Product-Chemical Profile for Nail Products Containing Toluene

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CalEPA California Environmental Protection Agency

DTSC Department of Toxic Substances Control

SAFER CONSUMER PRODUCTS

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1 ABOUT THIS PROFILE

(1) There must be potential public and/or aquatic, avian, or terrestrial animal or plant organism exposure to the Candidate Chemical(s) in the product; and

(2) There must be the potential for one or more exposures to contribute to or cause significant or widespread adverse impacts.

This Product-Chemical Profile (Profile) demonstrates that the regulatory criteria have been met and serve as the basis for Priority Product rulemaking. The Profile does not provide a comprehensive assessment of all available literature on adverse impacts and exposure ~~literature on~~ for toluene or ~~on~~ nail products. If this Priority Product regulation is adopted, the responsible entities must follow the reporting requirements pursuant to the SCP regulations.[3]

Candidate Chemical: A chemical that exhibits a hazard trait and is listed on one or more authoritative lists in the SCP regulations.

Product-Chemical Profile: A report generated by DTSC to explain its determination that a proposed Priority Product meets the SCP regulatory criteria for potential significant or widespread adverse impacts to humans or the environment.

Priority Product: A product-chemical combination as identified in regulation by DTSC that has the potential to contribute to significant or widespread adverse impacts to humans or the environment.

[3] California Code of Regulations, title 22, section 69503.7 and Article 5 (Alternatives Analysis)

Readers should consider the following:

- The Profile is not a regulatory document and does not impose any regulatory requirements.
- The Profile summarizes information compiled by DTSC as of ~~March 2020~~ January 2022 and includes consideration of stakeholder feedback[4] provided during the pre-regulatory comment period that closed on April 2, 2019, and the regulatory comment period, which ended on November 18, 2021. In preparation for rulemaking, DTSC also requested feedback on the scientific basis of this document from three external scientific peer reviewers. Their feedback was provided to DTSC on October 17, 2019.
- Since the public draft from April 2019, DTSC:
  - made several editorial changes to improve the clarity of the writing;
  - corrected a few minor errors identified by DTSC staff or by the external scientific peer reviewers;
  - made some clarifications and changes to address points raised by the external scientific peer reviewers;
  - added new references identified by External Scientific Peer Review (ESPR) commenters or DTSC staff since the publication of the public draft;
  - updated the chronic, 8-hour, and acute Reference Exposure Levels (RELs) for toluene based on the Office of Environmental Health Hazard Assessment's recently adopted values;
  - added information regarding DTSC's nail products lab study and information call-in; and
  - proposed an Alternatives Analysis Threshold for toluene.
- All substantive changes are unlined or struck out and in red font.
- By proposing to list this product-chemical combination as a Priority Product containing a Chemical of Concern, DTSC is not asserting that the product cannot be used safely. The proposal indicates only that there is a potential for exposure of people or the environment to the Chemical of Concern in the Priority Product, that such exposure has the potential to cause or contribute to significant or widespread adverse impacts, and that safer alternatives should be explored.

[4] https://calsafer.dtsc.ca.gov/cms/commentpackage/?rid=12742&from=search

2 SUMMARY OF THE RATIONALE FOR PRODUCT-CHEMICAL SELECTION

DTSC proposes to identify nail products containing toluene – including nail coatings and nail polish thinners – as a Priority Product with a Chemical of Concern. Toluene, formaldehyde, and dibutyl phthalate (DBP) have been historically called the "toxic trio" when used together in nail products. While nail product manufacturers have largely phased out use of formaldehyde and DBP, some nail products still contain toluene.

> The primary exposure route from nail products is vapor inhalation. Toluene has been detected in air in nail salons at levels above California regulatory standards, and nail technicians (also known as manicurists) have an especially high potential for exposure.

The U.S. Food and Drug Administration (FDA) has limited regulatory oversight of cosmetics and personal care products, including nail products. The FDA does not have the authority to require safety testing of cosmetics, and there is no approval process for cosmetics and personal care products prior to sale in the U.S. (except for color additives). Further, there is no legal requirement to report adverse impacts related to cosmetics and personal care products, and the FDA has no recall authority over such products.

Toluene is a solvent used in a variety of formulated products including nail products. It is a liquid at room temperature and readily volatilizes into air. Toluene exhibits several health hazard traits and appears on nine of the 23 authoritative lists that make up the Candidate Chemicals List in the SCP regulations. Exposure to toluene has the potential to cause or contribute to adverse human health impacts, including:

- **Nervous system effects.** Neurotoxicity is a critical human health concern following acute, intermediate, or chronic toluene exposure.
- **Developmental toxicity.** Toluene exposure is linked to adverse effects in developing fetuses and has the potential to cause birth defects.
- **Respiratory and kidney toxicity.** Toluene exposure has been linked to harm to the respiratory tract and kidneys.
- **Immune system, vision, and hearing effects**. Toluene exposure is also linked to adverse impacts to the immune system as well as vision and hearing impairment.

Use of nail products in salons and at home has the potential to expose nail technicians, other salon workers, patrons, and nail product consumers to toluene. The primary exposure route from nail products is vapor inhalation.[5] Toluene has been detected in air in nail salons at levels above California regulatory standards, and nail technicians (also known as manicurists) have an especially high potential for exposure. The magnitude of toluene exposure can be affected by several factors:

- **Ventilation.** Nail salons often have inadequate ventilation.
- **Length of the workday.** Salon workers often work more than eight hours per day and 40 hours per week.
- **Availability of information**. Salon workers are often not given adequate information on chemical safety. If Safety Data Sheets are available, workers may have difficulty reading and understanding them, especially if English is not their native language.
- **Use of personal protective equipment.** Salon workers are often not provided with proper personal protective equipment such as nitrile gloves and half-facepiece air purifying respirators with organic vapor filtering cartridges that can reduce exposure to toluene and the resulting adverse impacts.
- **Other factors.** Building size, room dimensions, air exchange rates, and weather conditions also influence the degree of toluene exposure in nail salons and at home.

Nail industry workers' exposure to chemicals is an environmental justice issue. In California, most nail technicians are Vietnamese immigrants of low socioeconomic status and are often women of childbearing age.

> Nail industry workers' exposure to chemicals is an environmental justice issue. In California, most nail technicians are Vietnamese immigrants of low socio-economic status and are often women of childbearing age.

Fetuses, infants, and children represent another group that is especially vulnerable to toluene exposure from nail products. Due to physiological differences, infants and children are more susceptible to adverse impacts from toluene exposure than adults. Nail technicians who work while pregnant risk exposing their fetuses to toluene in the womb. Toluene has been detected in breast milk, and nursing mothers who work in nail salons can expose their infants when they breastfeed. Salon workers who bring their infants and children to work may expose them to toluene vapors present in indoor air.

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[5] Toluene exposure can also occur through dermal application of products and orally from accidental ingestion and hand-to-mouth behavior.

Nail products and professional manicure/pedicure services are popular in the United States. In California alone, there are over 9,000 nail salons and more than 130,000 licensed manicurists. Nail products, including ones containing toluene, are also widely used at home. Retail sales of nail products exceed $1 billion per year in the U.S. In 2015-16, nail polish sales represented $741 million of this amount.

In 2020, DTSC requested information, on various nail products, from product manufacturers, importers, assemblers, retailers, distributors, and trade associations. Toluene was reported as an added ingredient in 11 nail products, including nail polish thinners and top coats, at concentrations ranging from 5 to 25 percent. Toluene was also reported as a contaminant or residual in 172 nail products, at concentrations ranging from 0 to 0.1 percent.

In addition, DTSC recently conducted analytical laboratory testing of 157 retail and professional-use nail products and detected toluene in 27 nail products at concentrations ranging from 31.4 ppm to 187,000 ppm (µg/mL).

Based on these factors, DTSC has determined that exposure to toluene-containing nail products may contribute to or cause significant or widespread adverse impacts to nail industry workers, women, infants, children, and environmental justice communities; thus, DTSC proposes to identify nail products containing toluene as a Priority Product.

California Code of Regulations, title 22, section 69503.5(c) states that DTSC may set an Alternatives Analysis Threshold (AAT) for a Chemical of Concern that is an intentionally added ingredient and must do so if the Chemical of Concern is a contaminant. Toluene can occur as an intentionally added ingredient or contaminant in nail products. Thus, DTSC proposes to set an AAT for toluene at 100 ppm in nail products.

3 PRODUCT-CHEMICAL DEFINITIONS AND SCOPE

This section introduces the Candidate Chemical(s) and the product that constitute the proposed product-chemical combination.

3.1 Scope of Candidate Chemical

Toluene, Chemical Abstract Service (CAS) Registry Number 108-88-3

Synonyms (ATSDR 2017; NIH 2020c)

- Methylbenzene
- Phenylmethane
- Benzene, methyl-
- Toluol
- Methylbenzol

Registered trade names (ATSDR 2017; NIH 2020c)

- Methacide
- Antisal 1A

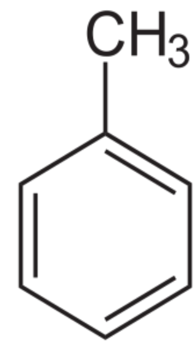

Figure 1. Chemical structure of toluene (NIH 2020c)

Molecular Formula: $C_6H_5CH_3$ or C_7H_8

Toluene is a clear, colorless, flammable, and volatile liquid that has a sweet and pungent odor. Toluene is produced in the process of making gasoline and other fuels from crude oil and in making coke from coal (ATSDR 2015; ATSDR 2017). Toluene is used as a solvent in a variety of nail products such as nail polish, nail hardeners, polish removers (FDA 2017), and nail polish thinners. Historically, toluene was used as a solvent in nail polish removers, but this use is now effectively banned by the California Air Resources Board (CARB) Consumer Products regulations, which limit the total concentration of volatile organic compounds in polish removers to one percent by weight (CARB 2017; CARB 2019; Wolf 2016).

Toluene is listed as a Candidate Chemical based on the following:

- Identified as a toxic air contaminant by CARB (CARB 2020);
- Identified on the Centers for Disease Control and Prevention's Fourth National Report on Human Exposure to Environmental Chemicals and Updated Tables (CDC 2009; CDC 2019);
- Identified with noncancer endpoints and listed with an inhalation Reference Exposure Level (REL) by the California Office of Environmental Health Hazard Assessment (OEHHA) under Health and Safety Code section 44360(b)(2) (OEHHA 2019);
- Listed as a developmental toxicant under Proposition 65 (Safe Drinking Water and Toxic Enforcement Act of 1986) (OEHHA 1991);

- Identified as a chemical for which a primary Maximum Contaminant Level (MCL) has been established and adopted under section 64431 or section 64444 of Chapter 15 of title 22 of the California Code of Regulations (SWRCB 2018);
- Identified as a priority toxic pollutant in California Water Quality Control Plans under section 303(c) of the federal Clean Water Act and in section 131.38 of title 40 of the Code of Federal Regulations or identified as pollutants by California or the U.S. Environmental Protection Agency (U.S. EPA) for one or more water bodies in California under section 303(d) of the federal Clean Water Act and section 130.7 of title 40 of the Code of Federal Regulations (SWRCB 2012; U.S. EPA 2000);
- Identified as a neurotoxicant in the Agency for Toxic Substances and Disease Registry's Toxic Substances Portal (ATSDR 2011); and
- Identified as a chemical for which a reference dose or reference concentration has been developed based on neurotoxicity in U.S. EPA's Integrated Risk Information System (U.S. EPA 2005a).

3.2 Scope of Product

The scope of this proposal covers nail products containing toluene, including nail coatings and nail polish thinners that contain toluene as an added ingredient, a residual, or a contaminant.

- ~~nail coatings, and~~
- ~~nail polish thinner.~~

This proposed product-chemical combination includes the following toluene-containing nail products, as defined below.

"Nail coating" means any clear or colored paint, polish, lacquer, enamel, or gel product marketed or sold for application to fingernails or toenails. There are two types of nail coatings: solvent-based nail coatings and UV gel nail coatings.

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"Solvent-based nail coatings" are clear or colored nail coatings that form a hard coating on nails upon evaporation of their solvents. Subproducts include nail polishes, lacquers, enamels, base coats, undercoats, top coats, and gel nail polishes.

- "Nail polish" is a varnish or paint applied to the fingernails or toenails to color them or make them shiny.
- "Lacquer" or "enamel" is a coating that dries by means of solvent evaporation.
- "Base coat" or "undercoat" is a clear or milky-colored coating that is used before applying other coatings to the nail. It may be marketed for strengthening or protecting the nail, restoring moisture to the nail, or helping other coatings to adhere to the nail.

- “Top coat” is a clear coating that is used after applying other coatings to the nail. It may be used to protect underlying coatings or to add shine, gloss, or matte to the nail.
- “Gel nail polish” or “gel polish” is a gel varnish coating with a look and feel similar to UV gel nail coatings but that does not require an ultraviolet (UV) or a light-emitting diode (LED) lamp to dry. Gel nail polish typically contains color but can also be a clear nail coating.

“UV gel nail coatings” are clear or colored gel nail coatings that are cured or hardened on nails using a UV or an LED lamp rather than solvent evaporation. Subproducts include UV gel nail polish, UV gel topcoat, UV gel base coat, hard gel, and Shellac.

- “UV gel nail polish” or “UV gel” or “Gel” or “nail gel” is a premixed coating that is hardened using a UV or an LED lamp. UV gel nail polish typically contains color but can also be a clear coating.
- “UV gel base coat” is a clear coating that is used before applying other UV gel coatings to the nail; it is cured using a UV or an LED lamp.
- “UV gel top coat” is a clear coating that is used after applying other UV gel coatings to the nail; it is cured using a UV or an LED lamp.
- “Hard gel” is a premixed coating with high solvent resistance; it is hardened using a UV or an LED lamp. It can be applied directly onto natural nails to provide additional strength or sculptured using nail enhancements.
- “Shellac” is the brand name for a nail product created by Creative Nail Design. It is a hybrid which is a combination of nail polish and gel. Shellac is applied directly onto natural nails, and it is cured through UV light.

Nail coatings include “nail art paint,” which is any decorative paint including various solvent-based or UV gel nail coating overlays of nail polish, UV gel, or hybrid coatings like Shellac or airbrush paint applied to fingernails, toenails, or both by any technique. “Airbrush nail art paint” is a subcategory of “nail art paint.”

- “Airbrush nail art paint” means a nail art paint that is designed or intended to be sprayed onto the nail by a device using compressed air. This product may also be labeled as ink, polish, paint, or pigment for airbrush nail art.

“Nail polish thinner” means any liquid product that is marketed or sold for the use of reducing viscosity of nail coatings. It may be marketed for the use of increasing the fluidity or restoring the consistency of nail coatings.

Nail coatings include, but are not limited to, products that can be categorized by Global Product Classification (GPC) identified by the following codes (GS1 2018):

- Segment: 53000000 – Beauty/Personal Care/Hygiene

- Family: 53160000 – Cosmetics/Fragrances
  - Class: 53161200 – Nail Cosmetic/Care Products
    - Brick: 10000360 – Cosmetics – Nails (nail coatings)
    - Brick: 10000359 – Nails – False
      - Attribute: 20000292 – Type of False Nails
        - Value: 30004466 – FALSE NAILS UV GEL
      - Attribute: 20000794 – Type of Material
        - Value: 30004342 – UV ACTIVATED GEL

3.3 Alternatives Analysis Threshold Definition

The AAT is the threshold concentration of a Chemical of Concern in a Priority Product below which the manufacturer is exempt from performing an Alternatives Analysis (AA).[6] DTSC may set an AAT for a Chemical of Concern that is an intentionally added ingredient and must do so if the Chemical of Concern is a contaminant. The Department may also specify an Alternatives Analysis Threshold concentration greater than the applicable Practical Quantitation Limit (PQL) for any Chemical of Concern that is a contaminant. DTSC proposes an AAT of 100 ppm for toluene in nail products; the justification for this proposal is provided in Appendix 2.

3.4 Chemical and Product Use and Trends

Toluene is a high production volume chemical. Approximately 10 billion to 20 billion pounds per year of toluene are produced in the United States (U.S. EPA 2018c). Toluene is also found naturally in crude oil and in the tolu tree (ATSDR 2017). It is a constituent of gasoline and is used to make many products, including nail products (ATSDR 2017) such as nail coatings and nail polish thinners (FDA 2017). Toluene is used as a solvent in nail polish to suspend the color, to form a smooth finish across the nail, and to evenly adhere polish to nails (ATSDR 2017; Zhou et al. 2016). Toluene-based thinners are sometimes added to nail polish and other coatings to increase fluidity (DTSC 2012). Toluene is reported as an ingredient in more than 50 nail coatings and one nail polish thinner in the California Safe Cosmetics Program Product Database (CDPH 2019). Environmental Working Group's (EWG) Skin Deep cosmetics database lists eight nail products, including nail coatings and thinners, that contain toluene (EWG 2019). Mintel's Global New Products Database identifies 43 toluene-containing nail coating products introduced to the U.S. retail market, and 930 worldwide, since 2006 (Mintel 2018).

Analytical testing data confirms the use of toluene in nail products. Zhou et al. (2016) detected toluene in 26 out of 34 nail products analyzed, including base coats, top coats, nail polish thinners, gels, removers, and nail polishes, with concentrations ranging from 1.36 to 173,000 ppm (µg/g by weight) (up to 17.3 percent). DTSC found comparable concentrations in its own testing of nail products in 2012.

[6] California Code of Regulations, title 22, section 69505.3

In that study, 10 of 12 nail coating products labeled “toluene-free” contained toluene, ranging in concentration from 42 to 177,000 ppm (17.7 percent) (DTSC 2012). Further, eight of 13 nail coating products that made no claims to be toluene-free contained toluene at levels ranging from 110 to 120,000 ppm (0.011 percent to 12 percent) (DTSC 2012). DTSC recently conducted analytical laboratory testing of 157 retail and professional-use nail products and detected toluene in 27 nail coatings and nail polish thinners, at concentrations ranging from 31.4 ppm to 187,000 ppm (0.00314 percent to 18.7 percent) (DTSC 2021).

Use of nail products containing toluene in salons and at home has the potential to expose nail technicians and other salon workers, nail salon patrons, and nail product consumers to toluene. Nail technicians who work with toluene-containing products may experience daily chemical exposures, which can be exacerbated by their longer workdays and workweeks compared to employees in other sectors (Nails Magazine 2016; Quach et al. 2008). In California, there are more than 9,000 nail salons (Nails Magazine 2017) with 130,336 licensed manicurists (DCA 2017) and 314,552 cosmetologists (DCA 2018), many of whom use toluene-containing products. Toluene exposure is not just a concern for nail industry workers and their customers. Retail stores sell millions of nail products to consumers annually (Drug Store News 2016), and consumers are potentially exposed to toluene when they apply and remove toluene-containing nail products.

In California, chemical exposure of nail industry workers is an environmental justice issue,[7] as a large majority of nail industry workers are people of color and lower socioeconomic status (Quach et al. 2008). Approximately 59 to 80 percent of California nail salon workers are women of Vietnamese descent, many of whom face workplace safety challenges due to language barriers, limited education on chemical exposure from products, and limited availability and use of personal protective equipment (Quach et al. 2008; Quach et al. 2013). Clients receiving services in nail salons are exposed to harmful chemicals such as toluene on every visit (Ford 2014), and nail salon workers are potentially exposed to toluene daily.

[7] California law defines environmental justice as “the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations and policies.” (Government Code, section 65040.12, subdivision (e))

4 POTENTIAL ADVERSE IMPACTS

This section summarizes findings related to the potential adverse impacts of the Candidate Chemical as described in the SCP regulations. The emphasis of the adverse impact factors is to characterize the Candidate Chemical's toxicity and physical properties, and its mobility in the environment. The findings for this Candidate Chemical relate to the potential for one or more exposures described in Section 3 to contribute to or cause significant or widespread adverse impacts. Further clarification of each adverse impact factor is included below.

4.1 Physicochemical Properties

Reference: California Code of Regulations, title 22, section 69503.3(a)(1)(D).

Physicochemical properties can be helpful in predicting a chemical's behavior. A chemical's behavior in humans, wildlife, ecosystems, and the environment may indicate potential adverse public health and environmental impacts.

Table 1. Physical and chemical properties of toluene (NIH 2020c)

Property	Value
Color	Colorless
Physical state	Liquid
Molecular weight	92.139 g/mol
Density at 20 °C	0.8623 g/cm^3
Melting point	-94.9 °C
Boiling point	110.6 °C
Vapor density	3.1 (air = 1)
Vapor pressure at 25 °C	28.4 mm Hg
Henry's Law constant at 25 °C	6.64 x 10^{-3} atm·m^3/mol
Corrosivity	Noncorrosive liquid
Odor	Sweet, pungent, benzene-like odor
Odor threshold in air	2.14 ppm (8 mg/m^3)
Water solubility at 25 °C	526 mg/L
Solubility	Soluble in ethanol, benzene, diethyl ether, acetone, chloroform, glacial acetic acid, and carbon disulfide
Log octanol-water partition coefficient (Log K_{ow})	2.73
Log organic carbon-water partition coefficient (Log K_{oc})	1.57 to 2.25
Autoignition temperature	480 °C (896 °F)
Flashpoint	4 °C (40 °F, closed cup)
Lower explosive limit (LEL)	1.27 % by volume in air
Upper explosive limit (UEL)	7 % by volume in air
Conversion factor ppm (v/v) to mg/m^3 in air at 1 atm	1 ppm = 3.77 mg/m^3

4.2 Fate and Transport

4.2.1 Environmental fate

Reference: California Code of Regulations, title 22, section 69503.3(a)(1)(E).

Environmental fate describes a chemical's mobility in environmental media, transformation (physical, chemical, or biological), or accumulation in the environment or biota. A chemical's environmental fate in air, water, soil, and living organisms relates to its exposure potential hazard traits, as defined in the California Code of Regulations, Title 22, Chapter 54.

See Table 1 in Section 2.1 for physicochemical properties.

Nail product use or disposal is not expected to result in a significant release of toluene to soils or water. Toluene is a volatile chemical and is expected to partition into ambient air following its release to the environment. Toluene is not environmentally persistent and rapidly degrades in soil, air, and water (ATSDR 2017; NIH 2020c).

Air

Based on an estimated vapor pressure of 28.4 mm Hg at 25 °C and as a function of toluene's physical properties, toluene readily volatilizes into the ambient atmosphere. Vapor-phase toluene degrades in the atmosphere by reacting with photochemically produced hydroxyl radicals and has an estimated half-life of 13 hours (ATSDR 2017; Howard 1991) or two days (NIH 2020c). Based on atmospheric conditions, the actual half-life may range from 10 to 104 hours (ATSDR 2017; Howard 1991). This hydroxyl radical degradation reaction forms cresol and benzaldehyde, which break down further into basic hydrocarbons (Killus and Whitten 1982). Toluene is not expected to degrade by direct photolysis since it does not absorb light at wavelengths greater than 290 nm (NIH 2020c). Toluene is also oxidized by nitrogen dioxide, oxygen, and ozone in the atmosphere, but at a much lower rate than by the hydroxyl radical reaction. Toluene oxidation by nitrogen dioxide, oxygen, and ozone can form benzyl nitrate and nitrotoluene (Atkinson 1990), and toluene photooxidation can form compounds such as carbonyl products (Cao and Jang 2008).

Soil

Toluene is expected to have high to moderate mobility in soil based on its K_{oc} values of 37 to 178 (NIH 2020c). Volatilization of toluene from moist soil surfaces is expected, given its Henry's Law constant of 6.64×10^{-3} atm·m^3/mole, and toluene may volatize from dry soil surfaces based on a vapor pressure of 28.4 mm Hg at 25 °C. With small releases of toluene, rapid volatilization is expected. For large releases, toluene's high soil mobility may result in migration to groundwater in addition to volatilization to air. Complete biodegradation of toluene in soil was observed in lab tests (NIH 2020c). The biodegradation half-life in various soils was reported as ranging from several hours to 71 days (NIH 2020c). These results suggest that biodegradation is an important environmental fate process in soil. Toluene is rapidly broken down in soils via oxidation processes under aerobic conditions and via nitrate or sulfate interactions under anaerobic conditions (ATSDR 2017).

Water

Toluene is moderately water soluble (526 mg/L) and rapidly degrades via oxidative metabolism under aerobic conditions in surface waters. It is also metabolized under anaerobic conditions through nitrate, sulfate, and phosphate interactions and microorganisms. Toluene's biodegradation half-life in groundwater is estimated to range from seven to 28 days (ATSDR 2017). Toluene rapidly volatilizes from surface water to air, with the volatilization rate dependent upon the water body and temperature conditions. The biodegradation half-life of toluene in surface waters is estimated to range from four to 22 days (ATSDR 2017).

At room temperature, toluene is a liquid VOC as indicated by its Henry's Law constant of 6.64×10^{-3} $atm \cdot m^3/mol$. Toluene in nail products is expected to enter the environment primarily through evaporation into air and disposal into water via down-the-drain releases. Toluene may also be released to water in industrial effluents and by gasoline spills or leaks (ATSDR 2017).

A low log K_{ow} of 2.73 and measured bioconcentration factor of 8, 13, and 90 in herring, eels, and golden ide fish suggest toluene has a low likelihood to bioconcentrate in the fatty tissues of aquatic organisms (EC 2003; Franke et al. 1994).

4.2.2 Other harmful chemicals generated from the Candidate Chemical

Reference: California Code of Regulations, title 22, section 69503.3(a)(1)(G).

A Candidate Chemical may degrade, form reaction products, or metabolize into other chemicals that have one or more hazard traits. These metabolites, degradation products, and reaction products (which may or may not be Candidate Chemicals) may cause different adverse impacts from those of the parent chemical. In some cases, a Candidate Chemical's degradation or reaction products or metabolites may have the same hazard trait, and may be more potent or more environmentally persistent, or both, than the parent chemical. In such cases, adverse impacts may be more severe, or may continue long after, the Candidate Chemical's release to the environment.

Metabolism

In the human body, toluene is metabolized to the major metabolite hippuric acid and the minor metabolites ortho-cresol (o-cresol), meta-cresol (m-cresol), para-cresol (p-cresol), and benzaldehyde. DTSC lists ortho-, meta-, and para-cresol as Candidate Chemicals (DTSC 2020a), and CARB identifies ortho-, meta-, and para-cresol, as well as mixed cresols, as toxic air contaminants (CARB 2020). The U.S. EPA Integrated Risk Information System (IRIS) also lists o-cresol and m-cresol as neurotoxicants

(U.S. EPA 2005a). DTSC also lists the family of cresols, or mixed cresols, as Candidate Chemicals (DTSC 2020a), and ATSDR and OEHHA consider mixed cresols neurotoxicants (ATSDR 2011; OEHHA 2019).

Toluene is lipophilic and partitions into fatty tissues. The half-life in humans ranges from minutes to an hour based on the fat content of the compartment in the human body. Toluene distributes widely in the body and preferentially to the brain, liver, and kidney; it is capable of crossing the blood-brain barrier and the placenta, exposing the developing fetus to toluene (U.S. EPA 2005b). Most inhaled toluene is transformed and excreted in urine; however, a small amount is released unchanged in expired air (ATSDR 2017). In humans, toluene is metabolized primarily by cytochrome p450 monooxygenases, alcohol dehydrogenases, and aldehyde dehydrogenases, which convert it to benzoic acid, which in turn binds with glycine and forms the primary urinary metabolite hippuric acid. However, a small amount of toluene may undergo aromatic ring oxidation to form the Candidate Chemicals o-cresol, m-cresol, and p-cresol (ATSDR 2017; IARC 1999; Pierce et al. 2002; WHO 2000).

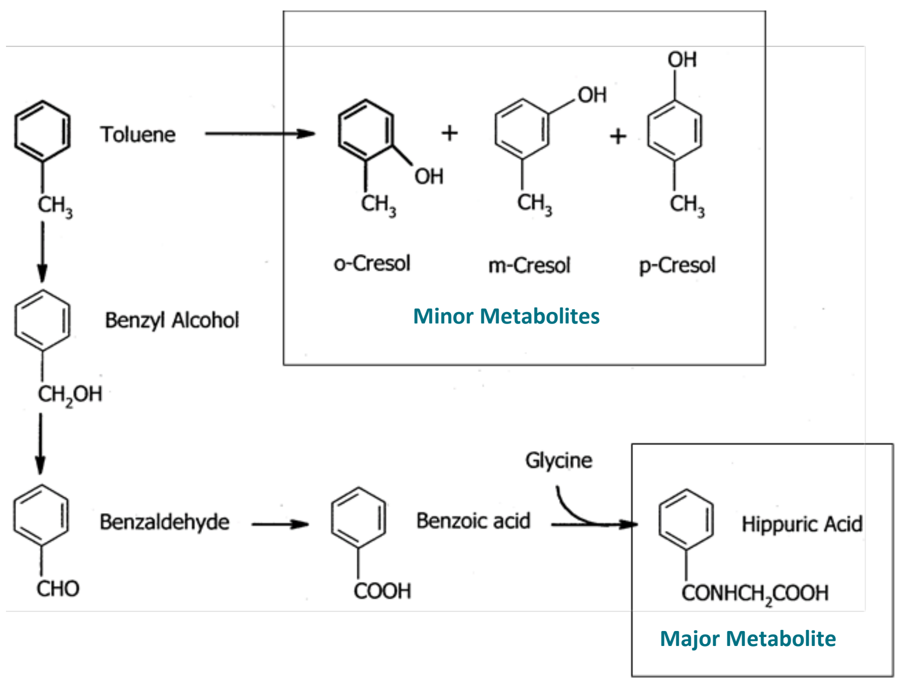

Figure 2. Pathways of toluene metabolism in humans (Pierce et al. 2002)

4.2.3 Behavior of the Candidate Chemical or its degradation products in the environment

Reference: California Code of Regulations, title 22, section 69503.3(b)(4)(H).

The Candidate Chemical and/or its degradation products can migrate into or distribute across different environmental media. These chemicals may persist or bioaccumulate in these environmental media or in biological tissues.

See Section 4.2.1 for additional information.

Toluene and its metabolites rapidly degrade across all environmental media and are not expected to accumulate in biological systems or persist in the environment. Volatilization to air is the predominant pathway for toluene release from the use and disposal of nail products (ATSDR 2017).

In 2010, CARB conducted a health risk assessment (HRA) of outdoor nail coating chemical emissions from nail salons. This HRA stated that outdoor air emissions from nail salons are not expected to have adverse health impacts to the public breathing the emissions outside of nail salons. This HRA focused on public health impacts from nail coatings emissions into outdoor air and did not evaluate the potential health impacts on nail salon workers from occupational chemical exposures (CARB 2010).

4.3 Hazard Traits and Environmental or Toxicological Endpoints

Reference: California Code of Regulations, title 22, section 69503.3(a)(1)(A).

The hazard traits and environmental or toxicological endpoints summarized in this section are defined in the SCP regulations sections 69501.1(a)(36) and (33), respectively, both of which refer to OEHHA's Green Chemistry Hazard Trait regulations (California Code of Regulations, title 22, Chapter 54).[8] These include exposure potential, toxicological, and environmental hazard traits.

The hazard trait studies on toluene discussed below focus primarily on adverse impacts resulting from inhalation, since inhalation is the primary exposure route of nail industry workers and nail product consumers. However, exposure may also occur through dermal application of products and orally, from accidental ingestion and hand-to-mouth behavior.

Neurotoxicity (California Code of Regulations, title 22, section 69503.12)

The Agency for Toxic Substances Disease Registry (ATSDR), the U.S. EPA Integrated Risk Information System (IRIS), the OEHHA Reference Exposure Level (REL) database, and the U.S. Centers for Disease Control and Prevention (CDC) Fourth National Report on Human Exposure to Environmental Chemicals all identify neurotoxicity as toluene's principal hazard trait (ATSDR 2017; CDC 2009; CDC 2017; CDC

[8] https://govt.westlaw.com/calregs/Browse/Home/California/CaliforniaCodeofRegulations?guid=I6E0E45C032A411E186A4EF11E7983D17&originationContext=documenttoc&transitionType=Default&contextData=%28sc.Default%29&bhcp=1

2019; OEHHA 2019; U.S. EPA 2005a). OEHHA has established a REL of 420 µg/m^3 (110 ppb) for chronic exposure, 830 µg/m^3 for 8-hour exposure (220 ppb), and 5,000 µg/m^3 (1,320 ppb) for acute exposure (OEHHA 2020a).

Neurotoxicity from toluene exposure is well documented in humans as well as experimental animals, and it is a significant hazard trait resulting from occupational inhalation exposure.

Toxic effects including dizziness, fatigue, headache, and decreased manual dexterity have been reported in workers chronically exposed to toluene in various occupational settings. Individuals who use toluene to get intoxicated have suffered similar adverse effects (ATSDR 2017). Neurotoxicity from toluene exposure is well documented in humans as well as experimental animals (ATSDR 2017; Hahn et al. 2019; U.S. EPA 2005a), and it is a significant hazard trait resulting from occupational inhalation exposure (U.S. EPA 2005a).

Most published human toluene exposure studies involve nervous system damage caused by toluene abuse or occupational exposure (Aydin et al. 2009; Aydin et al. 2002; Rosenberg et al. 1988a; Rosenberg et al. 1988b; Yucel et al. 2008). Chronic degenerative brain disorder has been observed in repeated toluene abusers. This disorder is characterized by potentially irreversible brain damage (Filey et al. 1990; Filley et al. 2004), which is characterized by a loss of gray and white matter differentiation and decreased blood flow to parts of the brain (specifically, to the cerebral cortex, basal ganglia, and thalami) (ATSDR 2017). Repeated toluene exposure has also been shown to cause brainstem, cerebral, and cerebellar atrophy (ATSDR 2017).

Occupational studies of toluene exposure include:

- Rotogravure printing[9] workers who were occupationally exposed to chronic mean toluene levels of 43 and 157 mg/m^3 (11 and 42 ppm), and more than 300 mg/m^3 (80 ppm) reported symptoms including fatigue (60 percent), recent short-term memory problems (60 percent), concentration difficulties (40 percent), and mood changes (27 percent) (Ørbæk and Nise 1989).

[9] Rotogravure printing is a "system of printing based on the transfer of fluid ink from depressions in a printing plate to the paper. It is an intaglio process, so called because the design to be printed is etched or engraved below the surface of the printing plate. At the start of the gravure printing process, the plate is covered with ink and the surface is then wiped clean. When paper is pressed against the inked plate, the paper penetrates the sunken parts slightly and draws out the ink." Encyclopædia Britannica (2020) Rotogravure printing. In. https://www.britannica.com/technology/rotogravure-printing Accessed March 2020

- Another study demonstrated that rotogravure printing workers exposed for 12-14 years to an average measured toluene concentration of 365 mg/m^3 (97 ppm) experienced a higher incidence of long-term auditory nervous system impacts compared to those in a group of workers of the same age (Abbate et al. 1993).
- Baelum et al. (1985) exposed two groups of subjects to 100 ppm (380 mg/m^3) toluene for 6.5 hours; one group consisted of printing workers with long-term occupational solvent exposure, and the other group had no history of solvent exposure. Both groups experienced decreased manual dexterity, decreased color discrimination, and decreased accuracy in visual perception compared to controls. Impairment of color perception after acute toluene exposure had previously been seen only in people with a long-term history of solvent exposure (Baelum et al. 1985).
- A 1990 study of 30 female workers in an electronic assembly plant found that toluene exposure affected manual dexterity, verbal memory, and visual cognitive ability (Foo et al. 1990). Similar effects were found in a follow-up study (Boey et al. 1997).
- Echeverria et al. (1989) exposed a group of 42 paid college students to toluene for seven hours over three days at three different exposure levels of 0, 75, and 150 ppm (0, 280 and 560 mg/m^3) and found that manual dexterity, verbal and visual short-term memory, and perception were affected in subjects with the highest toluene exposure level of 150 ppm (560 mg/m^3). In this study, the incidence of headaches and eye irritations also increased with increasing dose levels (Echeverria et al. 1989).
- Eller et al. (1999) found that workers occupationally exposed to lower levels of toluene (greater than 100 ppm) for more than 12 years exhibited a range of self-reported neurological symptoms including concentration difficulties, impaired memory, and visual impairments.

Low-level toluene exposure in occupational settings may result in adverse outcomes:

- Kang et al. (2005) demonstrated that exposure to toluene in occupational settings at concentrations below 100 ppm is linked to neurobehavioral changes, and high-concentration toluene exposure could cause attention and concentration impacts as well as motor performance deficits.
- Chouaniere et al. (2002) conducted a cross-sectional study of workers at two printing plants who were exposed to very low levels of toluene (less than 40 ppm) and found associations between these exposures and reductions in memory test performances.
- Other research studies concluded that low-level exposure to neurotoxicants common to nail salons may result in mild cognitive and neurosensory changes similar to those observed among solvent-exposed workers in other settings (LoSasso et al. 2001; LoSasso et al. 2002).

Several animal studies illustrate neurotoxicity linked to toluene exposure:

- Toluene exposure via inhalation affects behavior, memory, and motor coordination (Forkman et al. 1991; von Euler et al. 1993).
- Oxidative stress in the brain may contribute to toluene-induced neurotoxic outcomes as demonstrated by Kodavanti et al. (2015), who conducted acute (six-hour) and subchronic studies (six hours per day, five days per week for 13 weeks) assessing the effects on rats exposed to toluene vapor on a variety of endpoints of oxidative stress. Their results showed that subchronic exposure affected oxidative stress parameters more than the acute exposures did (Kodavanti et al. 2015).
- Hillefors-Berglund et al. (1995) demonstrated increased dopamine binding in rats' brains following chronic, low-dose (80 ppm and above) toluene inhalation exposure.
- Berenguer et al. (2003) also showed changes in neurotransmitter signaling following subchronic inhalation exposure of rats to 40 ppm toluene.
- A review by Win-Shwe and Fujimaki (2010) suggests that toluene, as shown in animal experiments, can adversely affect the hippocampus following acute and chronic inhalation exposure. The potential mechanisms involved in toluene toxicity in the brain may include the dysregulation of the neurotransmitter glutamate, the excretion of proinflammatory proteins, and increased oxidative stress (Win-Shwe and Fujimaki 2010).
- A number of other animal studies have also shown neurotoxic effects in rats following acute toluene exposure (ATSDR 2017; Bowen and Balster 1998; Bushnell et al. 1985; Conti et al. 2012; Hogie et al. 2009; Huerta-Rivas et al. 2012; Kim et al. 1998; Kishi et al. 1988; López-Rubalcava et al. 2000; Mullin and Krivanek 1982; Páez-Martinez et al. 2008; Páez-Martinez et al. 2003; Taylor and Evans 1985; Tomaszycki et al. 2013; Wood and Colotla 1990; Wood et al. 1983).

Developmental Toxicity (California Code of Regulations, title 22, section 69402.3)

The California Proposition 65 list, the OEHHA REL database, and the CDC Fourth National Report on Human Exposure to Environmental Chemicals identify toluene as a developmental toxicant (CDC 2009; CDC 2017; CDC 2019; OEHHA 1991; OEHHA 2019).

Animal studies clearly identify toluene as a developmental toxicant:

- A review by Donald et al. (1991) demonstrated in rats and mice that impaired fetal growth rate following prenatal exposure to toluene is the most consistently observed developmental endpoint in animal studies, as demonstrated by decreased pup weight and retarded skeletal development.
- One study found an association between maternal toluene exposure during pregnancy and decreased birth weight in rats, which persisted in male offspring into adulthood; maternal

malnutrition increased fetal susceptibility to the effects of toluene, as indicated by effects on development of the skeleton (da Silva et al. 1990).

- Ungváry and Tátrai (1985) exposed mice to toluene via inhalation during pregnancy and saw decreased pup weight and abnormal skeleton development.
- In a separate study, fetuses of pregnant mice exposed to toluene via inhalation during pregnancy had additional or missing ribs (Courtney et al. 1986).
- In another study, high-dose (2,000 ppm) inhalation exposure of toluene during pregnancy caused weight suppression in mothers and offspring, high fetal mortality, and embryonic growth retardation in rats, but no fetal skeletal abnormalities were observed (Ono et al. 1995). However, skeletal abnormalities were observed when investigators attempted to mimic inhalation toluene abuse patterns in pregnant rats (Bowen et al. 2009).

> Toluene exposure during pregnancy is associated with a greater risk of delivering low body weight offspring.

In addition:

- Bowen and Hannigan (2013) found that rat pups that had been exposed *in utero* to toluene via inhalation experienced a reduction in postnatal growth.
- Roberts et al. (2003) and Roberts et al. (2007) observed that exposure of pregnant rats to toluene via inhalation resulted in maternal and developmental adverse outcomes, including lower than average pup birth weight and skeletal anomalies.
- Soberanes-Chávez et al. (2013) showed that exposure to toluene combined with stress during pregnancy resulted in lowered body weight gain in both mothers and offspring, as well as endocrine effects in mothers and decreased offspring food intake during the first weeks of life.
- A number of other studies demonstrated that toluene exposure during pregnancy resulted in developmental toxicity (Bowen et al. 2005; Bowen and Hannigan 2006; Gospe and Zhou 1998; Gospe and Zhou 2000; Jones and Balster 1997; Shigeta et al. 1982).
- A review and comparison of multiple animal studies demonstrated that increasing toluene exposure during pregnancy is associated with a greater risk of delivering low body weight offspring. Dose, administration route, animal weighing date, and animal model used all affected this association (Callan et al. 2016).

Expectant mothers who inhale toluene as a drug of abuse have given birth to infants with physical and developmental defects similar to fetal alcohol syndrome (Hannigan and Bowen 2010). These include mental deficiencies, facial malformations, abnormally small head size, and deformities in the fingertips (Arnold et al. 1994; Arnold and Wilkins-Haug 1990; ATSDR 2017; Erramouspe et al. 1996; Goodwin 1988; Hersh 1989; Hersh et al. 1985; Lindemann 1991; Pearson et al. 1994; Wilkins-Haug and Gabow 1991).

Cosmetologists are routinely exposed to a wide range of VOCs, including toluene, and studies illustrate some adverse pregnancy outcomes for cosmetologists compared to those of other working populations:

- Halliday-Bell et al. (2009) found that cosmetologists had a 50 percent higher risk than teachers of having babies who were small for their gestational age.
- Herdt-Losavio et al. (2009) compared pregnancy outcomes of 15,003 New York State licensed cosmetologists (hair and nail technicians), 4,246 licensed Realtors, and 12,171 mothers from the general population. They found an increased risk of low birth weight among newborns of cosmetologists compared with newborns of Realtors and newborns in the general population.
- Quach et al. (2015) observed increased risk among Vietnamese manicurists and cosmetologists in California of giving birth to babies that are smaller for their gestational age than those born to women working in other sectors.
- In a study of 8,356 North Carolina cosmetologists, investigators found associations between spontaneous abortion and the number of hours worked per day in cosmetology, the number of chemical services performed per week, and work in salons where nail sculpturing was performed by other employees (John et al. 1994).

The effects reported in these studies were not attributed to toluene exposure alone. However, it is noteworthy that developmental toxicity was observed, given that toluene is a developmental toxicant present in some nail products.

Neurodevelopmental Toxicity (California Code of Regulations, title 22, section 69403.11)

While decreased body weight is toluene’s most consistently observed developmental endpoint, there is also evidence that toluene exposure may result in neurodevelopmental toxicity (Grandjean and Landrigan 2006):

- Laslo-Baker et al. (2004) showed that *in utero* exposure to organic solvents in the workplace is associated with impacts to cognitive function, language, and behavior.
- Hass et al. concluded that inhalation exposure to toluene during brain development resulted in prolonged neurodevelopmental toxicity in rats, as evidenced by increased motor activity in both sexes and impaired cognitive function in female offspring (Hass et al. 1999).

- Hougaard et al. (1999) showed effects on cognitive function among pups of rats exposed *in utero* to toluene. These effects on cognitive function were most pronounced in female offspring (Hougaard et al. 1999).
- Samuel-Herter et al. (2014) found age-dependent neurobiological effects when rats, ranging from adolescence to adulthood, were exposed to toluene via inhalation. The age of the rats at the time of exposure affected the time of recovery of motor functions resulting from intoxication.
- Chen et al. (2011) demonstrated that exposing rats to toluene during brain growth spurt and adolescence resulted in signaling biochemical changes in the hippocampus, which in turn could lead to neurobehavioral disturbances. This is notable since the hippocampus is responsible for memory and learning processes in the developing brain (Bauer and Pathman 2008).
- Interestingly, Win-Shwe et al. (2012) found that the pups of mice exposed to low levels of toluene (5 or 50 ppm) in air while pregnant exhibited increases of neuroinflammatory gene expression relative to controls. Changes in gene expression may indicate the potential for later changes in related proteins and toxic outcomes.
- A number of other researchers also demonstrated neurodevelopmental toxicity following toluene exposure (Arnold et al. 1994; Hersh 1989; Hersh et al. 1985; Pearson et al. 1994; Till et al. 2001; Till et al. 2005).

Respiratory Toxicity (California Code of Regulations, title 22, section 69403.1)

The OEHHA REL database and the CDC Fourth National Report on Human Exposure to Environmental Chemicals identify toluene as a respiratory toxicant (CDC 2009; CDC 2017; CDC 2019; OEHHA 2019).

Several studies report respiratory tract irritation due to intentional or accidental toluene exposure via inhalation:

- Deschamps et al. (2001) reported mucous membrane irritation in workers chronically exposed to toluene. Controlled studies of human exposure to toluene have shown similar results (Ørbæk et al. 1998; Österberg et al. 2003).
- Echeverria et al. (1989) and Andersen et al. (1983) reported nasal irritation in humans after acute exposure to airborne toluene at concentrations of 100 ppm (376.85 mg/m^3).
- Experimental animal studies also documented nasal irritation (ATSDR 2017). Specifically, the National Toxicology Program (NTP) demonstrated that inhalation exposure of both mice and

rats to toluene resulted in deterioration of the olfactory[10] and respiratory epithelium[11] and inflammation of the lining of the nasal cavity (NTP 1990).

- Chronic toluene abuse in humans is associated with lung damage and emphysema (Schikler et al. 1984).

One study of nail technicians demonstrated a higher prevalence of reported upper and lower respiratory symptoms in comparison to nonexposed controls; however, the cause or causes of the symptoms cannot be determined from this study design, as no clinical assessment was carried out (Harris-Roberts et al. 2011).

Nephrotoxicity (California Code of Regulations, title 22, section 69403.10)

The U.S. EPA IRIS identifies the kidney as a critical noncancer target following chronic oral exposure (U.S. EPA 2005a). NTP demonstrated increased kidney weight in mice and rats following oral exposure to toluene (NTP 1990). Numerous studies in humans support this finding; they document kidney damage after intentional, acute inhalation exposure to toluene (Bonzel et al. 1987; Bosch et al. 1988; Caravati and Bjerk 1997; Fischman and Oster 1979; Kamijima et al. 1994; Kroeger et al. 1980; O'Brien et al. 1971; Streicher et al. 1981; Taher et al. 1974; U.S. EPA 2005b). Abuse of toluene is associated with metabolic acidosis (i.e., acid accumulation in the body), hyperchloremia (i.e., abnormally high blood chloride levels), and hypokalemia (i.e., abnormally low blood potassium levels) – all signs of kidney damage (Batlle et al. 1988).

Dermatotoxicity (California Code of Regulations, title 22, section 69403.2)

Toluene is absorbed through skin (Aitio et al. 1984; ATSDR 2017; Boman et al. 1995; Brown et al. 1984; Bruckner and Peterson 1981a; Dutkiewicz and Tyras 1968; Sato and Nakajima 1978; Weschler and Nazaroff 2014), and a combination of solvents may enhance the penetration of toluene through the skin (ATSDR 2017). Dermal toluene exposure can cause skin irritation in humans, possibly due to its propensity to remove protective skin oils (ATSDR 2017; Matsushita et al. 1975; Winchester and Madjar 1986). Dermal exposure studies in guinea pigs, mice, and rabbits suggest that undiluted toluene is slightly to moderately irritating to the skin (Anderson et al. 1986; ATSDR 2017; Kronevi et al. 1979; Saito et al. 2011; Wolf et al. 1956).

Immunotoxicity (California Code of Regulations, title 22, section 69403.8)

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[10] The olfactory epithelium is specialized epithelial tissue inside the nasal cavity that is involved in smell.

[11] Respiratory epithelium is a type of ciliated epithelial tissue which lines most of the respiratory tract, where it serves to moisten and protect the airways.

The State Water Resources Control Board (SWRCB) established a Maximum Contaminant Level for toluene in drinking water based on immunotoxicity (OEHHA 1999; SWRCB 2018). Hsieh et al. showed a variety of immunotoxic effects including decreased thymus weight[12] and dose-dependent effects on suppression of antibody response; however, more studies are needed to confirm these effects (Hsieh et al. 1990; Hsieh et al. 1989; Hsieh et al. 1991).

Cardiovascular Toxicity (California Code of Regulations, title 22, section 69403.1)

Cardiac arrhythmia (i.e., irregular heart rate), tachycardia (i.e., fast heart rate), and bradycardia (i.e., slow heart rate) have all been reported in humans following acute toluene inhalation exposure (Anderson et al. 1982; ATSDR 2017; Camara-Lemarroy et al. 2015; Einav et al. 1997; Meulenbelt et al. 1990; Shibata et al. 1994; Vural and Ogel 2006). Death due to cardiac arrhythmia following intentional toluene inhalation has also been reported (ATSDR 2017). Of interest, animal studies with high-dose inhalation of toluene showed no impacts to the cardiovascular system (NTP 1990), and other laboratory animal studies do not provide convincing support for cardiovascular toxicity following toluene inhalation exposure (ATSDR 2017; Bruckner and Peterson 1981b; CIIT 1980; NTP 1990). Some individuals may be more susceptible than others to potentially fatal arrhythmias due to differences in cardiac response to toluene (ATSDR 2017).

Hepatotoxicity (California Code of Regulations, title 22, section 69403.7)

SWRCB established an MCL for toluene in drinking water based on hepatotoxicity (OEHHA 1999; SWRCB 2018). However, studies focused on chronic toluene abusers or occupationally exposed humans present conflicting findings on the potential liver impacts of toluene exposure (Bruckner and Peterson 1981b). Animal studies have yielded similarly inconsistent results (ATSDR 2017; Dick et al. 2014; Gotohda et al. 2009; Kanter 2012; Meulenbelt et al. 1990; NTP 1990; Tähti et al. 1983; Tas et al. 2013; Tas et al. 2011; Ungváry et al. 1982; Wang et al. 1996).

Ocular Toxicity (California Code of Regulations, title 22, section 69403.13)

The CDC Fourth National Report on Human Exposure to Environmental Chemicals identifies ocular toxicity as a hazard trait following toluene exposure (CDC 2009; CDC 2017; CDC 2019). Kiyokawa et al. (1999) reported that a group of 15 patients had severe vision effects, specifically optic nerve damage, after prolonged toluene abuse. Two independent studies evaluated the effects of occupational toluene vapor exposure on color perception and demonstrated a significant impairment compared to controls (Muttray et al. 1999; Zavalic et al. 1998a). Further, Echeverria et al. (1989) observed that eye irritations increased with increasing dose levels of toluene in a group of 42 paid college students exposed to toluene for seven hours over three days at three different exposure levels (0, 75, and 150 ppm or 0,

[12] Lower weight of the thymus, a specialized organ of the immune system, signifies potential adverse impact to the immune system.

280 and 560 mg/m^3). A significant number of human studies provide further evidence of ocular toxicity from toluene exposure (Andersen et al. 1983; Baelum et al. 1985; Campagna et al. 2001; Cavalleri et al. 2000; Gupta et al. 2011; Muttray et al. 1997; Muttray et al. 2019; Zavalic et al. 1998a; Zavalic et al. 1998b; Zavalic et al. 1998c).

Ototoxicity (California Code of Regulations, title 22, section 69403.14)

The CDC Fourth National Report on Human Exposure to Environmental Chemicals identifies ototoxicity as a hazard trait following toluene exposure (CDC 2009; CDC 2017; CDC 2019). McWilliams et al. (2000) demonstrated that toluene exposure for up to four weeks in guinea pigs resulted in reversible hearing loss, while Pryor et al. (1984) demonstrated that toluene-induced hearing loss in male rats persisted over a three-month period. Occupational studies assessing hearing loss suggest that short-lived mid- and high-frequency hearing loss occurs at inhaled toluene exposure concentrations greater than 50 ppm (ATSDR 2017). Occupational exposure to an average of 122 ppm toluene may lead to hearing loss (Morata et al. 1997). Other studies have also demonstrated that toluene exposure can adversely impact hearing quality (Abbate et al. 1993; Campo et al. 1997; Campo et al. 1998; Campo et al. 1999; Hsu et al. 2015; Lange and Condello 2017; Morata et al. 1997; Vrca et al. 1997; Vrca et al. 1996).

4.4 Related Chemicals and Their Adverse Impacts

4.4.1 Cumulative effects with other chemicals

Reference: California Code of Regulations, title 22, section 69503.3(a)(1)(C).

Cumulative effects occur from cumulative exposures to the Candidate Chemical and other chemicals with similar hazard traits or endpoints.

Nail salon workers are chronically exposed to several different chemicals simultaneously. A study of California nail salons measured work-shift VOC concentrations of toluene (0.02–1.0 ppm), ethyl acetate (0.02–5.50 ppm), and isopropyl acetate (0.02–0.15 ppm) in indoor air. The maximum toluene concentrations were much higher than the World Health Organization (WHO) recommended guideline of 0.26 mg/m^3 (0.069 ppm) and OEHHA's REL of 0.11 ppm (0.420 mg/m^3) for toluene in indoor air (OEHHA 2020a; Quach et al. 2011; WHO 2000). Nail salon workers reported health problems including headaches and eye, nose, and throat irritation (Quach et al. 2011). In another study, Nguyen (2016) measured indoor air VOC concentrations at eight Los Angeles nail salons, reporting average concentrations of acetone, isopropyl alcohol (IPA), and methyl methacrylate (MMA) as much as six times higher than those measured in other nail salon indoor air quality studies in Alameda County, California, by Quach (Quach et al. 2011) and Salt Lake City, Utah (Alaves et al. 2013).

Some studies indicate potential interactions between toluene and other chemicals may adversely impact metabolism, chemical excretion, and resulting toxicity. Simultaneous metabolism of toluene and xylene was reduced after co-exposure to high concentrations of both chemicals (ATSDR 2017;

Tardif et al. 1991; Tardif et al. 1992). Similarly, while co-exposure of toluene, methyl ethyl ketone (MEK), and IPA at low concentrations in rats had no effect on the urinary excretion of the toluene metabolite hippuric acid, co-exposure to concentrations of MEK and IPA that were more than twice that of toluene resulted in reduced toluene metabolite levels in urine (ATSDR 2017; Uaki et al. 1995). This may be relevant to nail salons due to the presence of MEK, isopropyl alcohol, and toluene in various nail products. In fact, MEK, IPA, and toluene were all detected in nail salons in the greater Los Angeles area (Nguyen 2016). These studies indicate the potential for toluene and other volatile organic solvents to operate under similar mechanisms of metabolism. In general, metabolic pathways for high doses of toluene, MEK, and IPA appear similar, and co-exposure to these chemicals from nail products may result in decreased chemical excretion from the body and increased adverse effects. However, it is unknown what levels of mixed chemical exposure could alter human metabolism and excretion of these chemicals. More studies are needed to understand these interactions and their role in contributing to adverse impacts.

4.4.2 Structurally or mechanistically similar chemicals

Reference: California Code of Regulations, title 22, section 69503.3(a)(3).

Some chemicals may lack sufficient data to definitively establish presence or absence of harm. In such cases, DTSC may also consider data from other chemicals closely related structurally to the Candidate Chemical to identify potential public health and environmental impacts.

DTSC is not basing its proposal on this factor.

4.5 Populations That May Be Harmed by the Candidate Chemical

4.5.1 Human populations and nonhuman organisms that may experience adverse impacts from exposure to the Candidate Chemical

Reference: California Code of Regulations, title 22, section 69503.3(a)(1)(F).

This section identifies specific populations of humans and environmental organisms that may be harmed if exposed to the Candidate Chemical, based on the hazard traits identified in Section 2.3 and the type of exposures (e.g., single, intermittent, or chronic).

See Section 4.3, Section 4.4, Section 5.2, and Section 5.3 for additional information.

Toluene has the potential to contribute to or cause adverse impacts to humans, especially chronically exposed populations such as nail industry workers, and sensitive subpopulations such as pregnant women, fetuses, infants, children, and adolescents.

Nail salon customers, nail product consumers, and their infants and children may potentially be exposed to toluene from nail products. Nail salon customers and nail product consumers may experience inhalation, dermal, or oral toluene exposure. Patrons and consumers generally experience less frequent, shorter-duration toluene exposures than nail salon workers and, consequently, their likelihood of experiencing adverse impacts from toluene exposure from nail products is correspondingly lower. Infants and children who accompany their parents to work at nail salons or use nail products themselves may also be exposed to toluene in nail products.

4.5.2 Sensitive subpopulations, species, or environments that have the potential for adverse impacts from exposure to the Candidate Chemical

Reference: California Code of Regulations, title 22, sections 69503.3(a)(1)(F) and 69503.3(a)(2).

Sensitive subpopulations, environmentally sensitive habitats, endangered and threatened species, and impaired environments have special consideration as they may be more vulnerable than the general population.

Sensitive subpopulations that may be impacted by exposure to toluene from nail products include nail industry workers, pregnant women (including their fetuses), infants, children, and adolescents.

Nail industry workers may be frequently impacted by exposure to toluene in the workplace, and some nail technicians work while pregnant; thus, their fetuses are also at risk of toluene exposure. Nail salon workers may have daily exposure to toluene. They often have longer workdays and workweeks compared to employees in other sectors (Quach et al. 2008). California's nail industry work force is composed of approximately 130,000 licensed nail technicians (DCA 2017). According to the U.S. Census Bureau, 90 percent of all nail salons in California are minority-owned, and 68 percent of salons are Vietnamese-owned (U.S. Census Bureau 2012). Reportedly, 97 percent of U.S. nail technicians are female, and many are of childbearing age (Nails Magazine 2017). Pregnant women and their fetuses may be at greater risk of adverse impacts from toluene exposure (Bowen and Hannigan 2006; Hannigan and Bowen 2010; Quach et al. 2008; Quach et al. 2013). (See Section 4.3 of this document for studies describing toluene-related developmental toxicity.)

Studies indicate that nail salon workers may suffer from a higher incidence of certain health problems than the general population. For instance, a 2008 study examined self-reported health effects of nail salon workers participating in a community outreach program (Roelofs et al. 2008). The nail salon workers surveyed were predominantly Vietnamese, female, and generally worked long hours (Roelofs et al. 2008). Health effects reported included musculoskeletal disorders, respiratory symptoms, skin problems, and headaches (Roelofs et al. 2008). In addition to higher incidences of specific health problems, a recent study suggests that nail care technicians experience a faster deterioration of their overall health compared to controls as a result of chronic exposure to low levels of VOCs (Grešner et al. 2017). However, there is currently insufficient evidence linking toluene exposure to exacerbation of respiratory conditions such as asthma and chronic obstructive pulmonary disease (COPD) (Nurmatov et al. 2015).

Studies indicate that nail salon workers may suffer from a higher incidence of certain health problems than the general population.

In California, chemical exposure of nail industry workers is an environmental justice issue, as a large majority of these workers are people of color and of lower socioeconomic status. It is estimated that 59 to 80 percent of nail salon workers in California are women of Vietnamese descent (Quach et al. 2008). Many of these workers face workplace safety challenges due to language barriers, limited education on chemical exposure from products, and limited availability and use of personal protective equipment (Quach et al. 2008; Quach et al. 2013). In addition, evidence suggests that some Asian populations may be genetically sensitive to toluene due to a defective gene for the aldehyde dehydrogenase enzyme, which leads to a decreased rate of toluene metabolism (Greenberg 1997).

Infants and children are especially vulnerable to toluene exposure from nail products if they accompany their parents to work at a nail salon or are nail salon customers. Even if they are not directly exposed to toluene-containing nail products, nursing infants and children may be exposed to toluene through their mothers' milk (Fabietti et al. 2004). Infants and children are a sensitive subpopulation due to their increased ingestion and inhalation rates per unit of body weight, rapid development, immature physiological ability to detoxify environmental contaminants, and behavioral characteristics that predispose them to increased exposures to environmental contaminants (U.S. EPA 2011). Further, studies demonstrate that infants and children have differences in metabolic enzyme levels, including differences in several phase II detoxification enzymes, compared to adults (Leeder and Kearns 1997; Nakajima et al. 1992; Vieira et al. 1996). Other studies show that infants and children have higher brain mass per unit of body weight, higher cerebral blood flow per unit of brain weight, and higher breathing rates per unit of body weight than adults (Miller et al. 2002). These differences result in greater sensitivity of infants and children and increased likelihood or severity of adverse impacts.

Nail salon customers, who may include pregnant women and children, may be exposed to toluene at nail salons and at home. In a 2010 personal-care product-use survey of 604 households in Northern and Central California, Wu et al. (2010) found that 45 percent of girls 5 years old and younger use nail polish, and this increased to 79 percent for girls over 5. This study showed a correlation between nail product use by parents and children in the same household, suggesting that either parents use nail products on their children or that parental use patterns influence those of their children, resulting in exposure to chemicals in the products (Wu et al. 2010).

Evidence suggests that females may be more susceptible to health effects from toluene exposure compared to men. Bowen et al. (2007) found that both single and repeated toluene exposures affected rats' locomotion, an endpoint commonly used to assess neurological impacts; these effects were more pronounced in females of all ages than in age-matched males. Similarly, Hass et al. (1999) observed greater learning and memory effects in female offspring of rats exposed to toluene via inhalation during pregnancy than in their male offspring. A similar outcome was observed in a human occupational study, where female workers in the printing industry exposed to different daily toluene concentrations at work showed a decrease in fertility compared to men (Plenge-Bönig and Karmaus 1999). As mentioned earlier, many nail salon technicians are females of childbearing age and therefore may be more sensitive to adverse outcomes elicited by toluene exposure.

5 FACTORS RELATED TO POTENTIAL EXPOSURE TO THE CANDIDATE CHEMICAL IN THE PRIORITY PRODUCT

This section summarizes significant findings related to the exposure factors that are relevant to this product-chemical combination, because they may contribute to or cause significant or widespread adverse impacts. Further clarification of each exposure factor is included below.

5.1 Presence and Use Patterns of the Product

5.1.1 Market presence of the product

Reference: California Code of Regulations, title 22, sections 69503.3(b)(1)(A) and (B).

Product market presence information may be used as a surrogate to assess potential exposures to the Candidate Chemical in the product. This information may include statewide sales by volume, the number of units sold, amount of sales generated, or information on the targeted customer base.

Toluene, formaldehyde, and DBP have been historically called the "toxic trio" when used together in nail products. While nail product manufacturers have largely phased out the use of formaldehyde and DBP, multiple nail products still contain toluene. These include nail polishes and other nail coatings, nail hardeners, nail polish thinner, and polish removers (CDPH 2019; EWG 2019; FDA 2017; Mintel 2018).

Multiple studies and databases report the presence of toluene in nail products. Zhou et al. (2016) detected toluene in 26 out of 34 nail products analyzed, including base coats, top coats, nail polish thinners, gels, removers, and nail polishes. EWG's Skin Deep cosmetics database lists eight nail products, including nail coatings and thinner, containing toluene as an ingredient (EWG 2019). Toluene is reported as an ingredient in more than 50 nail coatings and one nail polish thinner in the California Safe Cosmetics Program Product Database (CDPH 2019). Mintel's Global New Products Database identifies 43 toluene-containing nail coating products introduced to the U.S. retail market, and 930 worldwide, since 2006 (Mintel 2018). Mintel and the EWG's databases include only retail nail products (not intended for professional use); Mintel's data is limited to products under $25. Therefore, there may be a greater number of toluene-containing nail products available for sale or purchase in California. In 2020, DTSC conducted an information call-in to request ingredient information on various nail products from manufacturers, importers, assemblers, retailers, distributors, and trade associations (DTSC 2020b).[13] Toluene was reported in 11 nail products as an added ingredient at concentrations ranging from 5 to 25 percent (DTSC 2020b). Toluene was also reported as a contaminant in 172 nail products at concentrations of 0.1 percent or less. (See Appendix 3.) Additionally, DTSC conducted

[13] DTSC received partial product data for the information call-in request. Therefore, product counts are considered estimates rather than exact number of products.

analytical laboratory testing of 157 retail and professional-use nail products and detected toluene in 27 nail products at concentrations ranging from 31.4 ppm to 187,000 ppm (0.00314 percent to 18.7 percent) (DTSC 2021). (See Appendix 4.)

U.S. Census data and Simmons National Consumer Survey data calculated by Statista showed that 105.41 million women in the United States used nail polish or other nail products in 2017 (Statista 2017a), and this figure is projected to increase to 122.65 million in 2020 (Statista 2017b). Sales of various nail products from U.S. retail outlets exceed $1 billion per year (Drug Store News 2016). From June 2015 to May 2016, nail polish sales exceeded $741 million (or 204 million products sold) at chain drug stores, supermarkets, discount stores, and club and dollar stores (Drug Store News 2016).

The number of nail salons in California, recent revenue figures, the number of nail salon workers, and the types of services they provide all illustrate the potential for exposure to toluene and other chemicals from professional nail products and services. In 2016, $8.53 billion was spent on nail services in the United States (Nails Magazine 2017). In California alone, there are more than 9,000 nail salons (Nails Magazine 2017) with 130,336 licensed manicurists (DCA 2017) and an additional 314,552 licensed cosmetologists (DCA 2018). According to one survey, 95 percent of U.S. nail technicians offer nail polish services, 67 percent offer UV gels, 84 percent offer acrylics, and 82 percent offer nail art (Nails Magazine 2015).

Toluene exposure is not just a concern for nail industry workers and their customers. Retail stores sell millions of nail products to consumers annually (Drug Store News 2016), and consumers are potentially exposed to toluene when they apply and remove toluene-containing nail products. Acrylic nail products, nail polishes, and gel nail products that contain toluene are sold in retail stores and local beauty supply stores (EWG 2019; SF Environment 2017).

$8.53 billion was spent on nail services in the United States in 2016.

UV gels and gel polishes are among the nail products that may contain toluene. UV gels (also known as gel nails) have become a popular product at nail salons. UV gels are more durable than traditional nail polish and are easier to apply and remove compared to acrylics. As stated above, roughly 67 percent of nail technicians offer UV gels at their salons (Nails Magazine 2015). Gel polish is also a popular option for at-home use. Gel polish has the look, feel, and long-lasting quality of traditional UV and LED gels but does not require a UV or LED light to dry. Ten percent of women who apply nail polish at home report that they use gel polish (Romanowski 2015). U.S. at-home gel polish sales revenue in 2012 totaled $25 million and is expected to grow in subsequent years (Brookman 2013).

5.1.2 Intended use of the product

Reference: California Code of Regulations, title 22, sections 69503.3(b)(1)(C) and 69503.3(b)(4)(D)1.

Potential exposures can also be inferred by assessing how a product is typically used, the typical useful life (i.e., replacement frequency) of durable products, the typical rate of consumption of consumable products, the frequency of use, and the typical quantity consumed per use. The SCP regulations give special consideration to household and recreational use.

See Section 3.2, Section 5.1.1, and Section 5.2.2 for additional information.

The use of nail products containing toluene in salons and at home has the potential to expose nail technicians and other salon workers, nail salon patrons, and nail product consumers to toluene. Nail technicians who work with toluene-containing products may experience daily chemical exposures, which can be exacerbated by their longer workdays and workweeks compared to employees in other sectors (Nails Magazine 2016; Quach et al. 2008).

The frequency of consumer nail polish application and removal varies, but it is common for some nail salon customers to get a professional manicure every one to two weeks and to self-apply a top coat every two to three days (Sally Beauty Supply 2017). The frequency of other nail product services also varies.

In a 2010 study, data on use patterns of 30 personal care product types were collected from 604 households in Northern and Central California (Wu et al. 2010). Nail polish use frequency data was collected for female participants from various age groups. Female participants in this study included children, their mothers, and adults who were 55 years old or older in 2010 (Wu et al. 2010). The frequency of professionally applied and self-applied nail polish uses for adult females and child participants is shown in Table 2 (Wu et al. 2010).

Table 2. Nail polish use frequency per month for female participants in California in 2010 (Wu et al. 2010)

Participant Type and Age (in years)	Number of Participants	Nail Polish Self Use %	Nail Polish Professional Salon Use %
Adult < 55*	374	53	81
Adult > 55	99	39	77
Child $\leq$ 5	185	45	---
Child > 5	31	79	---

**All participants under 55 years of age had young children at home.*

***Participants older than 16 years old are considered as adults in this study.*

****In this study, the mothers with less than 12 years of education were oversampled to counter the well-known low rates of participation in research for this socio-demographic group.*

The majority of adult female participants in the study, in both age groups, received professional nail services more frequently than they self-applied nail polish; professional nail polish use frequency for females with young children was 81 percent (Table 2) (Wu et al. 2010). A greater proportion of college-educated women used professional nail services than non-college-educated women (Wu et al. 2010). Nail polish use was common among even the youngest study participants: 45 percent of girls age 5 and under and 79 percent of girls over 5 used nail polish (Table 2) (Wu et al. 2010). This study showed a correlation between use of nail products among parents and children in the same household, suggesting that parents use nail products on their children in similar patterns as they use them on themselves or that parental use patterns influence their children's use of nail products and, thus, their exposure to chemicals from the products (Wu et al. 2010).

5.1.3 Household and workplace presence of the product and other products containing the Candidate Chemical, and aggregate effects

Reference: California Code of Regulations, title 22, sections 69503.3(a)(1)(B) and 69503.3(b)(3).

The potential for exposure to the Candidate Chemical in the product relates to how common the product is in households and workplaces. The household and workplace presence of other products that contain the same Candidate Chemical may increase the potential for aggregate effects.

In addition to use in nail products, toluene is added to gasoline and is used in the manufacture of many products including paint thinners, adhesives, paints, inks, varnishes, glues, cleaning solutions, shoe and nail polishes, carpets, vinyl flooring, wood boards, rubber, and dyes (ATSDR 2017). The Consumer Products Information Database lists multiple toluene-containing products that may be used inside the home, including various home maintenance products, arts and crafts products, auto products, paints, and pet care products (CPID 2020). Tobacco smoke can also be a source of indoor toluene exposure (ATSDR 2017).

Nail technicians who use multiple toluene-containing nail products in a workday may experience aggregate exposure to the Candidate Chemical. Toluene is found in several different products within a nail salon (including nail polish and other coatings and nail polish thinner) (CDPH 2019; EWG 2019; FDA 2017; Mintel 2018; Zhou et al. 2016). As noted previously, Zhou et al. (2016) detected toluene in 26 out of 34 nail products analyzed, including base coats, top coats, nail polish thinners, gels, removers, and nail polishes, with concentrations ranging from 1.36 to 173,000 ppm (µg/g by weight) (up to 17.3 percent toluene content). In a study conducted by DTSC, 10 of 12 nail coating products labeled "toluene-free" contained toluene, ranging in concentration from 42 to 177,000 ppm (17.7 percent) (DTSC 2012). Further, eight of 13 nail coating products which made no claims to be toluene-free contained toluene, at levels ranging from 110 to 120,000 ppm (0.011 percent to 12 percent) (DTSC 2012).

The primary source of toluene in outdoor air is from automobile exhaust (ATSDR 2017). Outdoor air contaminated with toluene can migrate into indoor air environments such as homes and workplaces and potentially contribute to aggregate exposure.

Levels of toluene measured in ambient rural air, ambient urban air, and indoor air are an average of 1.3, 10.8, and 31.5 µg/m^3 (0.34, 2.9, and 8.4 ppb), respectively (U.S. EPA 2012). Urban air has higher toluene concentrations compared to rural air, which is likely due to automobile emissions. It is significant that indoor air has the highest detected toluene levels, suggesting additional sources inside buildings.

While toluene is found in multiple products and is detected in indoor air, DTSC is unable to adequately assess aggregate exposure from all these sources or how these exposures compare with toluene exposure from nail products. Nevertheless, toluene exposure by itself is of concern to nail salon workers' health regardless of potential aggregate exposure.

5.2 Potentially Exposed Populations and Product-Use Scenarios

5.2.1 Targeted customer base

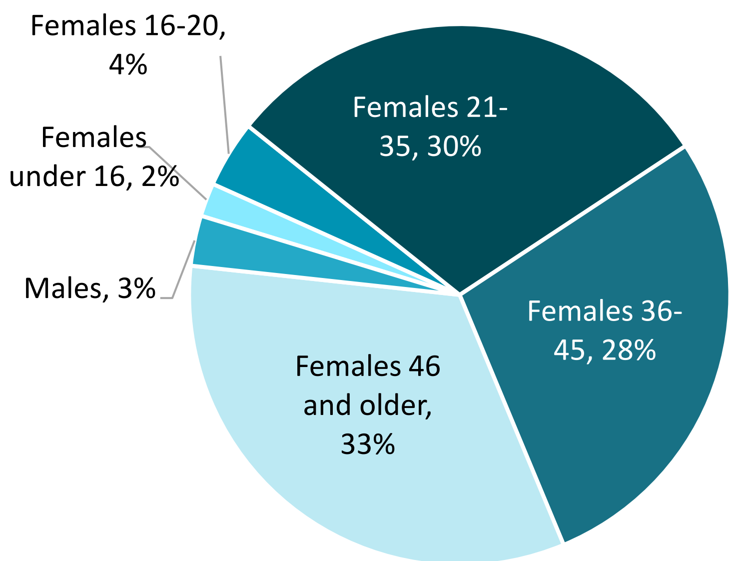
Reference: California Code of Regulations, title 22, section 69503.3(b)(1).

This section may include information on who typically buys or uses the product, and where the product is marketed or sold.

Most nail product purchasers and users in the United States are female. They come from various age groups and many belong to sensitive subpopulations such as nail industry workers, infants, children, adolescents, and pregnant women (Pak et al. 2013; Wu et al. 2010). U.S. nail industry workers are mostly low-income, women of color, and non-native English speaking women of childbearing age (Nails Magazine 2017).

Nationwide, there are approximately 69,738 nail salons with 393,581 licensed manicurists (Nails Magazine 2017); in California alone, there are more than 9,000 nail salons (Nails Magazine 2017) with 130,336 licensed manicurists (DCA 2017) and 314,552 cosmetologists (DCA 2018). Quach et al. (2008) estimate that 59 to 80 percent of nail technicians in California are of Vietnamese descent. According to the U.S. Census Bureau, 90 percent of all nail salons in California are minority-owned, and 68 percent are Vietnamese-owned (U.S. Census Bureau 2012). Reportedly, 97 percent of nail technicians are female, 64 percent are nonwhite, 56 percent are Vietnamese, and many are of childbearing age (Nails Magazine 2017; Pak et al. 2013). Nail technicians can be found in a variety of different types of salons including nail salons, full-service salons offering nail services, mobile or home-based salons, and spas (Nails Magazine 2017).

According to one survey, 97 percent of nail salon customers are female (Nails Magazine 2017). More than 60 percent of female nail salon customers are of childbearing age (Figure 3).



More than **60 percent** of female nail salon customers are of childbearing age.

Figure 3. Demographic makeup of nail salon customers (Nails Magazine 2017)

5.2.2 Use scenarios that may contribute to adverse impacts

Reference: California Code of Regulations, title 22, section 69503.3(b)(4)(D).

The SCP regulations consider a variety of uses that may contribute to the exposure to the product-chemical combination. These include household and recreational use, use by sensitive subpopulations, and use by workers, customers, clients, and members of the general public in homes, schools, workplaces, or other locations.

See Section 3.2, Section 5.1.2, 5.1.3, Section 5.3, and Section 5.5 for additional information.

Use of nail products containing toluene in salons and at home has the potential to expose nail technicians and other salon workers, nail salon patrons, and nail product consumers to toluene. Nail technicians who work with toluene-containing products experience potentially harmful daily chemical exposures, which can be exacerbated by their longer workdays and workweeks compared to employees in other sectors (Nails Magazine 2016; Quach et al. 2008).

Inhalation is an important exposure route for both nail salon workers and consumers who use toluene-containing products in salons and at home (Ford 2014). When nail products containing toluene are opened to allow for application, toluene volatizes into the indoor air and is breathed in by nail technicians and their customers. Building parameters, air exchange rates, ventilation, weather conditions, seasonal variations (Grešner et al. 2016), and the use of personal protective equipment (OSHA 2017; Quach et al. 2012; Quach et al. 2013) all affect toluene exposure potential. Ventilation is a critical factor in determining indoor air conditions and potential exposure to workers and consumers. While adequate ventilation reduces worker exposure, some salons don't have it (Goldin et al. 2014; NYSDOH 2016). Respiratory problems from chemical exposure are made worse by inadequate ventilation in salons (Marlow et al. 2012). Roelofs and Do (2012) showed that many salons in the Boston area did not have adequate ventilation.

The average nail salon is a single room with one to 10 workstations or tables (Yang and Han 2010) and is sometimes located in an enclosed building, such as an indoor mall (Quach et al. 2011). A nail technician sits on one side of a table facing a client on the other side. This proximity means that salon workers are using nail products close to their breathing zone, exposing themselves to the chemicals these products contain (Yang and Han 2010). Further, nail salons tend to be small work spaces (a mean area of 512 square feet in Alameda County, California) with inadequate ventilation, which increases the magnitude of potential inhalation exposure (Quach et al. 2011).

As noted previously, nail salon workers often work long hours and may be simultaneously exposed to multiple toluene-containing nail products. The median nail technician works 36 or more hours per week and services 16 to 20 customers (Nails Magazine 2017). Ten percent of nail technicians service 36 or more customers per week (Nails Magazine 2017).

Home users of toluene-containing nail products are generally exposed to lower air concentrations of toluene than salon workers (U.S. EPA 2005b). However, in some cases home users' exposure may be greater (e.g., if a consumer uses nail products in a small space with little or no ventilation) (Kopelovich et al. 2015; Marlow et al. 2012). Curry et al. (1994) described a personal monitoring study of inhalation exposure to toluene during normal in-home consumer use of nail coating products at five different residences in California. Prior to the nail coating application, toluene was not detected in any of the air samples above the detection limits of 200 µg/m^3 (50 ppb) in air. However, the average toluene levels measured in air during nail coating application ranged from 3,200 to 9,200 µg/m^3 (850 ppb to 2,400 ppb), while the post-application concentrations ranged from 200 to 1,700 µg/m^3 (50 to 450 ppb) (Curry et al. 1994). Measured toluene levels during nail coating application exceeded the OEHHA-established REL of 420 µg/m^3 (110 ppb) for toluene in indoor air (OEHHA 2020a).[14] These levels are potentially harmful to human health.

5.3 Exposures to the Candidate Chemical Throughout the Product Life Cycle

5.3.1 Indicators of potential exposures to the Candidate Chemical from the product

Reference: California Code of Regulations, title 22, section 69503.3(b)(2).

The SCP regulations consider various data that indicate potential for exposure to the Candidate Chemical or its degradation products, including: (i) the Candidate Chemical's presence in and release from the product; (ii) monitoring data indicating the Candidate Chemical's presence in the indoor and outdoor environment, biota, humans (e.g., biomonitoring studies), human food, drinking water, and other media; and (iii) evidence of persistence, bioaccumulation, lactational, and transplacental transfer.

See Section 5.3.2 for additional information.

Published studies show detected toluene concentrations in nail salons' indoor air and in the breathing zone of nail salon workers.

Studies have documented the presence of toluene in nail salons' indoor air, demonstrating potential exposure to workers, patrons, and visitors. Nail products containing toluene are opened for application, resulting in the volatilization of the Candidate Chemical into the indoor air which is then

[14] The REL for toluene is set at a level which is established to protect humans from adverse impacts to the respiratory and nervous symptoms. OEHHA (2019) OEHHA Acute, 8-hour and Chronic Reference Exposure Level (REL) Summary. Office of Environmental Health Hazard Assessment (OEHHA). In. https://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary Accessed March 2020

breathed in by nail technicians and their customers. Building parameters, air exchange rates, ventilation, weather conditions, seasonal variations (Grešner et al. 2016), and the use of personal protective equipment (OSHA 2017; Quach et al. 2012; Quach et al. 2013) all affect toluene exposure potential. In addition, toluene detections in nail salons have been positively correlated with salon occupancy, services provided, and carbon dioxide levels (Zhong et al. 2019). Carbon dioxide levels may be a good indicator of overall air quality (Pavilonis et al. 2018). Ventilation is a critical factor in determining indoor air conditions and potential exposure to workers and consumers. While adequate ventilation reduces worker exposure, many salons don't have it (Goldin et al. 2014; NYSDOH 2016). In one study, only eight of 22 nail salons in the Boston area had mechanical ventilation systems (Roelofs and Do 2012). Respiratory problems from chemical exposure are made worse by inadequate ventilation in salons (Marlow et al. 2012). While inhalation is the primary exposure route for toluene in nail products, people may also be exposed to toluene dermally via nail product application and accidental spills, and orally from accidental ingestion and hand-to-mouth behavior such as nail biting (Rister 2016).

Published studies detected toluene concentrations in nail salons' indoor air and in the breathing zone of nail salon workers. In a study of 30 nail salons throughout California, median and 90 percent upper confidence limit (UCL) on the arithmetic mean indoor air toluene concentrations were 100 and 138 ppb (380 $\mu g/m^3$ and 520 $\mu g/m^3$) (McNary and Jackson 2007). Additionally, the median and 90 percent UCL on the arithmetic mean for personal air monitoring of nail salon technicians were 200 and 260 ppb (754 and 980 $\mu g/m^3$) (McNary and Jackson 2007). One researcher sampled indoor air over a four-hour duration in a number of Los Angeles-area nail salons and detected toluene in 75 percent of the salons (Nguyen 2016). The highest detected toluene concentration of 130 ppb (490 $\mu g/m^3$) was above the chronic OEHHA REL of 110 ppb (420 $\mu g/m^3$) (Nguyen 2016; OEHHA 2020a).

Beyond California:

- Alaves et al. (2013) detected a maximum concentration of toluene in indoor air at nail salons in Salt Lake County, Utah, of 300 ppb (1,130 $\mu g/m^3$). This toluene concentration level exceeds the chronic OEHHA REL.
- Zhong et al. (2019) detected a maximum concentration of toluene in indoor air at nail salons in Michigan of 380 $\mu g/m^3$ (100 ppb) and a maximum personal air measurement of 650 $\mu g/m^3$ (170 ppb).
- Lamplugh et al. (2019) detected a maximum concentration of toluene in indoor air at nail salons in Colorado of 816 $\mu g/m^3$ (220 ppb).
- Hollund and Moen (1998) detected toluene in indoor air in Norwegian nail salons at a range of 40 to 110 $\mu g/m^3$ (10 to 30 ppb).
- Tsigonia et al. (2010) detected a maximum of 67 $\mu g/m^3$ (17 ppb) of toluene in indoor air at three nail salons. This detection was not greater than the chronic OEHHA REL.

- Peters et al. (2007) detected toluene at a six-day mean time-weighted average concentration of 100 ppb (380 µg/m^3) in nail salons in Brisbane, Australia.
- Ceballos et al. (2019) assessed toluene exposure of 10 nail technicians in seven nail salons in the Greater Boston area over the course of one workday. Air samples were collected from the breathing zone of each nail technician, as well as from the indoor air of the salons. The median toluene concentration in the personal air space samples was 39 µg/m^3 (10 ppb) and ranged from 4.8 to 85 µg/m^3 (1.3 to 22.5 ppb). The median toluene concentration in the samples of indoor air from the salons was 21 µg/m^3 (5.5 ppb) and ranged from 2.2 to 105 µg/m^3 (0.6 - 28 ppb) (Ceballos et al. 2019).
- Park et al. (2014) detected high concentrations of toluene in indoor air at Korean nail salons. They detected an arithmetic mean of 95,400 ppb (359,520 µg/m^3) and a maximum of 490,000 ppb (µg/m^3) toluene in indoor air (Park et al. 2014). These detections greatly exceeded the chronic OEHHA REL but may not be representative of indoor air conditions in California nail salons.
- Moradi et al. (2019) detected elevated toluene levels in indoor air at 36 beauty salons in Tehran at a mean concentration of 119 µg/m^3 (32 ppb).

DTSC compared concentrations of toluene in indoor air to the OEHHA-established chronic REL for toluene in indoor air (OEHHA 2020a). See Table 3 and

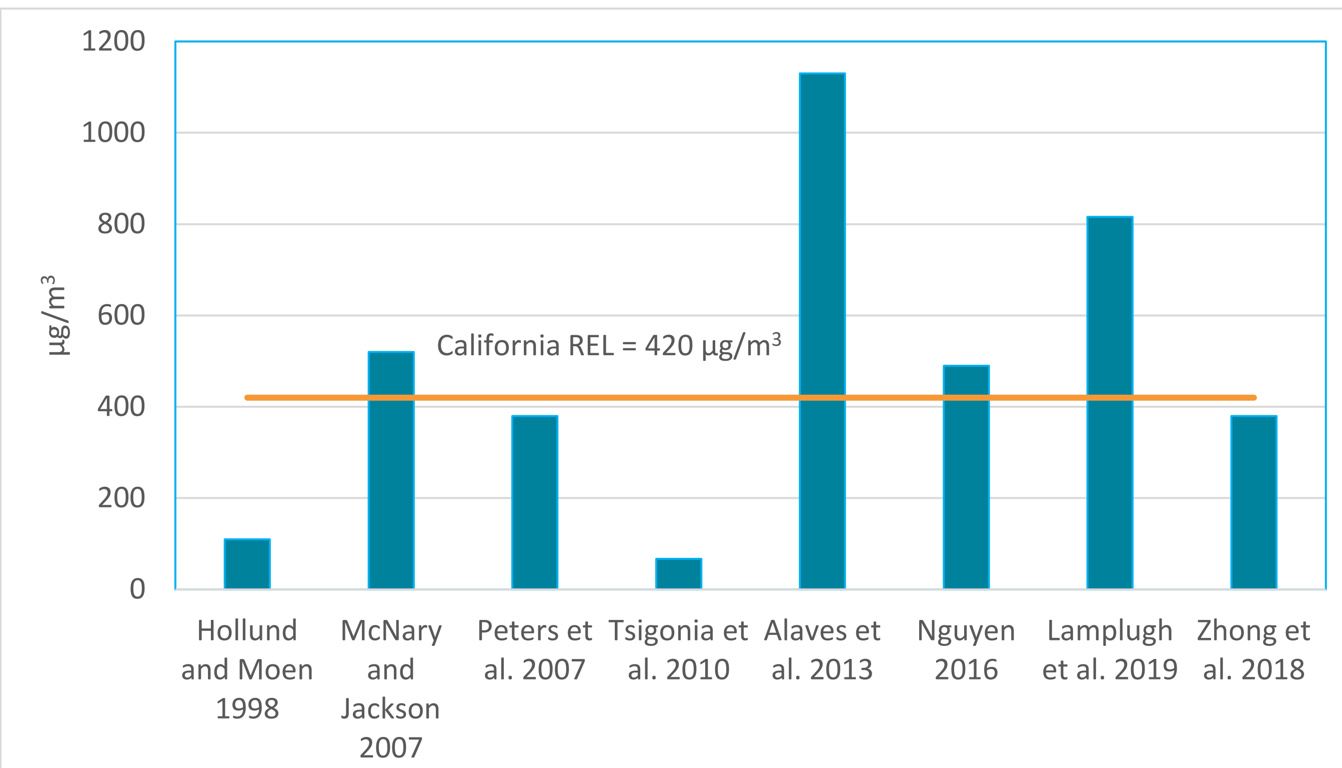


Figure 4.

Table 3. Maximum detected concentrations of toluene in indoor air studies

Concentration (µg/m^3)	Concentration (ppb)	Reference
110	30	(Hollund and Moen 1998)
520*	138*	(McNary and Jackson 2007)
380	100	(Peters et al. 2007)
67	17	(Tsigonia et al. 2010)
1,130	300	(Alaves et al. 2013)
490	130	(Nguyen 2016)
816	220	(Lamplugh et al. 2019)
380	100	(Zhong et al. 2019)
105	28	(Ceballos et al. 2019)
119**	32	(Moradi et al. 2019)
1,846,570***	490,000**	(Park et al. 2014)

**This concentration is the 90% UCL on the arithmetic mean.*

***This concentration is the mean value.*

**** This value may not be representative of indoor air conditions of nail salons in California.*

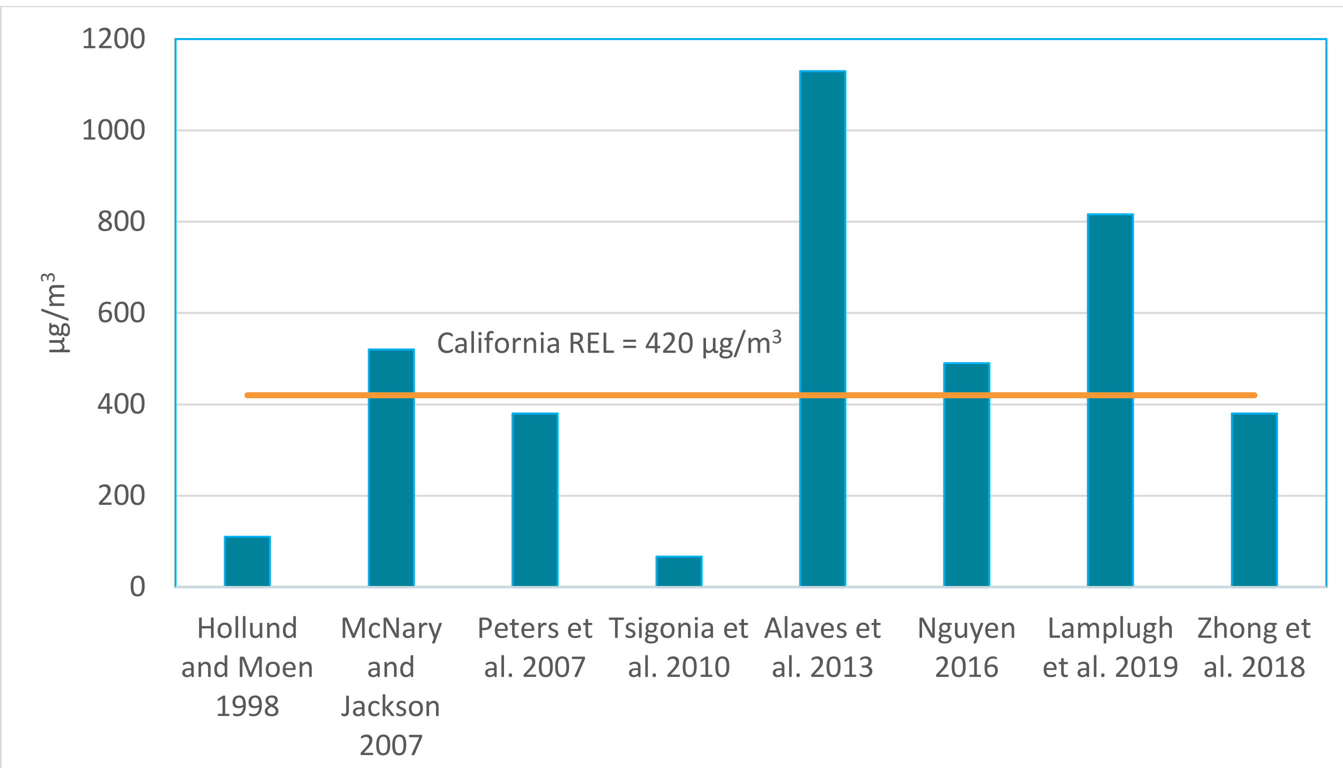


Figure 4. Detected maximum concentrations of toluene in indoor air studies compared to the California REL (420 µg/m^3)

In 20 Alameda County nail salons, Quach et al. (2011) measured the exposure of 80 workers to toluene, methyl methacrylate, and total VOCs using personal air monitors. The average measured toluene level of 150 ppb (560 µg/m^3) was nearly twice OEHHA's chronic inhalation REL of 110 ppb (420 µg/m^3). Twenty-one percent of surveyed nail technicians in this study reported nose, throat, lung, skin, or eye irritation (Quach et al. 2011). In two other studies in San Francisco Bay Area nail salons, toluene was measured in the personal air samples of all salon workers tested (Garcia et al. 2015; Quach et al. 2013).

As mentioned in Section 5.2.2, Curry et al. (1994) measured indoor air concentrations of toluene during at-home use of nail coating products at five different residences in California. The mean toluene levels measured in air during the nail coating application ranged from 3,200 to 9,200 µg/m^3 (850 to 2,400 ppb), while the post-application concentrations ranged from 200 to 1,700 µg/m^3 (50 to 450 ppb) (Curry et al. 1994). Toluene was not detected in any air samples above the detection limits of 200 µg/m^3 (50 ppb) prior to the nail coating applications (Curry et al. 1994).

5.3.2 Potential exposure to the Candidate Chemical during the product's life cycle

Reference: California Code of Regulations, title 22, section 69503.3(b)(4)(A).

Potential exposures to the Candidate Chemical or its degradation products may occur during various product life cycle stages, including manufacturing, use, storage, transportation, waste, and end-of-life management practices. Information on existing regulatory restrictions, product warnings, or other product use precautions designed to reduce potential exposures during the product's life cycle may also be discussed here.

See Section 4.2, Section 5.3.1, Section 5.3.3, Section 5.4, and Section 5.5 for additional information.

Nail products are manufactured in industrial facilities in California, other U.S. states, and worldwide. While workers in such facilities are potentially exposed to toluene during the manufacture of nail products, this evaluation of toluene in nail products is focused on exposure to nail industry workers and nail product consumers.

There is also the potential for indoor air contaminants, such as toluene, to migrate into adjacent buildings, businesses, and residents. In one case, a single large shopping center building was sampled for VOCs in indoor air and provided evidence suggesting that detected toluene and acetone originated from adjoining salons (Eklund et al. 2008).

5.3.3 Frequency, extent, level, and duration of potential exposure for each use and end-of-life scenario

Reference: California Code of Regulations, title 22, section 69503.3(b)(4)(E).

Frequency of product use (how often), and the extent (the number of routes of exposure), level (concentration of the Candidate Chemical), and duration (length of time) of use, are all considered when assessing the potential for exposure to the Candidate Chemical or its degradation products.

See Section 4.2, Section 5.3.1, Section, 5.3.2, Section 5.4, and Section 5.5 for additional information.

A variety of nail products contain toluene, including nail polishes and other coatings, nail hardeners, and nail polish thinner (CDPH 2019; EWG 2019; FDA 2017; Mintel 2018). Zhou et al. (2016) detected toluene in 26 out of 34 nail products analyzed, including base coats, top coats, nail polish thinners, gels, removers, and nail polishes, at concentrations ranging from 1.36 to 173,000 ppm (µg/g by weight) (up to 17.3 percent toluene content). In a study conducted by DTSC, 10 of 12 nail coating products labeled "toluene-free" contained toluene, ranging in concentration from 42 to 177,000 ppm (17.7 percent) (DTSC 2012). Further, eight of 13 nail coating products that made no claims to be toluene-free contained toluene at levels ranging from 110 to 120,000 ppm (0.011 percent to 12 percent) (DTSC 2012).

During product use, nail salon workers and consumers may be exposed to toluene in nail products via inhalation, dermally, or orally. Exposure to toluene via inhalation is well-studied and is more toxicologically significant than other exposure routes due to increased body absorption and distribution of inhaled toluene and its ability to cause or contribute to toxicological endpoints (ATSDR 2017; U.S. EPA 2005b). However, dermal and oral exposures to toluene in nail products also represent exposure pathways of toxicological concern.

Exposure of nail salon workers is influenced by the number of hours worked each week, the number of clients served in a day, the number of nail technicians providing services, the number of times toluene-containing nail products are opened or applied, and the concentration of toluene present in the nail products. Nail industry workers may be exposed to these products daily, potentially several times per day, and multiple times per week.

Workers in the nail industry often work hours in excess of a standard 40-hour workweek or an eight-hour workday (Quach et al. 2008). During those long work hours, nail salon workers are exposed to multiple nail products simultaneously that may contain toluene. This may result in a greater exposure over an occupational lifetime. One study showed a positive correlation between the number of nail services performed during a given workday and indoor air concentrations of toluene (Nguyen 2016).

Even with adequate ventilation, salons with several nail technicians performing services simultaneously can lead to elevated levels of VOCs in indoor air.

Factors affecting indoor air dynamics also contribute to concentrations of toluene in nail salons and result in worker exposures. Building dimensions, room ventilation, weather conditions, air exchange rates, and time of day also play a role in the concentration of toluene present in indoor air (OSHA 2017; Quach et al. 2012; Quach et al. 2013). Ventilation is the preferred exposure control method in nail salons; however, nail salons often lack adequate ventilation and, consequently, have toluene concentrations above acceptable exposure limits. Poor ventilation may be related to lack of or inefficient heating, ventilation, and air conditioning (HVAC) systems combined with the use of inadequate filters (Bennett et al. 2012).

Even with adequate ventilation, salons with several nail technicians performing services simultaneously can lead to elevated levels of VOCs in indoor air (Nguyen 2016). When adequate ventilation is not possible, the use of personal protective equipment (PPE) by nail technicians can reduce their exposure to toluene. The use of appropriate gloves reduces dermal exposure, and the use of half-facepiece air purifying respirators with organic vapor filtering cartridges reduces inhalation exposure (see Section 5.5.2) (OSHA 2017).

Similar factors influence a consumer's home use exposure to toluene in nail products. At-home nail product use is expected to cause less toluene exposure based on the number of times nail products are used in each day or week. However, indoor air dynamics, room size, ventilation, and the lack of at-home use of PPE could impact exposure and the likelihood of adverse impacts (SCCP 2008).

5.4 Potential Cases of Exposure to the Candidate Chemical in the Product from Various Life Cycle Segments – Special Situations

This section would be used to discuss potential exposures to a Candidate Chemical used in products that 1) may be made in, stored in, or transported through California but are not used in the state, or 2) are exempted from the statutory definition of a consumer product. Nail products with toluene do not meet either of these criteria; therefore, this section does not apply.

5.5 Factors That May Mitigate or Exacerbate Exposure to the Candidate Chemical

5.5.1 Containment of the Candidate Chemical within the product

Reference: California Code of Regulations, title 22, section 69503.3(b)(4)(F).

When assessing the exposure potential, the SCP regulations consider how the Candidate Chemical is contained or bound during product use (e.g., as an inaccessible component inside a product) and the degree to which the containment is protective at end-of-life (e.g., recycling or disposal).

Nail products are formulated mixtures of chemicals that include toluene as a solvent. Due to its high vapor pressure, toluene readily volatilizes at ambient and room temperatures, and it is potentially released from nail products during product use and end-of-life.

5.5.2 Engineering and administrative controls that reduce exposure concerns

Reference: California Code of Regulations, title 22, section 69503.3(b)(4)(G).

The SCP regulations also consider any administrative controls (e.g., warning labels on a product) or engineering controls (e.g., specialized ventilation equipment) that can reduce the potential for chemical exposures from the product during product manufacturing, use, or end-of-life.

Occupational exposures to harmful substances should be addressed via a well-documented hazard control methodology widely accepted by industrial hygiene professionals and safety organizations. CDC's National Institute for Occupational Safety and Health (NIOSH) recommends following a hierarchy of controls to protect workers from hazards in order of preference (NIOSH 2016):

1) elimination of the hazard;
2) substitution with a different chemical;

3) engineering controls, including processes and systems such as exhaust ventilation, which are designed to remove a hazard at the source, to reduce or eliminate worker exposure;
4) administrative controls, including the implementation of policies, procedures, and employee training; and
5) the use of PPE (NIOSH 2016).

Eliminating a chemical hazard entirely, or substituting a less hazardous chemical, is the most effective means of minimizing potential occupational exposures to workers (NIOSH 2016). Engineering controls can also be effective, especially when combined with administrative controls and PPE (NIOSH 2016). However, administrative controls and PPE are the least desirable approaches to control potential occupational exposure, because the original hazard is still present in the workplace (NIOSH 2016).

Nail industry workers are frequently exposed to volatile chemicals in nail salons (Quach et al. 2011). Nail salon workers typically work in small business establishments (e.g., a mean size of 512 square feet and mean volume of 5,882 cubic feet in California) that are poorly ventilated, and some salons are built in enclosed buildings such as indoor malls and high-rises (Quach et al. 2011).

If toluene-containing products cannot be avoided, it is crucial to follow engineering controls to reduce chemical exposure in nail salons. Proper ventilation reduces nail salon workers' exposure to airborne chemicals (NYSDOH 2016). NIOSH and the U.S. Occupational Health and Safety Administration (OSHA) recommend proper ventilation systems as an engineering control to reduce exposure to toluene and other chemicals (NIOSH 1999; OSHA 2012). However, many salons in California do not have adequate ventilation. In one study of 20 nail salons in Alameda County, California, only 8 percent of nail salons had table ventilators. Higher VOC levels were measured in the breathing zone of nail technicians who worked in nail salons without table ventilators (Quach et al. 2011). A study of 21 nail salons in Boston had similar findings: 15 of the salons (71 percent) had measured CO_2 levels exceeding 800 ppm, suggesting that these salons have insufficient ventilation; these salons had elevated levels of total VOCs and 2.5 µm particulate matter as compared with well-ventilated salons (Goldin et al. 2014).

Ventilation control systems fall into two main categories: local exhaust ventilation (LEV) and dilution ventilation. LEV systems aim to capture contaminants at or near the source of release and remove them before they can be inhaled by workers or others (NYSDOH 2016). LEV systems include downdraft ventilated tables (NIOSH 1999), portable source capture ventilation (SCV) systems, and ventilation systems that remove contaminants before they cross the breathing zone (Marlow et al. 2012). Dilution ventilation systems reduce contaminant concentrations within the room or area but do not remove the contaminant at its source. Dilution ventilation primarily provides conditioned air to an area for general comfort and odor control (NYSDOH 2016).

A 2012 NIOSH study examined the effectiveness of various SCV systems in nail salons (Marlow et al. 2012). Three different exhaust systems and four different collecting hoods were tested under controlled laboratory conditions. On average, the SCV systems reduced exposures by 50 to 60 percent (Marlow et al. 2012). Based on these findings, NIOSH recommends placing LEV units close to the area where artificial nail services are done, or performing nail services at ventilated work tables and exhausting this air to outside (NIOSH 1999). OSHA also recommends that salons use portable ventilation machines to remove dust and chemicals from the breathing zones of nail salon workers and their customers in order to reduce their chemical exposure (OSHA 2012).

An air monitoring study in California nail salons confirms the benefits of LEVs; salons with table ventilators had significantly lower levels of volatile chemicals in the air than salons that did not use them (Quach et al. 2011). Salons that used other forms of ventilation, including opening doors and windows, using table fans, and installing roof fans, had lower concentrations of VOCs in their air than salons that did not follow these practices (Quach et al. 2011). Further, nail salons located in enclosed buildings (e.g., high-rises or indoor malls) had higher measured concentrations of VOCs in indoor air (Quach et al. 2011).

Nail salons can implement a variety of other engineering and administrative controls to reduce exposure to toluene and other VOCs from nail products. They include:

- installing exhaust fans that pull air from one end of the salon and push it out of the salon, and always keeping the exhaust system on (OSHA 2012; OSHA 2017);
- always keeping the HVAC system on during work hours and replacing the filter once per year (OSHA 2012; U.S. EPA 2007);
- changing charcoal filters of ventilated tables at least once a month and cleaning out the catch basins at least once a week (OSHA 2012; OSHA 2017; U.S. EPA 2007);
- opening doors and windows (OSHA 2012; OSHA 2017);
- using less toxic products (OSHA 2012; Quach et al. 2012);
- reading product labels and Safety Data Sheets and following manufacturers' instructions when using all nail salon products (OSHA 2012; OSHA 2017; U.S. EPA 2007);
- storing chemicals in small bottles with small openings and labeling them with information from the manufacturer's label (OSHA 2012; U.S. EPA 2007);
- closing chemical bottles tightly when they are not being used, and not keeping extra product at workstations (OSHA 2012; OSHA 2017; U.S. EPA 2007);
- using metal trashcans with tight, self-closing lids (OSHA 2012; U.S. EPA 2007);
- following instructions and applicable hazardous waste regulations when disposing of used or unwanted chemicals (OSHA 2012; OSHA 2017; U.S. EPA 2007);
- training nail technicians in their native language on techniques and procedures to reduce workplace chemical exposures (Quach et al. 2013);
- taking regular breaks outside the salon (OSHA 2012; Quach et al. 2012);

- washing hands between clients and before eating, drinking, putting on cosmetics, and smoking (OSHA 2012; U.S. EPA 2007);
- keeping food and drinks covered at all times, and not storing or eating food in work areas (OSHA 2012; U.S. EPA 2007); and
- using PPE including protective eyewear or goggles, nitrile gloves, NIOSH-approved filtering facepiece respirators also known as N95 masks[15] (OSHA 2017; Quach et al. 2013; U.S. EPA 2007).

Using half-facepiece air purifying respirators (APRs) with organic vapor filtering cartridges (which offer protection from breathing in chemical vapors) can also protect workers from hazardous gases and vapors when performing tasks such as moving chemicals from large bottles to smaller bottles and cleaning up large spills. Use of APRs requires that the employer implement a respiratory protection program under U.S. Occupational Safety and Health Administration (OSHA) Respiratory Protection Standard 29 CFR 1910.134, which has certain requirements including training and fit testing (OSHA 2017). Further, employers must evaluate the appropriate cartridges for the job, provide cartridges to workers, and inform workers of how and when to change cartridges (OSHA 2017).

> While proper use of appropriate PPE can reduce toluene exposure from nail products, nail technicians are inconsistent in their use of PPE, and many technicians rarely or never use it.

While proper use of appropriate PPE can reduce toluene exposure from nail products, nail salon owners may not provide such PPE. Use of PPE is inconsistent among nail technicians, and many technicians rarely or never use it. In one survey, 66 percent of nail technicians indicated that they wear gloves at least sometimes when using nail products; however, most said they do not wear additional protective gear such as face masks or protective eyewear (Nails Magazine 2015). A study of nail technicians in Manhattan found that 415 out of 562 respondents (74 percent) were not wearing gloves despite legislation in New York requiring them to do so (Basch et al. 2016). A survey of 65 nail technicians in Oregon had similar findings; 72 percent and 32 percent, respectively, rarely or never use gloves and masks (White et al. 2015). Moreover, customers including pregnant women, their fetuses, and children who receive nail services do not wear PPE and are at risk of being exposed to toluene.

Even when nail technicians do wear PPE, they often use equipment that is not appropriate for the chemicals that are present in their workplaces. Goldin et al. (2014) found that some nail salon workers

[15] N95 masks help protect from dust, viruses, and germs. They do not provide protection from vapors or gases. Some N95s have filters that reduce chemical odors, but they may not protect from harmful chemical exposure levels.

wear surgical masks as PPE, even though these masks do not prevent exposure to chemical vapors or particulates. Salon workers may also choose gloves that do not protect against toluene exposure.

A recent in-person health and safety survey of nail technicians revealed a need for better training and availability of appropriate PPE (Shendell et al. 2018). Improved training combined with a better dissemination of information can reduce risks to workers and the likelihood of adverse effects associated with occupational exposures (Quach et al. 2013; Roelofs et al. 2007; White et al. 2015). One study describes a health and safety training program for cosmetology students that focused on chemical hazards and risks in the workplace; after participating in the programs, trainees had increased knowledge, improved safety practices, and enhanced communication about health and safety (Mayer et al. 2015). In 2018, DTSC published Healthy Nail Salon Recognition (HNSR) Program Guidelines to improve nail salon safety statewide in California (DTSC 2018). DTSC's HNSR program guidelines include training topics for salon workers such as use of: PPE; proper ventilation; safer products; and safe chemical handling, transfer, storage, and disposal (DTSC 2018). While better, more consistent training of salon staff may reduce toluene exposure to nail salon workers and their clients, the potential for exposure exists even in salons that have implemented such training programs.

6 ADVERSE WASTE AND END-OF-LIFE EFFECTS

Reference: California Code of Regulations, title 22, sections 69503.2(b)(1)(B) and 69501.1 (a)(8).

DTSC is most concerned about toluene exposures during the use phase. While toluene in discarded nail products can be released to the environment, the products are generally packaged in relatively small containers, limiting the amount of toluene released from an individual product. Toluene released from disposed nail products is expected to be diluted in ambient air or in wastewater and degraded by the processes discussed in Section 4.2.1. Consequently, DTSC is not basing its proposal on this factor.

7 ADDITIONAL CONSIDERATIONS

This section summarizes other relevant information not captured under the adverse impact and exposure factors named in section 69503.3 of the Safer Consumer Products regulations.

7.1 Other Relevant Factors Not Identified by the Regulation

In 2012, DTSC performed an investigation of nail products from California distributors and analyzed select products for metals, volatile, and semi-volatile compounds (DTSC 2012). A focus of this effort was on three chemicals used in nail products which have clear hazard traits – formaldehyde, toluene, and DBP – which are commonly referred to as the "toxic trio." This study found that a number of products advertised as "3-free" (i.e., free of formaldehyde, toluene, and DBP) actually contained DBP, toluene, or both (DTSC 2012). This study also detected other chemicals in the tested nail products, including some on the Safer Consumer Products Candidate Chemical list (DTSC 2012). While nail product manufacturers appear to have largely phased out use of formaldehyde and DBP, some nail products still contain toluene.

In the U.S. and Europe, market trends are moving toward minimizing or eliminating the use of certain chemicals in nail products. For example, Walmart has asked its suppliers to remove toluene from their products. Under the Walmart policy, manufacturers must list the targeted ingredients on packaging by 2018 and work to find alternatives (Coleman-Lochner and Martin 2016).

Other recent efforts in California have focused on nail product safety. In 2012, the San Francisco Department of the Environment (SF Environment) created a voluntary recognition program for nail salons that choose safer alternative chemicals in nail products, train their employees on safer practices that reduce exposure, provide and require employees to use personal protective equipment, and improve indoor air quality by installing mechanical ventilation units (SF Environment 2012). Since then, several other counties and cities have established voluntary Healthy Nail Salon Programs that recognize salons that use less toxic polishes and other nail products, improve ventilation, and participate in trainings that focus on best practices for a healthier workplace (CHNSC 2020).

In addition to voluntary recognition programs established by local jurisdictions, several recent California laws focus on the health, safety, and education of nail salon workers statewide:

AB 2125 (2015-2016) – The Healthy Nail Salon Recognition Program (Health and Safety Code section 25257.2)

- Includes recognizing businesses that use less toxic nail polishes and polish removers and improve ventilation.

- Calls upon DTSC to publish guidelines for cities and counties to implement voluntary local Healthy Nail Salon Recognition programs, including a list of chemicals that should not be used by salons seeking HNSR program recognition.[16]

AB 2025 (2015-2016) – Barbering and Cosmetology: Labor Law Education Requirements (amended Bus. & Prof. Code §§ 7312, 7314, 7314.3, 7337, 7347, and 7389)

- Provides for improved education and language access for salon workers.

AB 2437 (2015-2016) – Barbering and Cosmetology: Establishments: Posting Notice (Business and Professions Code section 7353.4)

- Requires salons to post notices regarding workplace rights and wage and hour laws in English, Spanish, Vietnamese, and Korean.

7.2 Key Data Gaps

DTSC has not identified specific data gaps that impact the proposal for this listing.

7.3 Conflicting Studies

The European Commission's Scientific Committee on Consumer Products (SCCP) concluded that occasional at-home consumer toluene exposure from nail products, in the range of 1 to 4 ppm, can be considered as safe (SCCP 2008). This opinion is based on the assumptions that exposure duration is less than 30 minutes, toluene air levels are 1 to 4 ppm in nonventilated rooms during at-home use, or client toluene exposure in ventilated nail salons is 0.26 ppm or less. This conclusion is based on an exposure-driven evaluation of both acute inhalation effects and reproductive toxicity. The SCCP did not evaluate nail salon workers in its assessment.

[16] DTSC published the Healthy Nail Salon Recognition Program Guidelines in April 2018.

8 DISCUSSION OF POTENTIAL FOR SIGNIFICANT OR WIDESPREAD ADVERSE IMPACTS

This section integrates the information provided in the Profile to demonstrate how the key prioritization principles, as identified in the SCP regulations, are met.

DTSC has determined that exposure to toluene through normal use of nail products may contribute to or cause significant or widespread adverse impacts to Californians, including sensitive subpopulations such as nail salon workers, pregnant women and their fetuses, infants, children, and adolescents. This determination is based on toluene's volatility and potential for inhalation exposure in nail salons and at home, the hazard traits associated with toluene, and data showing measured toluene levels in air samples collected in homes and nail salons.

Nail products and professional manicure/pedicure services that may expose salon workers and customers to toluene are very popular. In California there are over 9,000 nail salons (Nails Magazine 2017) and more than 130,000 licensed manicurists (DCA 2017). While nail salon workers and consumers may be exposed to toluene via dermal contact or ingestion, inhalation is the most significant exposure route (ATSDR 2017; U.S. EPA 2005b). Toluene is used as a solvent in several nail coating and nail polish thinner products (CDPH 2019; EWG 2019; FDA 2017; Mintel 2018). Building size, room dimensions, air exchange rates, ventilation, and weather conditions influence the concentration of toluene in salon air and, consequently, level of inhalation exposure for nail salon workers and consumers (Quach et al. 2008).

Toluene is a liquid at room temperature and readily volatilizes into indoor air (NIH 2020c). Several studies conducted in nail salons detected toluene at concentrations higher than California's chronic REL of 110 ppb (420 $\mu g/m^3$) (Alaves et al. 2013; Hollund and Moen 1998; Lamplugh et al. 2019; McNary and Jackson 2007; Nguyen 2016; Park et al. 2014; Tsigonia et al. 2010; Zhong et al. 2019). Further, a personal air monitoring study of 80 workers from 20 nail salons in California detected toluene and other VOCs in salon workers' breathing zones (Quach et al. 2011).

In addition to being a neurotoxicant, toluene is a developmental toxicant with potential to affect unborn fetuses (see Section 4.3). Research studies suggest that toluene exhibits other hazard traits including neurodevelopmental toxicity, respiratory toxicity, and kidney toxicity. Toluene has also been linked to immunotoxicity and vision and hearing impairment (see Section 4.3).

Nail salon workers' potential for exposure to toluene is exacerbated by several factors: They often work in excess of eight-hour days or 40-hour weeks; they are often not provided adequate information concerning chemical safety; they are often not provided with proper PPE; and their workplaces often lack adequate ventilation (Quach et al. 2008). Pregnant nail technicians and their fetuses are especially sensitive to adverse impacts of toluene exposure from nail products (see Section 4.5.2). Infants and children of nail technicians often accompany their parents to the workplace and may be exposed to toluene-containing nail products. Even if they are not directly exposed to toluene-containing nail products, nursing infants and children may be exposed to toluene, as indicated by detected toluene in human milk (Fabietti et al. 2004). Infants and young children are more susceptible than adults to adverse impacts from toluene due to physiological differences (see Section 4.5.2). Chemical exposure of nail industry workers is an environmental justice issue, as a large majority of nail industry workers are people of color and lower socioeconomic status.

Information DTSC received in response to its recent information call-in and laboratory study on nail provides additional evidence on the potential for exposure to toluene from these products. DTSC requested information on various nail products from manufacturers, importers, assemblers, retailers, distributors, and trade associations (DTSC 2020b). Toluene was reported in 11 nail products as an added ingredient in nail polish thinners and top coats at concentrations ranging from 5 to 25 percent (DTSC 2020b). Toluene was also reported as a contaminant in nail coatings in 172 products at concentrations of 0.1 percent or less. Additionally, DTSC conducted analytical laboratory testing of 157 retail and professional-use nail products and detected toluene in 27 nail coatings and nail polish thinners at concentrations ranging from 31.4 ppm to 187,000 ppm (0.00314 percent to 18.7 percent) (DTSC 2021).

As illustrated by the data and information described is this Profile, DTSC has determined that there is exposure to toluene from nail product use and this exposure may contribute to or cause significant or widespread adverse impacts.

9 ALTERNATIVES

Reference: California Code of Regulations, title 22, section 69503.2(b)(3).

This section summarizes information available to DTSC regarding alternatives that may or may not be safer than the Candidate Chemical. DTSC does not need to ensure that these alternatives are safer and may summarize their associated hazards to illustrate readily available information. The Sections below may include information such as how readily available an alternative is, product functions addressed by the alternative, and implications for manufacturers using the alternative (e.g., use limitations, product reformulation, different equipment needs).

Some of the alternative solvents to toluene currently used in nail products include ethyl acetate, butyl acetate, isopropanol (IPA), methyl ethyl ketone (MEK), and water. IPA and MEK are, like toluene, Candidate Chemicals. DTSC has summarized some readily available information on use in nail products and associated hazard traits but has made no determination about their safety relative to toluene. This section is not intended to be an exhaustive list of alternatives; there are other known chemical alternatives to toluene that are not described below.

9.1 Chemical Alternatives

9.1.1 Chemical name: Ethyl acetate

Discussion of applicability of the chemical alternative:

Ethyl acetate is a colorless liquid used as solvent in nail polish, base coats, nail polish removers, and other nail products (CIR 1989; NIH 2020b). It is volatile, soluble in water, and naturally occurs in many foods (NIH 2020b). The specifications of CARB's Consumer Products regulations prohibit ethyl acetate use in nail polish removers in California (CARB 2019).

Readily available hazard trait and exposure information:

Acute to chronic ethyl acetate exposure can result in respiratory dysfunction and eye, nose, and throat irritation (NIH 2020b). Higher concentrations can cause central nervous system effects such as headaches, sleepiness, and unconsciousness (NIH 2020b). Animals administered very high doses experienced decreased body and organ weights as well as decreased appetite (NIH 2020b). Animal data does not indicate that ethyl acetate is a skin irritant or sensitizer (CIR 1989; NIH 2020b).

Nail salon workers may potentially be exposed to ethyl acetate from nail products. Ethyl acetate was measured in 74 salons' indoor air in Norway at a concentration range of 0.01 to 1.19 ppm (Gjølstad et al. 2006).

Ethyl acetate readily volatilizes and rapidly degrades when released to the environment. Ethyl acetate is expected to evaporate rapidly from water and soil and is unlikely to adsorb to suspended solids and sediment. Ethyl acetate is biodegradable and is not expected to build up in aquatic organisms (NIH 2020b).

9.1.2 Chemical name: Butyl acetate

Discussion of applicability of the chemical alternative:

Butyl acetate is a clear colorless chemical used as a solvent in the production of lacquers and as a flavoring agent (IPCS 2005). It is used as a solvent across a wide variety of products including nail polish, nail polish removers, base coats, and other nail products (Arora and Tosti 2017; CIR 1989).

The specifications of the CARB Consumer Products regulations prohibit butyl acetate's use in nail polish removers in California (CARB 2019).

Readily available hazard trait information:

Butyl acetate is a minor respiratory irritant when inhaled and can cause irritation to the eyes, nose, and throat (NIH 2020a). When tested at an unspecified concentration and up to 25.5 percent in cosmetic formulations, butyl acetate was, at most, a mild irritant and was not a sensitizer to humans (CIR 1989). Butyl acetate primarily volatilizes to the atmosphere when released to the environment, where it will react with hydroxyl radicals and undergo photochemical oxidation. It is readily biodegradable and does not bioaccumulate in aquatic organisms (IPCS 2005).

9.1.3 Chemical name: Isopropanol

Discussion of applicability of the chemical alternative:

Isopropanol (IPA), commonly referred to as isopropyl alcohol, is an alcohol used as a solvent in nail polish and other coatings (CDPH 2019; EWG 2019; Mintel 2018).

Readily available hazard trait information:

IPA is listed as a Candidate Chemical (DTSC 2020a), and listed with inhalation or oral RELs by OEHHA. OEHHA identified noncancer endpoints of developmental toxicity, kidney toxicity, ocular toxicity, and respiratory toxicity (OEHHA 2019).

In animal studies, pups of pregnant rats that inhaled IPA showed decreases in fetal weight in a dose-dependent manner and developmental toxicity at very high doses (Nelson et al. 1988).

9.1.4 Chemical name: Methyl Ethyl Ketone

Discussion of applicability of the chemical alternative:

Methyl ethyl ketone (MEK) is a solvent used in nail products including nail coatings and nail polish thinner (EWG 2019; Mintel 2018).

Readily available hazard trait information:

MEK is identified as a toxic air contaminant by CARB for developmental toxicity, neurotoxicity, ocular toxicity, and respiratory toxicity (CARB 2020). MEK is also identified with noncancer endpoints for ocular and respiratory toxicity and listed with inhalation and oral reference exposure levels by OEHHA (OEHHA 2019).

In utero exposure to MEK causes developmental toxicity; in animals, studies have shown decreases in pup weights, organ weights, and skeletal anomalies (U.S. EPA 2003). Most human studies have focused on solvent abuse (intentional inhalation) and occupational exposures other than in nail salons, where inhalation and dermal exposures to high doses of MEK occurred (up to 100 percent MEK solvent) (U.S. EPA 2003). Many other occupational exposures to MEK occur with a mixture of other solvents, so it is not possible to relate observed hazards specifically to MEK exposure (U.S. EPA 2003). Studies with volunteers suggest MEK may also be a respiratory tract irritant at high doses (OEHHA 2008).

9.1.5 Chemical name: Water

There are some advantages and disadvantages to water-based nail polishes. Water-based nail polishes do not contain toxic solvents, but they may not last as long as traditional solvent-based polish (Malnou 2014). Challenges with water-based polish include longer drying time, difficulty hardening the polish, lack of polish brilliance, and lack of polish adherence to the nail (Malnou 2014).

9.2 Non-Chemical Alternatives

9.2.1 Discussion of applicability of the non-chemical alternative

Not applicable.

10 OTHER REGULATORY PROGRAMS

Reference: California Code of Regulations, title 22, section 69503.2(b)(2).

DTSC identified the following state and federal regulatory programs and laws related to the product or the Candidate Chemical in the product that are intended to protect public health and the environment. DTSC has assessed these programs to ensure that they do not overlap or conflict with this proposal to list nail products containing toluene as a Priority Product, nor with any subsequent regulation that may result for such listing.

10.1 U.S. Food and Drug Administration

The U.S. FDA is authorized by the Federal Food, Drug, and Cosmetic Act (FDCA) to oversee the safety of food, drugs, and cosmetics (FDA 2018b). The FDCA does not authorize the FDA to require safety testing of cosmetics, and there is no approval process for cosmetics products prior to sale in the U.S. (except for color additives). However, the FDA can and does inspect cosmetics manufacturing facilities to ensure that cosmetics are not adulterated (FDA 2018b).[17]

> The FDCA does not authorize the FDA to require safety testing of cosmetics, and there is no approval process for cosmetics products prior to sale in the U.S.

While cosmetic product manufacturers are legally responsible for ensuring the safety of their products, neither the FDCA nor FDA regulations require specific tests to demonstrate the safety of individual products or ingredients, and manufacturers are not required to share their safety information with the FDA. However, the FDA can pursue enforcement action against products on the market that it determines are not in compliance with the FDCA or the Fair Packaging and Labeling Act (FPLA), or against firms or individuals who violate these laws (FDA 2018b).

10.1.1 Federal Food, Drug, and Cosmetic Act

The FDCA is a set of laws passed by Congress in 1938 giving authority to the FDA to oversee the safety of food, drugs, and cosmetics (FDA 2018c). The FDCA defines cosmetics as “articles intended to be

[17] “Adulterated” cosmetics refers to product composition violations, whether they result from ingredients, contaminants, processing, packaging, or shipping and handling FDA (2018b) FDA Authority Over Cosmetics: How Cosmetics Are Not FDA-Approved, but Are FDA-Regulated. U.S. Food and Drug Adminstration (FDA). In. https://www.fda.gov/Cosmetics/GuidanceRegulation/LawsRegulations/ucm074162.htm Accessed March 2020

rubbed, poured, sprinkled, or sprayed on, introduced into, or otherwise applied to the human body ... for cleansing, beautifying, promoting attractiveness, or altering the appearance" (FDA 2018b). As noted above, the FDA does not preapprove cosmetic products. However, cosmetic products must be properly labeled and safe for consumers under labeled or typical conditions of use. The FDCA prohibits the marketing of adulterated or misbranded cosmetics in interstate commerce, and the FDA can remove cosmetics from the market that contain unsafe ingredients or that are mislabeled (FDA 2018b).

10.1.2 Fair Packaging and Labeling Act

The FPLA requires each package of household consumer products (including cosmetic products) to bear a label that includes a statement identifying the commodity (detergent, sponge, etc.); the name and place of business of the manufacturer, packer, or distributor; and the net quantity of contents in terms of weight, measure, or count (in both metric and English units). The FPLA is designed to facilitate value comparisons and to prevent unfair or deceptive packaging and labeling of many household consumer commodities (FDA 2009; FDA 2018d).

The specific labeling requirements for cosmetic products are specified in regulation in Title 21 of the Code of Federal Regulations, parts 701 and 740. Cosmetic products produced or distributed for retail sale to consumers for their personal care are required to bear an ingredient declaration (21 C.F.R. section 701.3 2016). Cosmetic products not typically distributed for retail sale (e.g., nail products used by professionals on customers at their places of work) are exempt from this requirement provided these products are not also sold to consumers at professional establishments or workplaces (FDA 2018a). However, the California Professional Cosmetics Labeling Law (described below) now requires that all professional cosmetic products manufactured and sold in California meet the labeling requirements for cosmetics pursuant to the FDCA and FPLA.

10.2 California Professional Cosmetics Labeling Law

The California Professional Cosmetics Labeling Law requires that all professional cosmetic products manufactured on or after July 1, 2020, and sold in California, must meet all labeling requirements for any other cosmetic pursuant to the federal Food, Drug, and Cosmetic Act and the federal Fair Packaging and Labeling Act (Health and Safety Code Section 110371).

10.3 U.S. Environmental Protection Agency

- Toluene is listed under the Toxic Substances Control Act (TSCA) of 1976, which was enacted by Congress to test, regulate, and screen all chemicals produced in or imported into the United States. TSCA requires any chemical that reaches the consumer marketplace to be tested for possible toxic effect prior to commercial manufacture (U.S. EPA 2018b). Under Section 8, TSCA requires reporting and record keeping by persons who manufacture, import, process, and/or distribute chemical substances in commerce. Under Section 8(e), any person who manufactures (which includes importing), processes, or distributes in commerce a chemical substance or mixture and who obtains information which reasonably supports the conclusion that such substance or mixture presents a substantial risk of injury to health or the environment should immediately inform U.S. EPA, except in situations where U.S. EPA has been adequately informed of such information (40 C.F.R. section 716.120 1994).

- Toluene is listed as a hazardous air pollutant under the Clean Air Act (42 U.S.C. section 7412 1999).
- Toluene is listed as an organic hazardous air pollutant under Federal Code of Regulations 40 C.F.R., Section 63, Subpart F, National Emission Standards for Organic Hazardous Air Pollutants from the Synthetic Organic Chemical Manufacturing Industry (40 C.F.R. section 63 2006).

10.4 U.S. Occupational Health and Safety Administration

The U.S. Occupational Health and Safety Administration (OSHA) has set a permissible exposure limit (PEL) for workers of 200 ppm for toluene in air averaged over an eight-hour workday (OSHA 1993; OSHA 2018a). OSHA acknowledges that many of its PELs are outdated and inadequate to ensure protection of worker health. Most of OSHA's PELs were issued shortly after adoption of the Occupational Safety and Health Act in 1970 and have not been updated since then. The OSHA PEL for toluene was set in 1971 (OSHA 2018b). Nevertheless, as noted above, changes to occupational exposure limits for a chemical are not among the regulatory response options that DTSC might eventually impose for toluene-containing nail products.

10.5 California Division of Occupational Safety and Health, Cal/OSHA

In 2012, the California Division of Occupational Safety and Health (DOSH), also known as Cal/OSHA, set a PEL for workers of 10 ppm (37.6 mg/m^3) for toluene in air averaged over an eight-hour workday (Cal/OSHA 2018; OSHSB 2012). If DTSC proceeds with rulemaking to list toluene-containing nail products as a Priority Product, the regulations would not affect existing occupational exposure limits like the PEL. DTSC might eventually impose one or more regulatory responses on manufacturers of toluene-containing nail products. However, regulatory responses must be selected from among seven options described in Article 6 of the Safer Consumer Products regulations; changes to occupational exposure limits for a chemical are not among these options.

10.6 California Office of Environmental Health Hazard Assessment

Toluene is listed as a developmental toxicant by OEHHA under Proposition 65 (Safe Drinking Water and Toxic Enforcement Act of 1986) (OEHHA 1991). By law, manufacturers must include a Proposition 65 warning label on products that contain toluene (OEHHA 2019; OEHHA 2020b). Businesses with 10 or more employees that have products containing toluene at their place of business must also provide a warning (OEHHA 2019; OEHHA 2020b). These warnings are unless the exposure is low enough to pose no significant risk of causing birth defects (OEHHA 2019; OEHHA 2020b). The maximum allowable dose level for toluene is 7,000 µg/day for ingestion and 13,000 µg/day for inhalation (OEHHA 2013). Business who cause exposure to toluene are responsible for determining whether the exposure poses no significant risk (OEHHA 2017; OEHHA 2020b).

10.7 California Department of Public Health, California Safe Cosmetics Program

The California Department of Public Health (CDPH) created the California Safe Cosmetics Program (CSCP) in response to the passage of the California Safe Cosmetics Act. Beginning in 2009, cosmetic manufacturers with aggregate sales greater than $1 million must report to CSCP products they sell in California which have intentionally added chemical ingredients identified by authoritative bodies as known or suspected carcinogens or reproductive or developmental toxicants (CDPH 2016). Triphenyl phosphate must be reported to CSCP if it is an ingredient in a cosmetic product (CDPH 2020).

While the intention of the Safe Cosmetics Act is to improve access to information about potentially harmful ingredients in cosmetics and to influence the reformulation of some products toward safer alternatives, it does not duplicate the SCP regulations. The Safe Cosmetics Act requires manufacturers to report certain chemical ingredients in products, but it does not require manufacturers to evaluate those products for safer chemical alternatives.

10.8 California Air Resources Board

CARB's Consumer Products regulations restrict the manufacture and sale of specific products that contain VOCs, a broad grouping of chemicals that have the potential to react to form air pollutants including ground-level ozone and particulates (CARB 2018; CARB 2019). Under these regulations, no person shall sell, supply, offer for sale, or manufacture for sale in California any nail polish remover which, at the time of sale or manufacture, contains one percent VOCs by weight (CARB 2019). Toluene concentrations in removers would greatly exceed one percent; thus, toluene is not allowed as a compound in nail polish remover in California (CARB 2017). Acetone has been exempted from the requirements of this regulation (CARB 2019). There are currently no CARB regulations for nail polish or nail polish thinner.

10.9 California Board of Barbering and Cosmetology

The California Board of Barbering and Cosmetology (BBC) protects the public health, safety, and welfare by regulating the practices of the beauty industry (e.g., professional barbers, cosmetologists, estheticians, manicurists, and tanning salon workers). BBC qualifies and licenses individuals and businesses, establishes and enforces administrative rules and laws, and provides information for the public to make informed decisions. The BBC does not restrict or prohibit the use of toluene in nail products.

ACRONYMS AND ABBREVIATIONS

Abbreviations used in this document

AA	Alternatives Analysis
AAT	Alternatives Analysis Threshold
ATSDR	Agency for Toxic Substances and Disease Registry
Cal/OSHA	California Division of Occupational Safety and Health
CARB	California Air Resources Board
CAS	Chemical Abstract Service
CDC	Centers for Disease Control and Prevention
CDPH	California Department of Public Health
CFR	Code of Federal Regulations
CPID	Consumer Products Information Database
CSCP	California Safe Cosmetics Program
DBP	dibutyl phthalate
DCA	Department of Consumer Affairs
DOSH	California Division of Occupational Safety and Health, also known as Cal/OSHA
DTSC	Department of Toxic Substances Control
EWG	Environmental Working Group
ESPR	External Scientific Peer Review
FDA	Food and Drug Administration
FDCA	Federal Food, Drug, and Cosmetic Act
FPLA	Fair Packaging and Labeling Act
GPC	Global Product Classification
HNSR	Healthy Nail Salon Recognition
HRA	Health Risk Assessment
HVAC	heating, ventilation, and air conditioning
IARC	International Agency for Research on Cancer
IPA	isopropyl alcohol
IPCS	International Programme on Chemical Safety
IRIS	Integrated Risk Information System
LED	light-emitting diode
LEL	lower explosive limit
LEV	local exhaust ventilation
MCL	Maximum Contaminant Level
MEK	methyl ethyl ketone
N95 masks	NIOSH-approved filtering facepiece respirators
NIOSH	National Institute for Occupational Safety and Health
NTP	National Toxicology Program
NYSDOH	New York State Department of Health
o-cresol	ortho-cresol
OEHHA	Office of Environmental Health Hazard Assessment
OSHA	Occupational Health and Safety Administration
p-cresol	para-cresol
PEL	Permissible Exposure Limit
PPE	personal protective equipment

PPN	Priority Product Notification
PQL	Practical Quantitation Limit
Proposition 65 list	chemicals listed as “Known to the State to Cause Cancer or Reproductive Toxicity” under California’s Safe Drinking Water and Toxic Enforcement Act of 1986
REL	Reference Exposure Level
SCCP	Scientific Committee on Consumer Products
SCP	Safer Consumer Products
SCV	source capture ventilation
SF Environment	San Francisco Department of the Environment
SWRCB	State Water Resources Control Board
UEL	upper explosive limit
UCL	upper confidence limit
U.S. EPA	United States Environmental Protection Agency
UV	ultraviolet
VOC	volatile organic compound
WHO	World Health Organization

Units

atm	atmosphere
atm·m^3/mol	atmosphere times cubic meter per mol
°C	degrees Celsius
°F	degrees Fahrenheit
ft^2	square feet
ft^3	cubic feet
g	gram
g/cm^3	gram per cubic centimeter
g/mol	gram per mol
kg	kilogram
K_{oc}	organic carbon-water partition coefficient
K_{ow}	octanol-water partition coefficient
m	meter
m^3	cubic meter
mm Hg	millimeter of mercury
mg/L	milligram per liter
mg/m^3	milligram per cubic meter
nm	nanometer
ppb	parts per billion
ppm	parts per million
v/v	volume/volume
µg	m~~M~~icrogram
µg/mL	micrograms per milliliter

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40 C.F.R. section 63 (2006) Code of Federal Regulations, Title 40, Protection of Environment, Chapter I, Part 63, National Emission Standards for Hazardous Air Pollutants for Source Categories. Appendix Table 2 to Subpart F of Part 63, Organic Hazardous Air Pollutants.

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APPENDIX 1 – REPORT PREPARATION

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APPENDIX 2 – ALTERNATIVES ANALYSIS THRESHOLD RATIONALE

Alternatives Analysis Threshold Explanation

Section 69505.3 of title 22 of the California Code of Regulations states that when a Chemical of Concern is present in a Priority Product at or below the Alternatives Analysis Threshold (AAT), the product's manufacturer may be exempt from submitting an Alternatives Analysis (AA) if they instead submit an AAT Notification, either concurrently with the Priority Product Notification (PPN) or by the due date for the Preliminary AA Report. Section 69501.1(a)(12) defines the AAT as either the Practical Quantitation Limit or some higher value specified by the Department of Toxic Substances Control (DTSC). The Practical Quantitation Limit (PQL) is defined as "the lowest concentration of a chemical that can be reliably measured within specified limits of precision and accuracy using routine laboratory operating procedures." (California Code of Regulations, title 22, § 69501.1(a)(52).) Further, DTSC must set an AAT if a Chemical of Concern occurs solely as a contaminant in a Priority Product.

Alternatives Analysis Threshold Value

DTSC proposes to set the AAT for toluene in nail products at 100 parts per million (ppm).

DTSC chose the AAT for nail products containing based on the following factors:

- Our goal is to protect nail salon workers and nail product consumers from intentionally added toluene as an ingredient in nail products.
- Data received in 2020 from nail product manufacturers and other entitles indicate that toluene is found in nail products both as a contaminant and as an added ingredient.
- DTSC recently conducted analytical laboratory testing of 157 nail products and detected toluene in 27 nail coatings and nail polish thinners at concentrations ranging from 31.4 ppm to 187,000 ppm, indicating that toluene is in some products as an added ingredient and others as a contaminant.
- During a pre-regulatory public comment period, industry stakeholders requested that DTSC set the AAT above contaminant levels. When toluene is present as a contaminant in nail products, the concentration is generally 100 ppm or lower, according to these stakeholders.
- Several other states have enacted laws requiring that manufacturers report products marketed to children that contain toluene and other specified chemicals above a contamination threshold of 100 ppm:
    - Oregon Toxic Free Kids Act (OHA 2021);
    - Washington Children's Safe Products Act (WA DOE 2021); and
    - Vermont Chemicals of High Concern to Children Law (VDP 2021).

Analytical Methods

To determine the concentration of toluene in nail products, DTSC recommends using a gas chromatography/mass spectrometry (GC/MS) method designed for analysis of volatile organic compounds (VOCs) in solid and aqueous samples, such as Method 8260D, as described in U.S. EPA SW-846 (U.S. EPA 2018a). Any other analytical technique that meets the Method Performance Criteria described below may be used for sample preparation and measurement of toluene concentrations in nail products.

Nail product samples recently analyzed by DTSC's Environmental Chemistry Laboratory contained toluene and other VOCs at concentrations ranging from low ppm to high ppm levels (DTSC 2021). Some carry-over of VOCs from one sample into one or more subsequent blank samples was not uncommon. Therefore, to avoid this issue when verifying that toluene concentrations do not exceed the AAT, laboratories may wish to begin by diluting samples with methanol using a 5,000-fold dilution factor.

Requirements and Reporting

When a manufacturer submits an AAT Notification instead of an Alternatives Analysis, it must demonstrate and certify that the concentrations of toluene in its nail products do not exceed the AAT. A manufacturer may demonstrate the AAT exemption has been met by measuring the concentration of toluene in each Priority Product and submitting laboratory testing results or by receiving certificates of analyses from the ingredient suppliers, of ingredients which are known are suspected to contain toluene, that specify the concentration of toluene in the source materials to make each Priority Product. Further, if a manufacturer provides information from the ingredient suppliers, the manufacturer must also submit calculations of the final concentration of toluene for each formulated Priority Product. When submitting laboratory testing results, manufacturers must also provide the analytical data, the laboratory analytical testing methodology, and the quality control and assurance protocols followed to measure each Chemical of Concern in the Priority Product, and the name and location of the testing laboratory that conducted the analysis. Trade secret or confidential business information submitted for compliance certification can be submitted through DTSC's CalSAFER website, which is equipped to receive and securely handle such information.

In addition, each AAT Notification must also include a demonstration that the manufacturer will continue to meet the AAT value. If, at any point, the concentration of toluene in the Priority Product no longer falls at or below the AAT, the manufacturer is required to notify DTSC within 30 days of the change and must submit a Preliminary AA Report or a chemical or product replacement or removal notification within 180 days of the change.

Any testing laboratory that conducts the analysis used by the manufacturer to certify that the concentration of toluene in a nail product do not exceed the AAT must meet the method performance criteria described below.

Sample Preparation Criteria

1. Each nail product must be gently mixed or shaken prior to taking an aliquot of the product to ensure the aliquot is representative of the contents in the container.
2. A sample may be introduced into the analytical instrument by various techniques including, but not limited to, purge-and-trap, automated static headspace, and direct injection, provided that all other performance criteria are met.

Analytical Method Criteria

1. It is recommended to use a gas chromatograph/mass spectrometer (GC/MS) method designed for analysis of volatile organic compounds (VOCs) in solid and aqueous samples, such as Method 8260D, as described in U.S. EPA SW-846 (U.S. EPA 2018a). Any other analytical technique that meets the method performance criteria may be used for sample analysis and determination of toluene concentrations in nail products.
2. Either toluene-d_8 may be used as the internal standard, using an isotope dilution method, or chlorobenzene-d_5 may be used as an internal standard (IS) and toluene-d_8 used as a surrogate. The IS must be added to each sample, prior to introduction into the analytical instrument, at a concentration within the calibration range for toluene.
3. A signal-to-noise (S/N) ratio of 3:1 or greater must be met for all quantitation ions for toluene in all quantified samples.
4. The quantitation limit for toluene should be 30 ppm or less.

Instrument Criteria

1. All study samples must be analyzed on a properly calibrated instrument that meets instrument manufacturer specifications. If the instrument calibrations or other instrument check requirements (i.e., mass spectrometer tune, mass calibration check, or qualitative identification criteria) are outside the acceptable criteria, standard measures to correct the problem must be performed prior to analyzing samples.
2. The use of a gas chromatograph/mass spectrometer is recommended for the separation and fragmentation of analytes for identification. The ratios of qualifier ions to quantitation ions must be established during calibration and must be maintained throughout sample analysis to verify the identity of toluene and ensure that there are no interfering peaks.
    a. Laboratories may use mass spectrometer full scan, selected ion monitoring (SIM), or multiple reaction monitoring (MRM) scanning modes to analyze samples and meet the LOQ requirement.
    b. Methods must incorporate, at a minimum, one quantitation and one qualifier ion for toluene (see Table 4).

3. The method must incorporate, at minimum, one quantitation ion for internal standards and surrogates. Further, the method may additionally include one or more qualifier ions for internal standards and surrogates (see Table 4).

Table 4. Mass Spectrometer Ions for Compounds of Interest

Compound	Full Scan and SIM
Toluene	Quantitation Ion: 92
	Qualifier Ions: 91
Toluene-d_8	Quantitation Ion: 98
Chlorobenzene-d_5	Quantitation Ion: 117

Calibration Criteria

1. The instrument tune checks must be done prior to calibration and at the beginning of each 12-hour analytical run. For analysis run by full scan GC/MS, it is recommended to use 4-bromofluorobenzene (BFB) as the tune verification standard. For SIM and MRM, it is recommended to follow the manufacturer's instrument tuning criteria. All samples, including quality control (QC) and calibration standards, should be introduced into the GC/MS for analysis within 12 hours of the analysis of the tune check standard. Samples and QC standard solutions that are not analyzed within the 12-hour time window cannot be reported.
2. Requirements for calibration standards and samples:
   a. After the initial calibration, the RT of each IS in the sample must be within 10 seconds of the RT of each IS at the midpoint of initial calibration (ICAL); and
   b. The RRT of the analyte of interest should be within 0.06 compared to the midpoint of the ICAL or CCV standard. This is the ratio of the internal standard’s retention time, in decimal minutes, to the analyte’s retention time, as a ratio of the IS RT to the analyte RT.
3. The fitted line of the ICAL must consist of a minimum of at least five non-zero calibration concentrations. The concentration of the analyte in the lowest standard solution must be accurate within 50 percent of its true concentration value and all other calibration levels must be within 30 percent of their true value. The fitted line of the initial calibration shall meet one of the criteria below.
   a. The relative standard deviation, expressed as a percentage, shall not exceed 20 percent. This is the ratio of the standard deviation to the mean of the response factor for toluene; or
   b. The linear fit shall have a correlation coefficient greater than 0.99.

4. An initial calibration verification (ICV) standard solution, with a concentration at or near the mid-point of the calibration curve, must be analyzed immediately following the initial calibration and the calculated toluene concentration must be within 30 percent of its true concentration value. No samples should be run until the ICV is analyzed.
5. A CCV standard solution must be analyzed before sample analysis and at the end of analysis within 12 hours of the instrument tune check. The measured concentration of CCV standard solution must be within 20 percent of its true concentration value. If the calibration verification does not meet the acceptance criteria, standard measures to correct the problem must be implemented , and another aliquot of the CCV standard solution must be analyzed. If the response of the CCV standard solution is still not within 20 percent of its true concentration value, then a new initial calibration may be conducted.

Quality Control Criteria

1. All data must adhere to a quality control protocol that includes, for each batch of 20 samples, for each type of nail product analyzed:
    a. Preparation and analysis of a duplicate sample;
    b. Preparation and analysis of a matrix spike and matrix spike duplicate.
    c. Preparation and analysis of a laboratory control sample and laboratory sample duplicate.
2. Each product sample, method blank, sample duplicate, laboratory control sample, laboratory control sample duplicate, matrix spike, and matrix spike duplicate must be spiked with a surrogate standard solution prior to analysis. A recommended protocol is outlined below. Alternate protocols are acceptable as long as they include method blanks and meet analytical accuracy and precision requirements for each sample and can demonstrate a relative percent difference (RPD) less than or equal to 20 percent for duplicate samples and a spike recovery between 70 to 130 percent of known spiked concentrations.
3. Insert a sufficient number of solvent blanks between samples to verify no carryover or cross contamination of toluene from one sample to the next.
4. Recommended Quality Control Protocol:
5. The measured concentration of the surrogate standard solution in each product sample, method blank, sample duplicate, laboratory control sample, laboratory control sample duplicate, matrix spike, and matrix spike duplicate undergoing analysis must be within 70 to 130 percent of the spiked concentration.
6. A method blank is run with every batch of up to 20 samples. The concentration of toluene in each method blanks must not exceed one half of the limit of quantitation.
7. A laboratory control sample and laboratory control sample duplicate are analyzed with every batch of 20 samples; both samples must be accurate within 30 percent of the true concentration value and precise, with a RPD less than or equal to 20 percent.

8. A matrix spike and matrix spike duplicate must be analyzed with every batch of 20 samples. The measured concentration in both samples must be between 70 and 130 percent of the spiked concentration and a RPD must be less than or equal to 20 percent. The laboratory may establish more rigorous internal control limits but must not exceed the 70 to 130 percent accuracy recovery range.
9. The RT of the target analyte in the sample must be within 10 seconds of the RT time of either the mid-point concentration standard solution of the ICAL or the first CCV standard solution of the 12-hour analytical sequence.

Definitions[18]

"Aliquot" is a measured portion of a total amount of a sample solution or suspension.

"Continuing Calibration Verification (CCV) Standard" is a mid-range concentration standard analyzed before, during, and at the end of an analytical batch and verifies that the instrument response has not drifted from the initial calibration response. This standard solution contains a known concentration of the target analyte and is typically derived from the same source as the initial calibration standards.

"Correlation Coefficient (r^2)" is a statistical measure of the strength of relationship between two variables.

"Initial Calibration (ICAL)" is a determination of the instrument response over a range of known concentrations of an analyte or analytes. A series of standard solutions is prepared from a certified reference material and analyzed on the instrument prior to any samples. Five or more standard solutions containing progressively higher concentrations of the analytes of interest are generally prepared.

"Initial Calibration Verification (ICV) Standard" is a certified solution from a source other than used for the initial calibration standards and is used to verify the accuracy of the initial calibration.

"Internal Standard (IS)" is a chemical substance that is similar, but not identical, to the target analyte and is added to each sample at a known concentration. The internal standard mimics the behavior of the target analyte but has a different signal than the analyte. An internal standard is used for quantitation of target analytes and to account for matrix effects and/or variability in instrument response by normalizing the response of the target analytes and surrogates, thereby decreasing measurement bias.

"Laboratory Control Sample/Laboratory Control Sample Duplicate (LCS/LCSD)" is a clean matrix which has been spiked with a known concentration of the target analyte. It is prepared and analyzed in the

[18] Partially adapted from Chapter One of the SW-846 Compendium for Hazardous Waste Test Methods (U.S. EPA 2014).

same analytical batch and in exactly the same manner as the other samples. The laboratory control sample and laboratory control sample duplicate are used to assess general method performance based on the ability of the laboratory to successfully recover target analytes.

"Matrix Spike/Matrix Spike Duplicate (MS/MSD)" are quality control samples that contain known concentrations of target analytes which have been added before extraction and analysis.

"Method Blank" is a clean matrix containing only the internal standard and is used to assess background interference or contamination in the analytical system that might lead to reporting of elevated concentration levels or false positive data. Concentrations of the target analyte shall not exceed one half of the lower limit of quantitation.

"Multiple Reaction Monitoring (MRM)" is a highly sensitive analytical method using a triple quadrupole mass spectrometer. The target analyte is ionized in the ion source which creates a specific ion which is characteristic of the target analyte. This ion is then fragmented into product (quantitation and qualifier) ions which are selectively passed through the third quadrupole and are detected. Multiple product ions can be detected at once.

"Percent Recovery" is the proportion of the concentration of a target analyte measured in a sample relative to the known concentration spiked into a sample, conveyed as a percentage.

"Quantitation limit (QL)" is the lowest calibration concentration multiplied by the dilution factor.

"Relative Percent Difference (RPD)" is the absolute difference between two measurements, divided by their average, converted to percentage.

"Relative Standard Deviation (RSD)" is the standard deviation of a group of measurements in a data set, divided by their average, converted to percentage. Percent RSD is an indicator of how a group of measurements in a data set are scattered around the mean.

"Response Factor" is the ratio between a signal produced by an analyte, and the concentration of analyte which produced the signal.

"Selected Ion Monitoring (SIM)" is a mass spectrometry technique in which a limited set of ions with specific mass-to-charge (m/z) ratios is monitored by the instrument. This technique typically results in increased sensitivity relative to full scan mass spectrometry.

"Signal to Noise Ratio (S/N)" is a measure that compares the level of a desired signal (i.e., the change in instrument response to the presence of a substance) to the level of background noise (i.e., the fluctuation in the instrument background signal).

"Surrogate" is the compound that is used to monitor extraction and analysis efficiency of the method.

APPENDIX 3 – DTSC'S INFORMATION CALL-IN DATA OF NAIL PRODUCTS

Table 5. Toluene-containing nail products reported for DTSC's information call-in (DTSC 2020b).

Main Product Category	Subproduct	Reported Concentration Range	Number of Products Reported
Other nail products	Primers/bonders/bond-aid products	0-0.1%	1
	Removers	0-0.1%	1
	Thinners	5-10%	1
Solvent-based nail coatings	Base coat	0-0.1%	2
	Gel polish/gel-like polish (no UV required)	0-0.1%	1
	Gel top coat	0-0.1%	1
	Top coat	0-0.1%	1
		10-25%	10
	Traditional nail polish, aka varnish, lacquer, enamel	0-0.1%	4
		0-0.1%	159
UV gel nail products	UV base and top coat	0-0.1%	1
	UV gel polish	0-0.1%	1

APPENDIX 4 – MEASURED TOLUENE CONCENTRATIONS IN NAIL PRODUCTS FROM DTSC'S ANALYTICAL LABORATORY STUDY

Table 6. Concentrations of toluene in nail products as detected in DTSC's anlaytical laboratory testing of nail products (DTSC 2021)

Product	Result (ppm)
Acrylic Liquid Monomer #1	33
Acrylic Liquid Monomer #2	33
Airbrush Top Coat #1	187,000
Airbrush Top Coat #2	117,000
Anti-nail bite polish	94
Hard Gel #1	51
Hard Gel #2	32
Hardener #1	161,000
Hardener #2	169
Multi-functional (top coat, base coat, and hardener) #1	31
Multi-functional (top coat, base coat, and hardener) #2	890
Multi-functional (top coat, base coat, and hardener) #3	35
Nail Art	106
Nail Glue	114
Nail Prep Dehydrator	2,700
Nail Primer #1	35
Nail Primer #2	36
Thinner #1	167,000
Thinner #2	176,000
Top Coat #1	87,200
Top Coat #2	132,000
Top Coat #3	7,320
Top Coat #4	42
Top Coat #5	409
UV Gel Polish #1	57
UV Gel Polish #2	44
UV Gel Polish #3	55