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Application News

Gas Chromatograph-Mass Spectrometry / GCMS-QP2020 NX

Analysis of Polycyclic Aromatic Hydrocarbons (PAHs) in Tattoo Inks Using GC-MS

Hyeongwon Mun, Jin Jang, Hangji Ok
Shimadzu Scientific Korea

User Benefits

- GCMS-QP2020 NX supports effective analysis of PAHs in Tattoo inks.
- It provides an MFDS-based GC-MS method for PAHs in tattoo inks, enabling compliance with Korean regulations.

■ Introduction

Tattoo inks have been utilized for diverse purposes throughout history, serving as cultural identifiers and means of personal expression. In contemporary society, tattooing extends beyond aesthetics and self-expression to include medical applications such as camouflage of scars and post-operative rehabilitation. Because these inks are injected directly into the dermal layer, rigorous safety and hygienic control are essential to ensure human health protection.

Among the regulated constituents in tattoo inks, polycyclic aromatic hydrocarbons (PAHs) are of particular concern. PAHs comprise over a hundred structurally related compounds, commonly generated through incomplete combustion processes, vehicle exhaust, and tobacco smoke. Several PAHs have been classified as carcinogenic, and chronic exposure may lead to bioaccumulation and subsequent adverse health effects.

In January 2022, the European Union implemented stringent restrictions through updated REACH regulations, limiting the presence of approximately 4,000 hazardous substances in tattoo and permanent make-up inks, including PAHs.[1)] These regulations prohibit the use of carcinogenic, mutagenic, and sensitizing substances previously detected in such products. Since the enforcement date, only compliant inks are permitted for distribution and use within the EU.

In South Korea, tattoo inks were regulated as consumer chemical products under the Ministry of Environment until June 2025. Due to increasing safety concerns, they have since been reclassified as sanitary products under the authority of the Ministry of Food and Drug Safety (MFDS), resulting in the implementation of more stringent safety requirements.[2)]

This application news introduces the analytical methodology for quantification of PAHs in tattoo inks based on the MFDS regulatory standards (Notice 2025-36). Samples were prepared in accordance with the prescribed protocol, and PAH concentrations were determined using gas chromatography–mass spectrometry (GC-MS) in selected ion monitoring (SIM) mode.

■ Analytical Conditions

For the determination of PAHs in tattoo inks, a GCMS-QP2020 NX system was employed, as shown in Figure 1. The instrumental parameters and selected ion monitoring (SIM) conditions used for PAH analysis are summarized in Table 1.

Table 1. Analytical conditions

Gas chromatograph Nexis-GC2030	
Column	: SH-35 (30 m x 0.25 mm I.D., 0.25 µm f.t.)
Column Oven Temp.	: 90 ˚C (1 min) → 30 ˚C/min → 250 ˚C → 2 ˚C/min → 280 ˚C (13 min)
Column Flow	: 1.0 mL/min
Flow Control Mode	: Constant column flow
Injection Temp.	: 270 ˚C
Injection Mode	: Splitless
Injection Volume	: 1 µL
Mass spectrometer GCMS-QP2020 NX	
Ion Source Temp.	: 280 ˚C
Interface Temp.	: 230 ˚C
Acquisition Mode	: SIM (*m/z*)
	Benz[a]anthracene (*228, 229, 226)*
	Chrysene (*228, 226, 229)*
	Benzo[b]fluoranthene (*252, 253, 126)*
	Benzo[j]fluoranthene (*252, 253, 126)*
	Benzo[k]fluoranthene (*252, 253, 126)*
	Benzo[a]pyrene (*252, 253, 126)*
	Benzo[a]pyrene-D_{12} (ISTD) (*264, 260, 132)*
	Benzo[e]pyrene (*252, 253, 126)*
	Dibenz(a,h)anthracene (*278, 139, 279)*

Figure 1. AOC™-30i + GCMS-QP2020 NX

■ Materials and Preparation

Standard

A mixed standard solution containing eight target PAHs (1,000 mg/L each) was obtained commercially and used for analytical purposes. For calibration, the stock solution was diluted with toluene to prepare a 1 mg/L working standard.

Internal standard

Benzo[a]pyrene-d12 was used as the internal standard (ISTD). A stock solution (1,000 mg/L) was prepared by dissolving Benzo[a]pyrene-d12 in toluene and subsequently diluted with toluene to obtain a working concentration of 2.5 mg/L.

Calibration curve standard

Seven-point calibration standards were prepared with final PAH concentrations of (0.002, 0.005, 0.01, 0.02, 0.05, 0.1, and 0.2) mg/L, and an ISTD concentration of 0.005 mg/L. Aliquots of the 1 mg/L mixed standard were transferred into 5 mL volumetric flasks to obtain the target concentration levels. 10 µL of ISTD (2.5 mg/L) were added to each flask, and the solutions were made up to volume with toluene.

Recovery test

To evaluate the accuracy and precision of the analytical method, recovery studies were performed at three spiking levels: 0.005 mg/L (low), 0.02 mg/L (medium), and 0.1 mg/L (high). Tattoo ink samples were fortified with PAH standards followed by the complete sample preparation procedure and subsequent GCMS measurement. Each concentration level was analyzed in quintuplicate, and the mean recoveries and relative standard deviations (%RSD) were calculated.

Sample preparation of tattoo ink

Sample preparation was performed in accordance with the MFDS Sanitary Products Standards and Specifications (Notice No. 2025-36). 1 g of each tattoo ink sample was accurately weighed into a polypropylene tube, followed by the addition of 20 µL of ISTD solution and 10 mL of toluene. The mixture was vortexed thoroughly and sonicated at 60 °C for 1 h. The extract was purified using an XTR-SPE cartridge (70 mL, 14.5 g, Chromabond). The cartridge was preconditioned with 100 mL of toluene. Without drying, the entire sample extract was loaded onto the cartridge, and PAHs were eluted with 20 mL of toluene repeated eight times (total 160 mL). The eluate was concentrated to approximately 1 mL using a rotary evaporator, filtered through a 0.45 µm PTFE syringe filter, and subjected to GC-MS analysis (Figure 2).

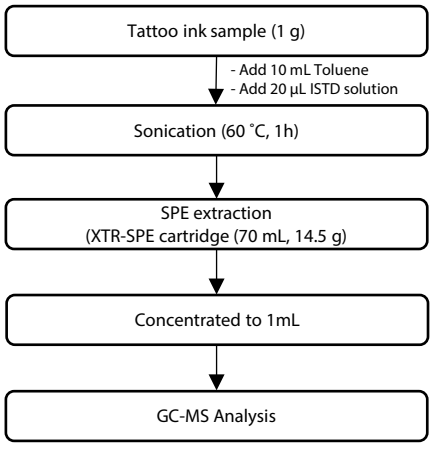

Figure 2. Preparation scheme for PAHs analysis in tattoo inks

■ Results

Linearity

To evaluate the linearity of the analytical method, seven calibration standard solutions were analyzed by GC-MS, and calibration curves were constructed by plotting peak area against concentration. All analytes exhibited excellent linearity, with coefficients of determination (R^2) greater than 0.999 (Figure 3).

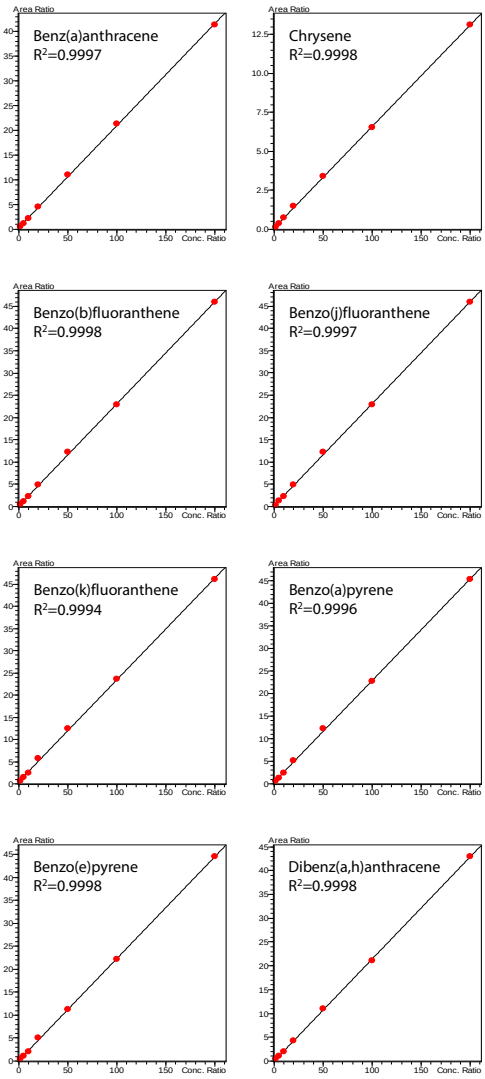

Figure 3. Calibration curves for eight PAHs

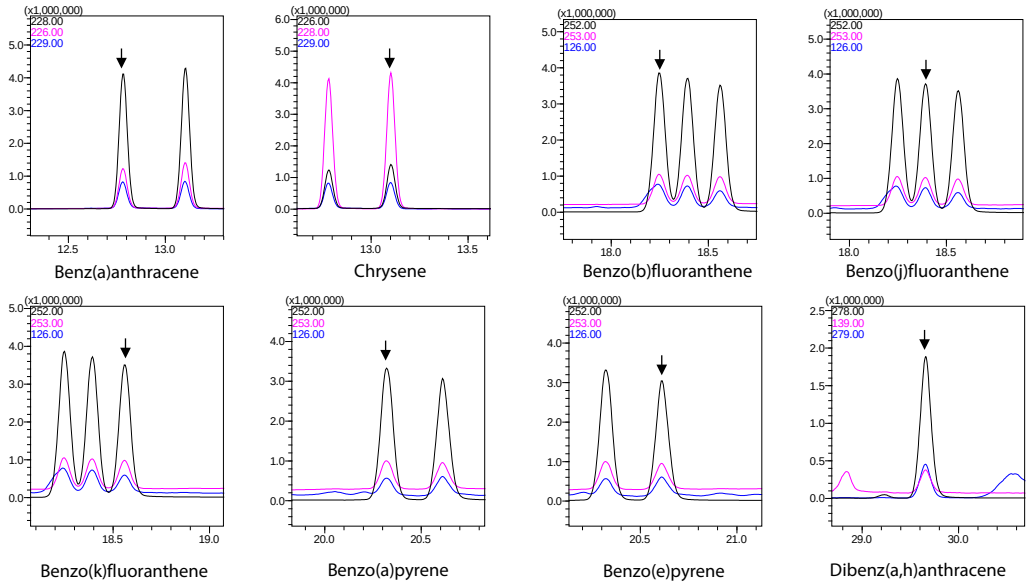

Figure 4. SIM Chromatograms for Eight PAHs (High-Spike Level)

Table 2. Recovery results for Eight PAHs (*n*=5)

Compounds	Low		Medium		High	
	Recovery (%)	%RSD	Recovery (%)	%RSD	Recovery (%)	%RSD
Benz(a)anthracene	91.1	3.13	101.8	0.30	85.6	0.42
Chrysene	92.0	2.98	103.1	1.37	95.5	0.81
Benzo(b)fluoranthene	111.5	2.49	109.6	0.63	101.4	0.31
Benzo(j)fluoranthene	112.2	0.84	108.3	0.22	98.1	0.11
Benzo(k)fluoranthene	81.6	2.25	86.7	0.78	90.6	0.49
Benzo(a)pyrene	95.5	1.27	97.5	0.29	95.8	0.36
Benzo(e)pyrene	115.1	1.63	100.7	0.61	90.2	0.46
Dibenz(a,h)anthracene	114.6	2.03	97.8	0.23	101.4	0.37

Accuracy and precision

The accuracy and precision of the analytical method were assessed by conducting recovery tests in which tattoo ink samples were spiked with PAH standard solutions at final concentrations of 0.005, 0.02, and 0.1 mg/L. Accuracy was evaluated based on mean recoveries at each level, while precision was assessed using the relative standard deviation (%RSD). A representative chromatogram of the high-concentration spike sample was presented in Figure 4.

The results obtained from five replicate analyses at each concentration level were summarized in Table 2. Mean recoveries ranged from 91.1–114.6% at the low level, (86.7–109.6) % at the medium level, and (85.6–101.4) % at the high level, with corresponding %RSD values of (0.84–3.13) %, (0.22–1.37) %, and (0.11–0.81) %, respectively. These results demonstrated that the method provides excellent accuracy and precision for the determination of PAHs in tattoo inks. Slightly higher %RSD values were observed at the low concentration level, which may be attributed to increased variability from sample preparation loss or instrumental sensitivity limitations commonly encountered at trace levels.

■ Conclusions

Quantitative analysis of PAHs in tattoo inks was performed using the GCMS-QP2020 NX. Sample preparation followed the procedure outlined in the MFDS 'Standards and Specifications for Sanitary Products.' All eight PAH analytes showed excellent linearity, with correlation coefficients (R^2) exceeding 0.999. Recovery tests showed values between 81.6% and 115.1%, with relative standard deviations (%RSD) ranging from 0.11% to 3.13%, demonstrating good accuracy and precision. These results confirm that the GCMS-QP2020 NX is a suitable instrument for PAH analysis in tattoo inks.

■ Reference

1) (EU) REACH 2020/2081
2) Korean MFDS standards Notice 2025-36 'Standards and Specifications for Sanitary Products'

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