Preliminary Screening of "Polycyclic Aromatic Hydrocarbons (PAHs)" as a Class for Future Consideration as Potential Designated Chemicals

November 16th, 2026 Meeting of the Scientific Guidance Panel
Biomonitoring California[1]

Biomonitoring California staff have prepared this preliminary screening document for the Scientific Guidance Panel (SGP) regarding the possible future consideration of the class of "polycyclic aromatic hydrocarbons (PAHs)" to be added to the Program's list of designated chemicals.

Currently, only nine PAHs (see Attachment A) are included as designated chemicals due to their inclusion in the National Reports on Human Exposure to Environmental Chemicals program of the Centers for Disease Control and Prevention (CDC). These select PAHs have been on Biomonitoring California's list of designated chemicals since the inception of the Program. In March 2009, the SGP recommended that specific hydroxy metabolites of three designated PAHs also be added as priority chemicals (see Attachment A).

The class of PAHs includes hundreds of chemicals, some of which have been identified in human urine and blood (CDC NHANES 2021; Ramesh et al. 2014; Zhao et al. 2024), and studies have reported PAHs in California populations (Hurley et al. 2026; John et al. 2025; Lin et al. 2022). While some PAHs are already designated, many other PAH compounds that are critical for biomonitoring research are excluded from the current list.

Adding PAHs as a class to the list of designated chemicals will allow Biomonitoring California to measure all PAHs that have been identified as carcinogens as well as other toxic PAHs that cause adverse health effects such as liver, reproductive, and developmental effects. It will also allow the Program to measure PAHs that are on the US Environmental Protection Agency (US EPA)'s Priority Pollutant List but currently excluded from Biomonitoring California's list of designated chemicals. Moreover, adding PAHs as a class will allow Biomonitoring California studies to measure specific PAHs, including substituted PAHs, that can be used to distinguish between petrogenic and pyrogenic exposure sources, advancing the program's core priorities.

[1] California Environmental Contaminant Biomonitoring Program, codified at Health and Safety Code section 105440 et seq.

This document presents preliminary screening information relevant to possible future consideration of adding PAHs as a class to the list of designated chemicals, including:

- Chemical identity
- Use of urinary metabolites of substituted PAHs for exposure source identification
- Examples of PAHs that are carcinogenic and not currently designated

At the November 16, 2026 SGP meeting, the Panel will provide input on possible next steps for adding PAHs as a class to the Program's list of designated chemicals. These could include further screening of the class, or development of a potential designated chemical document on PAHs.

Chemical identity

Polycyclic aromatic hydrocarbons (PAHs) are defined as a class of organic compounds with at least two fused aromatic rings. Exposure to PAHs via ambient air is driven by petroleum refinery emissions, diesel and gasoline vehicle exhaust, oil spills and leaks, and municipal waste incineration. Indoor exposure to PAHs is heavily associated with tobacco smoke, residential wood stoves, high-temperature cooking methods, and wildfire smoke. Dietary exposures also occur as the result of bioaccumulation of PAHs present in the environment, and formation of PAHs in foods that are grilled, smoked, or charbroiled (Harasym and Nizio 2026).

PAHs can exist as unsubstituted or substituted compounds. Studies indicate that pyrogenic and petrogenic sources release both unsubstituted and substituted (alkylated, oxygenated, nitrated, and hydroxylated) PAHs (Ghetu et al. 2021). However, alkylated PAHs have been observed mostly in petrogenic sources of unburned fossil fuels as compared with pyrogenic sources (e.g., combustion-related PAH generation) (Lin et al. 2021). For this reason, alkylated PAHs, particularly methylphenanthrenes (MePHEs), have been used as tracers of ambient PAHs originating from petrogenic sources (Saha et al. 2009).

This approach has been applied in human studies to investigate source-specific exposures. Alkylated and other substituted PAHs (that are not currently designated chemicals) and their metabolites have been measured in urine and blood samples (Table 1).

Table 1. Examples of observations from human studies that measured substituted PAHs or their metabolites in urine/blood

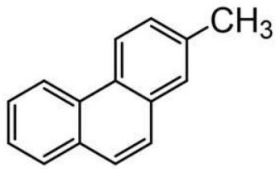
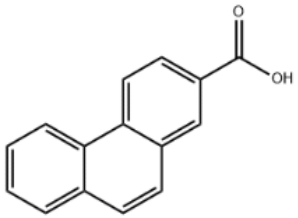
Substituted PAHs or their Metabolites	Study Observations
Alkylated-PAHs Nitrated-PAHs	Among tested substituted PAHs in petrochemical workers, alkylated-PAHs were predominant in blood, and levels were approximately 5 and 23 times higher than those of hydroxylated-PAHs and nitrated-PAHs, respectively (Zhang et al. 2026).
Methylated-PAHs (Me-PAHs) Nitrated-PAHs	126 PAHs (unsubstituted, methylated, nitrated, and hydroxylated-PAHs) were assessed and detected in the blood and urine of workers at a petrochemical plant. Unmetabolized PAHs (e.g., unsubstituted, methylated-, and nitrated-PAHs) were frequently detected in urine (Zhao et al. 2024).
1-Pyrenecarboxylic acid (1-PYRCA)	Urinary levels of 1-pyrenecarboxylic acid (1-PYRCA), a metabolite of 1-methylpyrene, significantly increased in people who were exposed to a campfire for four hours (Wang et al. 2025). The authors suggest that urinary 1-PYRCA can be used as a biomarker for woodsmoke exposure.
Methylnaphthols (Me-OHNAPs)	Levels of urinary methylnaphthols (metabolites of methylated naphthalene) were much greater than levels of urinary monohydroxy-PAHs (commonly recognized PAH exposure biomarkers) in smokers compared to non-smokers. This study suggests that biomarkers for alkylated and other substituted PAHs should also be measured when assessing exposures to PAHs (Li et al. 2014).

Some studies have also used urinary metabolites of substituted and unsubstituted PAHs to evaluate exposure sources. For example, the ratio of urinary concentrations of 2-phenanthrenecarboxylic acid (2-PHECA) to total hydroxyphenanthrenes (ΣOH-PHEs) has been used as an index to evaluate the relative contribution of petrogenic and pyrogenic sources to human exposures to PAHs (Table 2).

2-PHECA ← Metabolite of 2-methylphenanthrene (a substituted PAH)

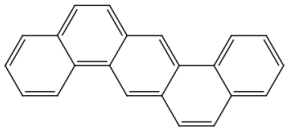
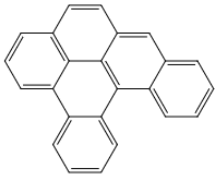
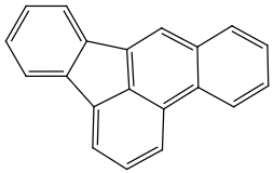
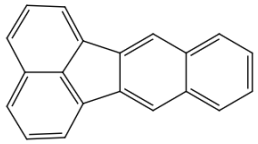
ΣOH-PHEs ← Total hydroxylated metabolites of phenanthrene (an unsubstituted PAH)

Table 2. Examples of observations from human studies measuring metabolites of substituted PAHs in urine to differentiate between petrogenic and pyrogenic exposure sources

Substituted PAH	Urinary Metabolite of Substituted PAH	Study Observations
 2-Methylphenanthrene (2-MePHE)	 2-Phenanthrenecarboxylic acid (2-PHECA)	• Urinary metabolites of PAHs were measured in Los Angeles residents before, during, and after they spent time in Beijing, China. This study reported that the 2-PHECA/ΣOH-PHEs ratio was significantly higher when participants were in Los Angeles than when they were in Beijing, suggesting higher exposures to petrogenic PAHs in Los Angeles (Lin et al. 2021). • In another study, urinary levels of 2-PHECA were significantly associated with levels of 2-MePHE (substituted PAH) but not phenanthrene (unsubstituted PAH) measured in personal air $PM_{2.5}$ samples of urban residents in China after adjusting for seasonal effects. This supported the use of urinary 2-PHECA as an exposure biomarker of 2-MePHE. Significant associations were also found between the 2-PHECA/ΣOH-PHEs ratio in urine and the 2-MePHE/PHE ratio in personal $PM_{2.5}$ air samples, which can indicate exposures to petrogenic vs pyrogenic sources (Lin et al. 2022).

There are PAHs that are carcinogenic but are not currently on Biomonitoring California's list of designated chemicals. Some of these chemicals are also included on the US EPA's priority pollutant list (Table 3).

Table 3. Examples of PAHs that are carcinogenic and not included on Biomonitoring California's list of designated chemicals

Chemical Name ***(CAS #)***	**Chemical Structure**	**Carcinogenicity Classification**	**Included on US EPA's Priority Pollutant List** [1]
Dibenz[a,h]anthracene *(53-70-3)*		• IARC[2]: Group 2A (probably carcinogenic to humans) • Proposition 65[3] listed carcinogen • RoC[4]: Reasonably Anticipated to be a Human Carcinogen	Yes
Dibenzo[a,l]pyrene *(191-30-0)*		• IARC: Group 2A (probably carcinogenic to humans) • Proposition 65 listed carcinogen • RoC: Reasonably Anticipated to be a Human Carcinogen	No
Benzo[b]fluoranthene (*205-99-2)*		• IARC: Group 2B (possibly carcinogenic to humans) • Proposition 65 listed carcinogen • RoC: Reasonably Anticipated to be a Human Carcinogen	Yes
Benzo[k]fluoranthene (*207-08-9)*		• IARC: Group 2B (possibly carcinogenic to humans) • Proposition 65 listed carcinogen • RoC: Reasonably Anticipated to be a Human Carcinogen	Yes

[1]US EPA Priority Pollutant List (2014) https://www.epa.gov/sites/default/files/2015-09/documents/priority-pollutant-list-epa.pdf
[2] IARC List of Classifications https://monographs.iarc.who.int/list-of-classifications/
[3] Safe Drinking Water and Toxic Enforcement Act of 1986 https://www.p65warnings.ca.gov/chemicals
[4] The Report on Carcinogens https://ntp.niehs.nih.gov/research/assessments/cancer/roc

References:

CDC (Centers for Disease Control) 2021. National Report on Human Exposure to Environmental Chemicals [Online Database March 2022-]. https://www.cdc.gov/exposurereport/data_tables.html

Ghetu CC, Scott RP, Wilson G, Liu-May R, Anderson KA. 2021. Improvements in identification and quantitation of alkylated PAHs and forensic ratio sourcing. Anal Bioanal Chem 413:1651-1664.

Harasym J, Nizio E. 2026. Environmental behavior, toxicological pathways, and risk assessment of polycyclic aromatic hydrocarbons (PAHs): from molecular structure to human health. Molecules 31:2211.

Hurley S, Castorina R, Sultana D, Thompson M, Jarmul S, et al. 2026. High levels of urinary naphthalene metabolites measured in a sample of California schoolchildren: a call to expand monitoring and identify exposure sources. Front Public Health 14:1789602.

John EM, Koo J, Keegan TH, Ingles SA, Nguyen JT, et al. 2025. Timing of puberty in girls and serum polycyclic aromatic hydrocarbon (PAH)-albumin adduct levels: the California PAH Study. J Expo Sci Environ Epidemiol 35:956-964.

Li Z, Romanoff LC, Trinidad DA, Pittman EN, Hilton D, et al. 2014. Quantification of 21 metabolites of methylnaphthalenes and polycyclic aromatic hydrocarbons in human urine. Anal Bioanal Chem 406:3119-3129.

Lin Y, Gao X, Qiu X, Liu J, Tseng CH, et al. 2021. Urinary carboxylic acid metabolites as possible novel biomarkers of exposures to alkylated polycyclic aromatic hydrocarbons. Environ Int 147:106325.

Lin Y, Zhang H, Han Y, Qiu X, Jiang X, et al. 2022. Field evaluation of a potential exposure biomarker of methylated polycyclic aromatic hydrocarbons: association between urinary phenanthrene-2-carboxylic acid and personal exposure to 2-methylphenanthrene. Environ Sci Technol Lett 9:166-172.

Ramesh A, Kumar A, Aramandla MP, Nyanda AM. 2014. Polycyclic aromatic hydrocarbon residues in serum samples of autopsied individuals from Tennessee. Int J Environ Res Public Health 12:322-334.

Saha M, Togo A, Mizukawa K, Murakami M, Takada H, et al. 2009. Sources of sedimentary PAHs in tropical Asian waters: Differentiation between pyrogenic and petrogenic sources by alkyl homolog abundance. Mar Pollut Bull 58:189-200.

Wang X, Lin Y, Liu X, Craig EA, Stapleton HM, et al. 2025. Urinary pyrene carboxylic acid as a novel exposure biomarker of woodsmoke. Environ Sci Technol Lett:1294-300.

Zhang X, Wang X, Wang S, Zhou L, Liang W, et al. 2026. Substituted polycyclic aromatic hydrocarbons (SPAHs) in petrochemical park workers: external and internal exposure assessment and half-lives. Environ Sci Technol 60:1713-1722.

Zhao K-X, Jiang C, Han Y, Li W-L, Li Y-W, et al. 2024. Differential occupational health risks between methylated PAHs and PAHs: monitoring 126 PAHs and 6 oxidative stress markers in paired serum–urine samples. Environ Health 2:150-160.

Attachment A. PAHs currently on Biomonitoring California's lists of designated and priority chemicals

PAHs on the list of designated chemicals[1]	PAH metabolites on the list of priority chemicals[2]
Benz[a]anthracene	
1-Hydroxybenz[a]anthracene	
3-Hydroxybenz[a]anthracene	
9-Hydroxybenz[a]anthracene	
Benzo[a]pyrene	
3-Hydroxybenzo[a]pyrene	3-Hydroxybenzo[a]pyrene
Benzo[c]phenanthrene	
1-Hydroxybenzo[c]phenanthrene	
2-Hydroxybenzo[c]phenanthrene	
3-Hydroxybenzo[c]phenanthrene	
Chrysene	
1-Hydroxychrysene	
2-Hydroxychrysene	
3-Hydroxychrysene	
4-Hydroxychrysene	
6-Hydroxychrysene	6-Hydroxychrysene
Fluoranthene	
3-Hydroxyfluoranthene	
Fluorene	
1-Hydroxyfluorene	
2-Hydroxyfluorene	
3-Hydroxyfluorene	
9-Hydroxyfluorene	
Naphthalene	
1-Hydroxynaphthalene	
2-Hydroxynaphthalene	
Phenanthrene	
1-Hydroxyphenanthrene	
2-Hydroxyphenanthrene	
3-Hydroxyphenanthrene	3-Hydroxyphenanthrene
4-Hydroxyphenanthrene	
9-Hydroxyphenanthrene	
Pyrene	
1-Hydroxypyrene	

[1] For the parent chemicals listed below, metabolites or other targets for measurement are shown indented underneath.

[2] The SGP recommended that the three hydroxy-PAHs shown be listed as priority chemicals. These three hydroxy-PAHs are metabolites of benzo[a]pyrene, chrysene and phenanthrene, respectively.