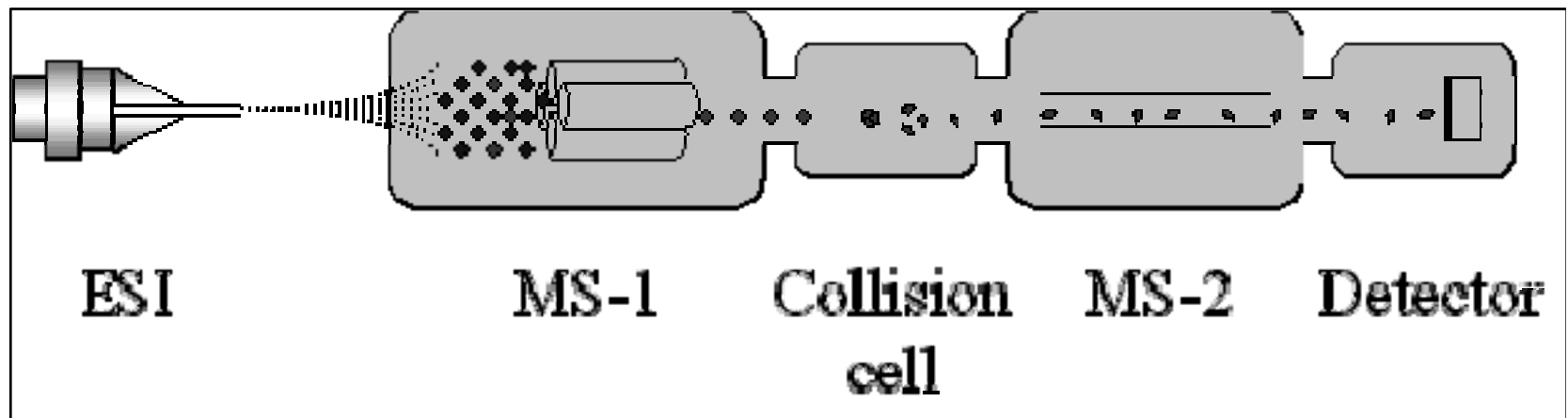
- 코로나 방전
- 열적으로 안정한 화합물에 적합

Tandem Mass Spectrometry (MS/MS)



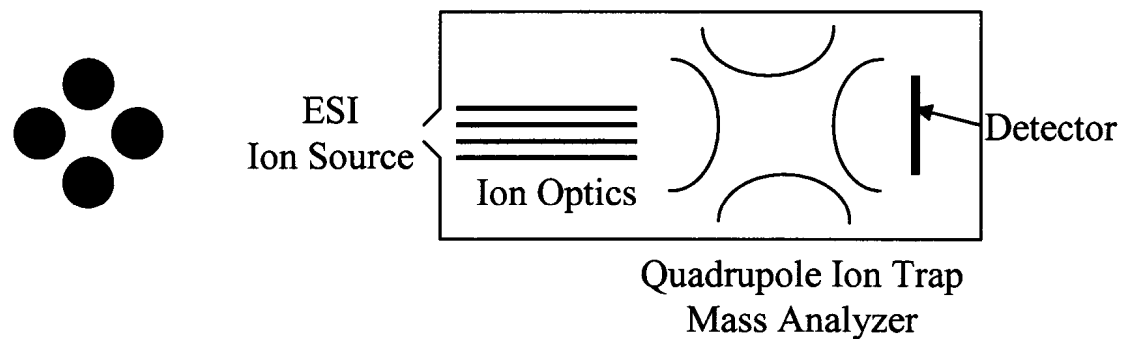
Tandem Mass Spectrometry (MS/MS)

- ✓ **Full scan** 스펙트럼에서 특정 이온을 선택 후 토막화
 - ✓ quadrupole - quadrupole
 - ✓ magnetic sector - quadrupole
 - ✓ magnetic sector - magnetic sector
 - ✓ quadrupole - time-of-flight (Q-TOF)
 - ✓ Ion trap
 - ✓ Ion Cyclotron Resonance (ICR)

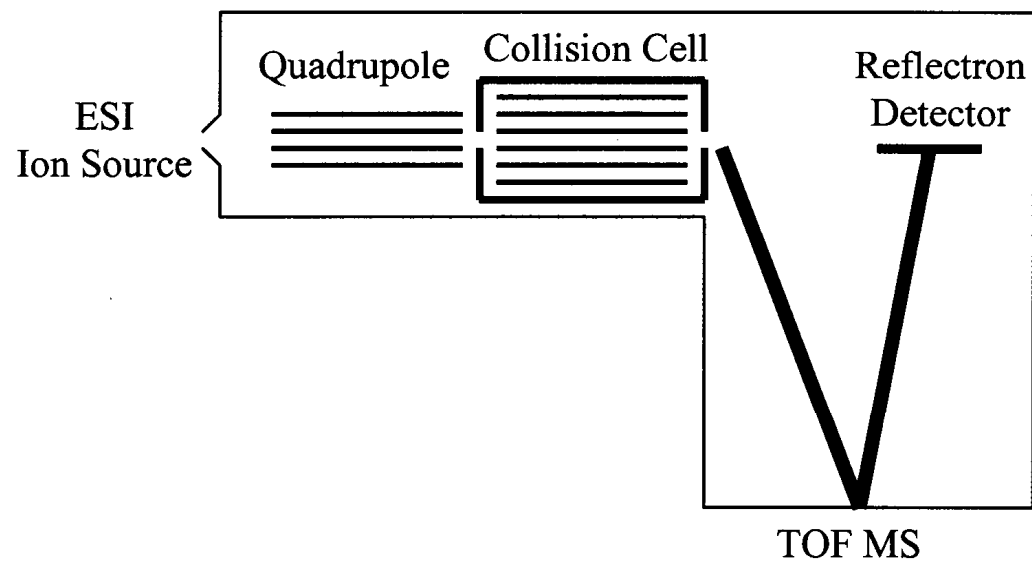


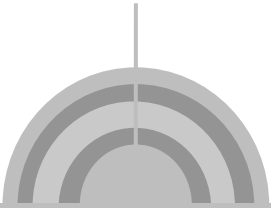
Tandem “in Time” or “in Space”

ESI - ION TRAP (“MS/MS” in Time)



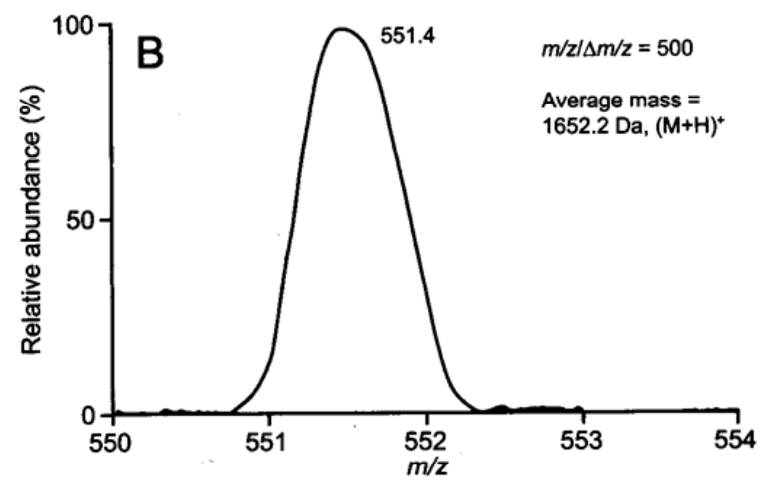
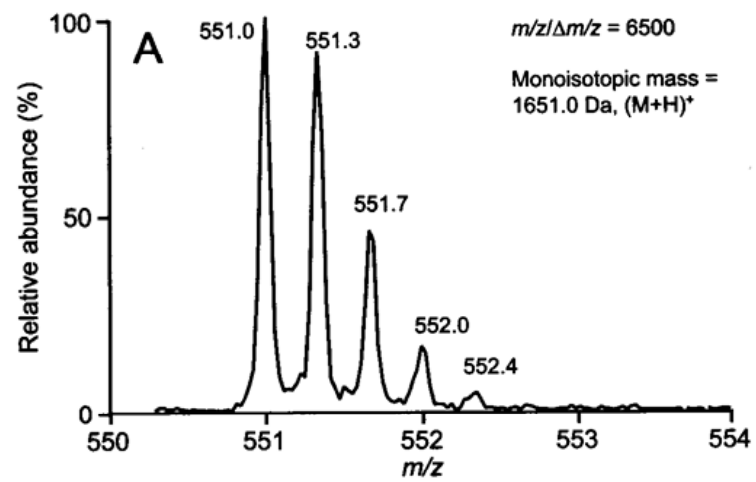
ESI - QTOF (“MS/MS” in Space)

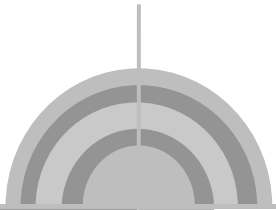




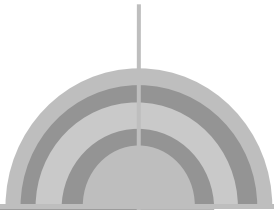
분해능 (Resolution)

- **Resolution = $m / \Delta m$**
- **Low resolution: 100 - 1,000 ; Medium resolution: 2,000 - 10,000 ; High resolution: >10,000**
- **C_5H_7O : nominal mass=83, exact mass = 83.0495**
- **C_6H_{11} : nominal mass = 83, exact mass = 83.0858**
- **$\Delta m = 83.0858 - 83.0495 = 0.0363$**
- **resolution = $83.0858 / 0.0363 = 2288$**
- **100; 100 - 101**
- **1000; 100.0 - 100.1**
- **10000; 100.00 - 100.01**



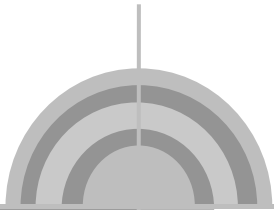


오염물질 동향



신규 오염물질

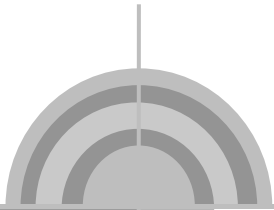
- 나노물질
- PFOA/PFOS 및 perfluorinated 화합물
- 의약품, 호르몬, 내분비계장애 물질
- 소독부산물
- 햇빛차단제/자외선 차단제
- 브롬화 난연제
- Benzotrazoles
- Dioxane
- Naphtenic acids
- Chiral contaminants
- 조류독소
- 퍼클로레이트
- 농약 분해산물과 새로운 농약
- 비소 화합물
- Sucralose
- 안티몬 화합물
- Siloxanes
- 사향(Musks)
- Melamine-Cyanuric acid



나노물질-1

☑ 나노물질 ?

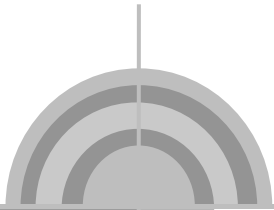
- 용도: 화장품, 햇빛차단제, 의류, 페인트, 자동차 타이어, 라켓, 윤활제, 전자부품, 비누, 샴푸, 세제 등
- 기업, 공공연구기관, 대학 등에서 연구활발 및 영역확장
- 환경오염물질로 대두
- 1-100 nm 크기, 높은 강도, 열적인 안정성, 저 침투성, 고 전도도
- Chemotherapy, 약물전달, 식품 병원체의 식별(“nanobarcodes”)



나노물질-2

☑ 종류

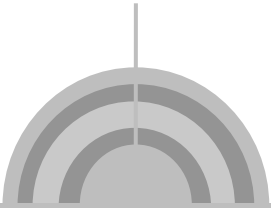
- Fullerenes, Functionalized fullerenes
- Quantum dots
- Metal oxanes
- TiO_2 나노입자
- Zerovalent iron particles



나노물질-3

☑ 분석방법

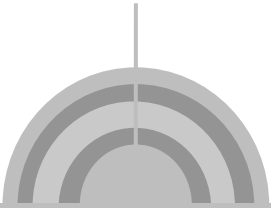
- LC/ESI-(-)-MS : fullerenes ($C_{60} - C_{98}$)
 - 검출한계 : $0.02 \mu\text{g/L}$
- LC/APPI-(-)-MS : C_{60} , C_{70}



PFOA/PFOS 와 Perfluorinated Compounds-1

☑ PFOA/PFOS ?

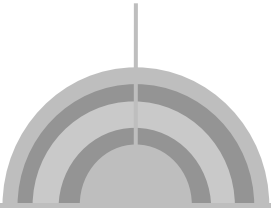
- 용도: 카펫과 직물류의 얼룩 방지제, 페인트, 접착제, 왁스, 광택제, 금속, 전자제품, 식품포장(유탄유 저항 코팅)
- Perfluorinated compounds (PFCs) : fluotelomer acids, alcohols, and sulfonates
- 친수성, 소수성 성질을 가짐
- 강력한 C-F 결합, 환경 중에서 매우 안정
- PFCs의 대표 물질 : perfluorooctane sulfonate (PFOS) 와 perfluorooctanoic acid (PFOA)



PFOA/PFOS & Perfluorinated Compounds-2

종류

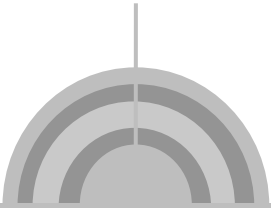
- Perfluorinated compounds (PFCs) : fluotelomer acids, alcohols, and sulfonates
- perfluorooctane sulfonate (PFOS) , perfluorooctanoic acid (PFOA)
- perfluorohexanesulfonate (PFHS), perfluorooctane sulfonamide (PFOSA)
- 2-(Nethylperfluorooctane sulfonamide) acetic acid
- 2-(N-methylperfluorooctane sulfonamide) acetic acid
- Perfluorononanoic acid (PFNA)



PFOA/PFOS 와 Perfluorinated Compounds-3

☑ 분석방법

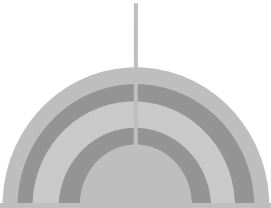
- PFOA, PFOS와 더불어 long-chain perfluorinated acid & alcohols로 관심이 확대
- LC/MS, LC/MS/MS 보편적; LC system (fluoropolymer 코팅된 seal 등)에 의한 오염이 존재
- GC/MS, GC/MS/MS가 대신 사용되기도 함
- 대상 매트릭스: 하천수, 빗물, 먹는물, 식품 등



PFOA/PFOS 와 Perfluorinated Compounds-4

☑ 검출

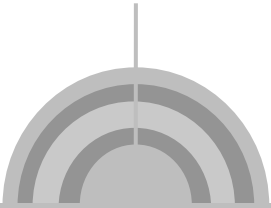
- Serum: PFOS (33.1 $\mu\text{g/L}$), PFOA(15.1 $\mu\text{g/L}$), 검출한계 : tissue (0.3 – 13.6 ng/g)
- 먹는물 : PFOA (3640 ng/L), perfluorohexanoic acid (PFHA) (247 ng/L), PFOS (193 ng/L), perfluoroheptanoic acid (PFHpA) (148 ng/L), perfluoropentanoic acid (93 ng/L)
- 식품 : N-ethylperfluorooctane sulfonamide (N-EtPFOSA), PFOSA, N,N-diethylperfluorooctane sulfonamide, N-methylperfluorooctane sulfonamide, N,N-dimethylperfluorooctane sulfonamide.



PFOA/PFOS 와 Perfluorinated Compounds-6

☑ 검출

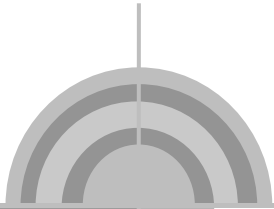
- 강물 : PFOS (99 ng/L), PFOA (260 ng/L), 미량의 PFBS, PFHS, PFOSA, PFHA, PFHpA, PFNA, PFDA, and PFUn-DA 검출
- 공기 : GC/MS에 의한 PFOHs, N-alkylated fluoroctane sulfonamides (FOSAs), sulfonamidoethanols (FOSEs). 최대 190 pg/m³.



의약품질, 호르몬, EDCs-1

☑ 의약품질, 호르몬, EDCs ?

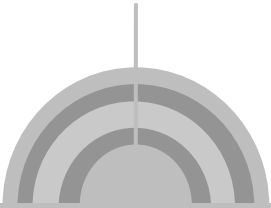
- 중요한 신규 오염물질
- 물에 존재하기 때문에 먹는물 원수를 오염시키며, 야생생물과 인간에게 estrogenic 효과 등을 나타낼 가능성
- 인간 뿐만 아니라 가축, 야금, 물고기 등에 사용되는 동물용 의약품
- 극성이 큰 화합물



의약품질, 호르몬, EDCs-2

☑ 종류

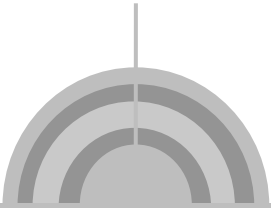
- 진통제, 항생제, 당뇨치료제, 베타-차단제, 피임약, 지질 조절제, 우울증 치료제, 발기부전 치료제 등 3,000 종
- 환경 중에서 관심대상은 약 150 종



의약품질, 호르몬, EDCs-2

☑ 분석방법

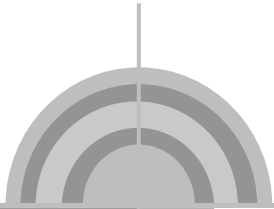
- LC/MS(/MS) : ESI (electrospray), APCI (atmospheric pressure chemical)
 - MRM (multiple reaction monitoring)
- 유도체화 후 GC/MS(/MS)
- Q-TOF-MS
- HLB cartridge 사용하여 추출
- UPLC/MS/MS : 짧은 분석시간



의약품질, 호르몬, EDCs-4

☑ 검출

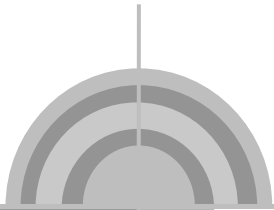
- 먹는물 : 의약품질의 대사체, 분해산물 규명을 위해 MS/MS 이용
 - opioids, tranquilizers, antiepileptics, cocaine metabolite benzoylecgonine, antidepressant doxepin, calcium channel blocker verapamil. (ng/L)
- 하천수 : 50-170 pg/L
- 폐수 : 0.3-11 ng/L



소독부산물-1

☑ 소독부산물 ?

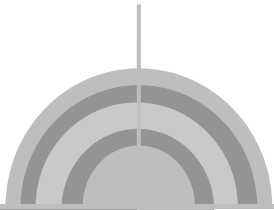
- 소독부산물 : DBP (disinfection byproducts)
- 먹는물과 수영장에서 DBP
- 먹는물 : chloramines, ozone과 같은 소독제의 사용에 의한 생성
- 수영장: 호흡, 수영 또는 샤워시 피부흡수



소독부산물-2

☑ 종류

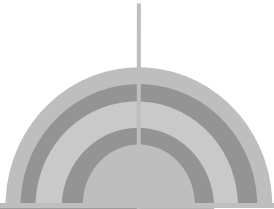
- Brominated DBP, Iodinated DBP, Nitrogen-containing DBP (“N-DBP”)
- Brominated DBP & Iodinated DBP : Iodinated DBP는 chlorination에 의해 생성 증가, Brominated DBP는 preozonation에 의해 증가
 - iodo acids, bromonitromethanes, iodo trihalomethanes (THMs), brominated forms of MX, haloaldehydes, haloamides.
- N-DBP : chloramination 혹은 chlorination에 의해 생성됨
 - NDMA(nitrosodimethylamine), N-nitrosodiethylamine, N-nitrosodipropylamine, N-nitrosodiphenylamine, N-nitrosopyrrolidine



소독부산물-3

☑ 분석방법

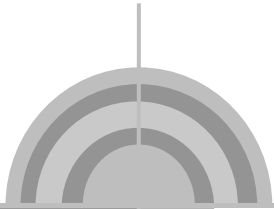
- Haloamides : GC/MS에 의해 bromoiodoacetamide 검출
- Nitrosamines: NDMA (ng/L 검출), N-nitrosodiethylamine, N-nitrosodibutylamine, N-nitrosopropylamine, N-nitrosomethylethylamine, N-nitrosopyrrolidine



소독부산물-4

☑ 수영장

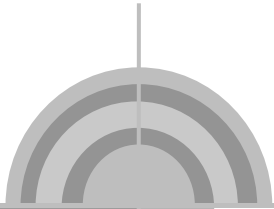
- Headspace SPME-GC/MS 방법으로 수영장 이용한 사람의 소변에서 THMs 측정
- 수영장에서 trichloramine, dichloromethylamine, dichloroacetonitrile 검출
- NDMA, 기타 nitrosamines을 GC/NCI-MS/MS (EPA Method 521)로 측정 (수영장에서 ng/L 검출됨)
- N-Nitrosodibutylamine , N-nitrosopiperidine 검출



소독부산물-5

☑ High molecular weight DBP

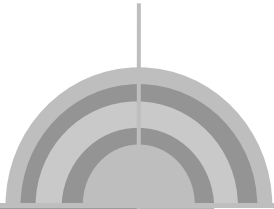
- 염소 소독 된 먹는물에서 500 Da 이상인 TOX (total organic halogen) 검출
- ESI-MS/MS 사용
- 구조규명은 않됨



소독부산물-6

☑ 오염물의 DBPs

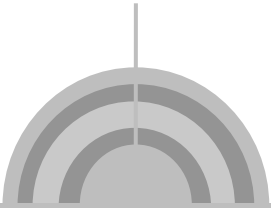
- 소독물질과 NOM (natural organic matter)과 반응하여 생성
- Pharmaceuticals, personal care products, estrogens, pesticides, textile dyes, alkylphenol surfactants, UV filters, diesel fuel 등과 소독물질과 반응하여 생성
- Pesticide DBP : 예) chlorpyrifos 와 chlorine이 반응하여 3,5,6-trichloro-2-pyridinol 생성
- Disperse azo dye의 염소화반응에 의한 생성



햇빛/자외선 차단제-1

☑ 자외선 차단제 (UV filter) ?

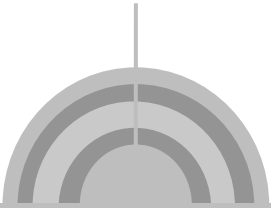
- 햇빛 차단제, 화장품 등에 사용
- 몇몇 uv filter는 estrogenic 효과 나타냄



햇빛/자외선 차단제-2

☑ 종류

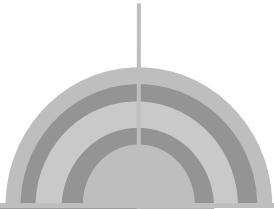
- Organic UV filter : UV를 흡수 함
 - Sunscreens, cosmetics, beauty creams, skin lotions, lipsticks, hair sprays, hair dyes, shampoos :
 - benzophenone-3 (BP-3), 4-hydroxybenzophenone (HBP), 2-hydroxy-4-methoxybenzophenone (HMB), 2,4-dihydroxybenzophenone (DHB), 2,2'-dihydroxy-4-methoxybenzophenone (DHMB), 2,3,4-trihydroxybenzophenone (THB), octyl-dimethyl-*p*-aminobenzoic acid (ODPABA), 4-methylbenzylidene camphor (4-MBC), ethylhexyl methoxycinnamate (EHMC), octyl methoxycinnamate (OMC), octocrylene (OC), butyl methoxydibenzoylmethane (BM-DBM), terephthalylidene dicamphor sulfonic acid (TDSA), ethylhexyl triazone (EHT), phenylbenzimidazole sulfonic acid (PBSA), ethylhexyl salicylate (EHS), benzhydrol (BH), and 1-(4-*tert*-butylphenyl)-3-(4-methoxyphenyl)- 1,3-propanedione (BPMP).
- Inorganic UV filter (TiO_2 , ZnO) : UV를 반사 또는 산란시킴



햇빛/자외선 차단제-3

☑ 분석방법

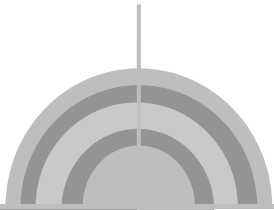
- GC/MS, LC-UV
- 물고기에서 검출 : homogenize → Soxhlet extraction → GPC & SPE clean-up → LC/ESI-MS/MS 분석
- 하천수, 해수, 폐수에서 BP-3, 4-MBC, OC, PBSA, ODPABA, BM-DBM, phenyldibenzimidazoletetrasulfonic acid (PDT), benzophenone-4 (BP-4), isoamylmethoxycinnamate (IAMC) 가 7-46 ng/L 농도 검출
- BP-3, BH, HBP, HMB, DHB, DHMB, THB를 MSTFA로 유도체화 반응 후 GC/MS 검출 : 5 – 100 ng/L 범위



브롬화 난연제

☑ 브롬화 난연제(brominated flame retardants) ?

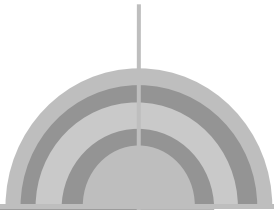
- 사용: 의자 , 컴퓨터, 플라스틱, 전자제품의 foam cushion, 어린이 잠옷
- 175 종의 난연제
- PBDEs



브롬화 난연제-2

☑ 분석방법

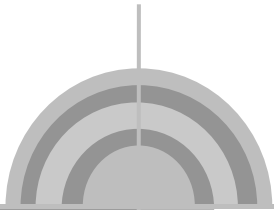
- GC/MS, LC/MS
- NCI-MS, EI-MS, EI-high resolution-MS, MS/MS
- GC × GC
- 혈액, 우유, 조직 등 주로 생체 시료에서 분석



Benzotriazoles

☑ Benzotriazoles ?

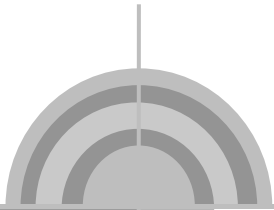
- 사용 : 부식방지제(엔진 냉각제, 항공기 결빙방지 등), 식기세척기에서 은 보호제
- 종류 : Benzotriazole, tolyltriazole
- 분석: 하천수, 폐수에서 SPE-LC/MS/MS 로 측정 ($\mu\text{g/L}$ 농도)



Dioxane

☒ **Dioxane ?**

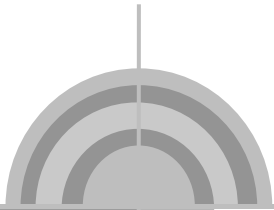
- 1,4-dioxane
- 종이, 면, 직물, 자동차 냉각제, 화장품, 샴푸등에서 사용
- SPME-GC/MS 사용 : 0.5 $\mu\text{g/L}$ 정량한계



Naphthenic acids

☒ **Naphthenic acids ?**

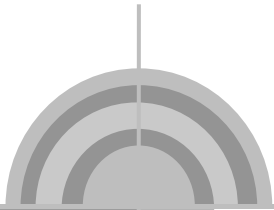
- Alkyl-substituted acyclic & cycloaliphatic carboxylic acid의 혼합물
- 중성 또는 알칼리 pH 에서 물에 잘 녹으며 계면활성제 성질이 있음
- 원유에서 자연적으로 발생
- GC × GC-TOF-MS로 분석
- LC/Q-TOF-MS 분석



Chiral 오염물질

☑ Chiral ?

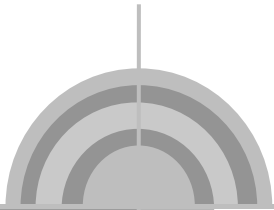
- Chiral isomer : 화학적으로는 비슷하나 ,환경중에서 다르게 작용
- 종류: Chiral pesticides, PCB, terpenes
- 분석: chiral column을 가진 GC, LC, CE 사용
- Chiral selectors : cyclodextrins, proteins, crown ethers, polysaccharides, polyacrylamides, polymeric chiral surfactants, macrocyclic antibiotics, ergot alkaloids



조류 독소(*Algal toxins*)

☑ 조류독소 ?

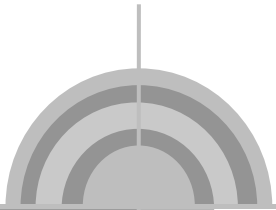
- 종류: microcystins, nodularins, anatoxins, cylindrospermopsin, saxitoxins.
- 분석방법: LC/MS(/MS), MALDI-MS, ESI-FAIMS-MS, LC, ELISAs
(ng/L – ug/L)
- 정수장, 강물, 호수에서 UPLC/MS/MS로 검출



Perchlorate

☑ Perchlorate ?

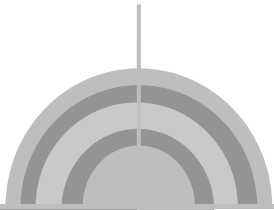
- Ammonium perchlorate가 로켓, 미사일, 불꽃놀이에 사용
- Perchlorate : 음이온, 매우 수용성이며 안정함
- 식물(상추, 밀 등)에 축적됨
- 일반 수처리 방법으로 제거가 않됨 → 따라서, 먹는물에 오염
- 소젖, 모유, 소변에서 검출됨
- 포도주, 맥주, 우유, 차, 주스 등에서도 검출됨 ($\mu\text{g/L}$ 농도)
- 미국의 먹는물에서 1-18 $\mu\text{g/L}$ 검출
- 분석법 : IC/ESI-MS/MS, LC/ESI-MS/MS



농약 분해산물과 신농약

☑ 농약 ?

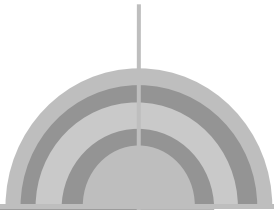
- 가수분해, 산화, 광분해, 생분해 등 분해/변형 생성물에 연구 초점
- LC/MS, LC/MS/MS, TOF, Q-TOF 가 분해산물의 구조규명에 사용됨



비소(Arsenic)

☑ 비소 ?

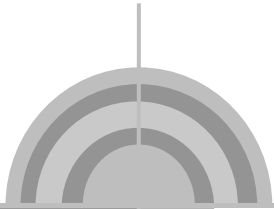
- 물의 오염은 자연 오염원
- 식품, 먼지, 토양, 공기 등에도 오염
- 종류 : arsenite, arsenate, monomethylarsonic acid, monomethylarsonous acid, dimethylarsinic acid, dimethylarsinous acid, trimethylarsine oxide, trimethylarsine, arsenobetaine, arsenocholine, tetramethylarsonium ion, dimethylarsinoyl ethanol, arsenosugars 등 20여종 이상
- IC/ICP-MS, LC/ICP-MS 로 측정 : $\mu\text{g/L}$ 농도



Sucralose

☑ Sucralose ?

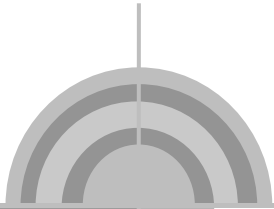
- Splenda 혹은 SucraPlus 라하는 인공감미료
- 잔류성이 매우 큼(반감기가 몇 년)
- 열적으로 안정하므로 빵구울 때 사용, 탄산음료에 사용
- SPE-LC/ESI(-)-MS/MS로 분석: 검출한계 10 ng/L
- 강물에서 1 ug/L 까지도 검출됨



안티몬(Antimony)

☑ 안티몬 ?

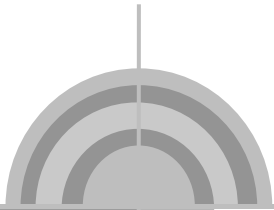
- 급성, 만성 독성
- 석유 정제, 구리 혹은 납의 용해로부터 오염
- polyethylene terephthalate (PET) 플라스틱 물병에서 검출됨 ← PET 플라스틱 제조시 antimony trioxide 가 촉매로 사용되기 때문
- 먹는물에서 2-6 ug/L로 미국, 유럽에서 규제



Siloxanes

☑ Siloxanes ?

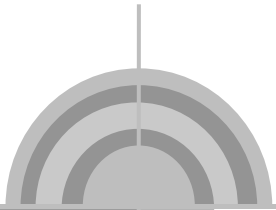
- 화장품, 방향제, 비누, 린스, 머리 염색약, 자동차 왁스, 주방용품, 가구 광택제 등에 사용
- 종류: octamethylcyclotetrasiloxane (D4), decamethylcyclopentasiloxane (D5), dodecamethylcyclohexasiloxane (D6), tetradecamethylcycloheptasiloxane (D7)
- 분석법: headspace-GC/MS (검출한계 10 ng/L)
- 폐수 : 31-400 ng/L 검출



Musks

☑ Musks ?

- 향수, 로션, 햇빛차단제, 방향제, 세탁 세제 등에 첨가제로 사용
- 종류:
 - Nitroaromatic 구조 : musk xylene (1-tert-butyl-3,5-dimethyl-2,4,6-trinitrobenzene) , musk ketone (4-tert-butyl-2,6-dimethyl-3,5-dinitroacetophenone),
 - polycyclic 구조 : 7-acetyl-1,1,3,4,4,6-hexamethyl-1,2,3,4-tetrahydronaphthalene (AHTN; trade name, tonalide) , 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethylcyclopenta-(g)-2-benzopyran HHCB; trade name, galaxolide).
- 분석방법: SPME-GC/ECD, GC/MS (ng/L 농도)



감사합니다

