Haftalik

Product-Chemical Profile   
for Nail Products Containing

Methyl Methacrylate (MMA)

**Discussion Draft – February 2020**

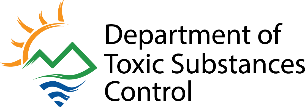
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# About This Profile

The Department of Toxic Substances Control (DTSC) identifies product-chemical combinations for consideration as Priority Products in accordance with the process identified in Article 3 of the Safer Consumer Products (SCP) regulations.[[1]](#footnote-2) DTSC finds methyl methacrylate (MMA) in nail products meets the key prioritization criteria[[2]](#footnote-3) for listing a Priority Product:

(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.

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

The SCP regulations allow DTSC to use a narrative standard to show how these criteria are met. This Product-Chemical Profile (Profile) provides that narrative, demonstrating that the regulatory criteria have been met and serving as the basis for Priority Product rulemaking. The Profile does not provide a comprehensive assessment of all available literature on adverse impacts and exposure for MMA or nail products. DTSC will finalize this Profile after considering public comments and may then start the rulemaking process. If this Priority Product regulation is adopted, the responsible entities must follow the reporting requirements pursuant to the SCP regulations.[[3]](#footnote-4)

Readers should consider the following:

1. This Profile is not a regulatory document and does not impose any regulatory requirements.
2. The Profile summarizes information compiled by DTSC as of February 2020.
3. DTSC requests that stakeholders provide data on the chemical and product described in this document to assist us in the discernment process that may lead to our regulatory proposal. Written comments can be submitted using our information management system, CalSAFER,[[4]](#footnote-5) prior to March 20, 2020.
4. 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.

# Summary of the Rationale for Product-Chemical Selection

Methyl methacrylate (MMA) is a monomer[[5]](#footnote-6) used in the preparation of acrylic nails and nail coatings including nail polishes and gel nail products. It is a liquid at room temperature and readily volatilizes into air. MMA exhibits several health hazard traits and appears on one of the 23 authoritative lists that make up the Candidate Chemicals List in the Safer Consumer Product (SCP) regulations. People who use MMA-containing nail products may be exposed to and harmed by MMA. For this reason, DTSC proposes to identify nail coatings and acrylic nails containing MMA as a Priority Product with a Chemical of Concern.

Approximately 100 million women use nail products in the United States each year, and annual sales of retail nail products exceed $1 billion. Products that may contain MMA such as acrylic nail products and nail polishes represent almost 62 percent of total nail product sales in the United States.

Sensitive subpopulations, including children and pregnant women, may be exposed to MMA and other potentially harmful chemicals by using these nail products. A study found that 45 percent of children younger than 5 years old use nail polish, and this increases to 79 percent for children over the age of 5.

The primary exposure route from nail products is vapor inhalation. People who apply MMA-containing nail products at home may experience the same, or higher, exposures as nail technicians.

People who apply MMA-containing nail products at home may experience the same, or higher, exposures as nail technicians who use methacrylate-containing products at work. Several factors may increase home users’ exposures. Home environments may have relatively poor ventilation and consumers are not trained on the safe use of these products, which are generally not labeled with information on exposure potential. Consumers may also apply them frequently, since doing so is more convenient and affordable than visiting a salon for nail services. There are no minimum age limits for purchasing or using MMA-containing retail nail products, and they are sometimes purchased by adolescents, who may understand the exposure potentials even less than adults.

The primary exposure route of MMA from nail products is vapor inhalation. MMA can also be absorbed from nail products dermally through direct skin contact. Exposure can also occur from accidental ingestion and hand-to-mouth behavior especially in children. In the National Electronic Injury Surveillance System, 769 exposures related to acrylic nails that may contain MMA were recorded in 1991 through 1993 and 54.7 percent of the emergency department visits involved children younger than 6 years old. Eighty nine percent of these incidents occurred at the child’s own home. In a survey conducted among pregnant women in New York City from 2003 through 2006, 69 percent of the participants said they used nail products at some point throughout their pregnancy.

Exposure to MMA has the potential to cause or contribute to adverse human health impacts, including:

* **Dermal toxicity.** MMA exposure is linked to skin irritation and inflammation, nail damage, nail discoloration, infection, redness, and pain.
* **Respiratory toxicity.** MMA exposure has been shown to harm the respiratory tract.

One study found acrylate and methacrylate concentrations above 90 percent in some samples of ultraviolet (UV)-curing nail polishes (i.e., UV gels) for home use that may contain MMA as an ingredient. Severe skin reactions and allergic contact dermatitis were observed in 7 study participants, ranging in age from 15 to 41 years old, who used acrylate or methacrylate-containing products. Sixty-five additional study participants, including nail technicians who had used methacrylate-containing nail polishes at home and in salons reported hand eczema; itching and pain in the fingers; permanent nail damage; and eczema on the lips, throat, and around the eyes. Another study documented allergic contact dermatitis, pain in fingers, and eczema in 4 female patients between ages of 35 to 65 years old who had used UV gel nail polish kits at home; 3 out of 4 patients had positive patch tests for methacrylates, including MMA, and all 4 patients had positive patch tests for acrylates.

MMA’s metabolites also have potential adverse impacts. Two of them, formaldehyde and methanol, are Candidate Chemicals. The International Agency for Research on Cancer (IARC) and the Office of Environmental Health Hazard Assessment (OEHHA) identify formaldehyde as a carcinogen, and OEHHA identifies methanol as a developmental toxicant on the Proposition 65 list.

Despite regulatory actions prohibiting MMA, MMA continues to be detected in indoor air in nail salons.

In the early 1970s, the U.S. Food and Drug Administration (FDA) removed the nail products that contain 100 percent MMA from the market and, in 2015, California’s Board of Barbering and Cosmetology (BBC) prohibited the use of MMA-containing nail products with any MMA concentration in licensed hair and nail salons and cosmetology schools. Despite these regulatory actions, MMA continues to be detected in indoor air in nail salons, sometimes above occupational exposure limits. There are several possible sources of this MMA. Retail nail products that contain less than 100 percent MMA are being legally sold in the market. In some cases, clients may bring MMA-containing retail products into nail salons to be applied by their technicians. In others, salons may have continued using MMA-containing professional-use nail products despite the 2015 BBC ban in California. Another possible source may be nail products formulated with polymethyl methacrylate (PMMA), which have been found to contain residual, unreacted MMA. The Nail Manufacturers Council reported that residual MMA in PMMA-containing products can be up to 1.5 percent of the total PMMA content in the product. The use of a nail product in a salon with PMMA as a listed ingredient containing MMA as a residual is a legal use of an MMA-containing nail salon product.

MMA has been detected in retail nail products for home use; thus, nail product consumers, pregnant women and their fetuses, infants, and children are at risk of being exposed to MMA from nail products that are intended for home use. In addition, MMA has been detected in salon indoor air; therefore, nail technicians may be exposed to MMA at work. Nail technicians working while pregnant or bringing their children to work may expose them to MMA vapors in salon indoor air. Moreover, pregnant customers receiving nail services in salons risk exposing their fetuses and customers bringing their children to the salon may expose them to MMA. Due to physiological differences, infants and children are more susceptible to adverse impacts from MMA exposure than adults.

Despite the MMA ban in California nail salons, customers may bring MMA-containing retail products into nail salons and salon owners may still purchase MMA from other states or overseas. For instance, according to a survey conducted in 2019, salon owners reported that MMA can still be purchased from Colorado nail supply stores despite the MMA ban in Colorado. Similarly, despite the MMA ban in New York and New Jersey, MMA was detected in salons according to a study performed in 2019. In addition, MMA may be a residual or MMA may be released as a result of depolymerization of PMMA in nail products containing PMMA. Therefore, nail technicians are still at risk of being occupationally exposed to MMA. Further, 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.

The FDA does not have the authority 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). Even after the FDA’s action, there is no restriction on the use of MMA in other cosmetic products or on the sale of retail nail products with MMA concentrations lower than 100 percent. Many such products exist, as illustrated by the recent recall of products with more than 90 percent MMA in Europe, due to the implementation of Cosmetics Regulation 1223/2009/EC in 2013. Moreover, there is no regulation addressing MMA release as a result of depolymerization of PMMA or MMA as a residual from PMMA-containing nail products.

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

# Product-Chemical Definitions and Scope

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

## 1.1 Scope of Candidate Chemical

**Methyl Methacrylate, Chemical Abstract Service (CAS) Registry Number: 80-62-6**

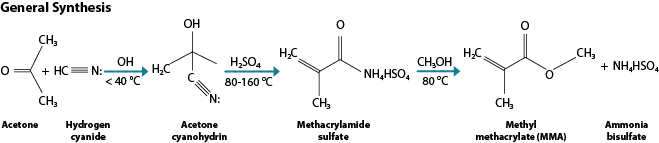
Systematic IUPAC name: methyl 2-methylprop-2-enoate (NCBI 2017).

Other names:

* Methyl 2-methylpropenoate
* Methyl methacrylate monomer
* MMA
* Methacrylic acid methyl ester (Sigma-Aldrich 2017)
* 2-(methoxycarbonyl)-1-propene
* CH2=C(CH3)COOCH3

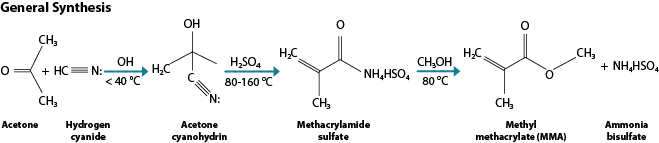
**Molecular Formula: C5H8O2**

MMA is a clear, colorless, highly flammable, and volatile liquid monomer which has a strong fruity odor (Tomenson et al. 2005). MMA is not known to occur naturally (IARC 1994).



*Figure 1. Chemical structure of methyl methacrylate (MMA) monomer (NCBI 2017).*

MMA is commercially produced through acetone cyanohydrin (ACH) (see Figure 2). The ACH process is performed by condensation of acetone and hydrogen cyanide. The cyanohydrin is hydrolyzed in the presence of [sulfuric acid](https://en.wikipedia.org/wiki/Sulfuric_acid) (H2SO4) to a [sulfate ester](https://en.wikipedia.org/wiki/Sulfate_ester) of [methacrylamide](https://en.wikipedia.org/wiki/Methacrylamide) and [methanolysis](https://en.wikipedia.org/wiki/Methanolysis) of this ester produces [ammonia bisulfate](https://en.wikipedia.org/wiki/Ammonium_bisulfate) (NH4HSO4) and MMA (Almazán-Sánchez et al. 2014).

**General Synthesis**

*Figure 2. General synthesis of MMA (Almazán-Sánchez et al. 2014).*

MMA monomers polymerize (i.e., combine to form polymer chains) to polymethyl methacrylate (PMMA) resins in the presence of heat to yield highly transparent, strong, and durable materials (IHS Markit 2016).

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

* Identified as a toxic air contaminant by the California Air Resources Board (CARB 2011).

## 1.2 Scope of Product

The scope of this proposal covers nail coatings and acrylic nails containing MMA.

“Nail coating” means any clear or colored paint, polish, lacquer, enamel, or gel product marketed or sold for application to fingernails or toenails. Subproducts include nail polishes, lacquers, enamels, base coats, undercoats, top coats, gel nails, gel nail polishes, Shellac, hard gels, nail art products, and airbrush nail art paints.

* “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 used after applying other coatings to the nail. It may be marketed for the use of protecting underlying coatings or to add shine, gloss, or matte to the nail.
* “Gel” or “UV gel” or “nail gel” is a pre-mixed coating that is hardened using an ultraviolet (UV) or light-emitting diode (LED) lamp.
* “Gel nail polish” or “gel polish” is a gel varnish coating with a look and feel similar to UV gel but which may not require UV or LED lamp heat to dry. Gel polish typically contains color but can also be a clear nail coating.
* “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.
* “Hard gel” is a nail enhancement that can be sculpted and shaped like acrylic nails but hardens through UV or LED light rather than through evaporating solvents.
* “Nail art” means any technique of decorative art applied to fingernails and/or toenails including various overlays of nail polish, UV gel, or hybrid coatings like Shellac or airbrush paint. This definition only includes nail art that falls within the definition of “nail coatings.”
* “Airbrush nail art paint” is a coating that is 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.

“Acrylic nails” are artificial nails that are sold in two separate parts: an acrylic powder and a liquid acrylic monomer (sometimes labeled “acrylic liquid” or “liquid”). The powder and liquid are combined immediately prior to application to the nail.

Nail coatings include, but are not limited to, products that can be categorized as Global Product Classification (GPC) used by the following codes (GS1 2017):

* 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: 30000720 – COMBINATION

Value: 30003886 – FALSE NAILS

Value: 30004464 – FALSE NAILS ACRYLIC MASS

Value: 30004466 – FALSE NAILS UV GEL

* + - * + Attribute: 20000794 – Type of Material

Value: 30004418 – ACRYLIC

Value: 30004342 – UV ACTIVATED GEL

## 1.3 Chemical and Product Use and Trends

MMA is a high production volume chemical and approximately 1 to 5 billion pounds per year of MMA are produced in the United States (U.S. EPA 2018). In 2016, approximately 80 to 85 percent of MMA was used worldwide for residential and commercial construction, remodeling, automotive applications, and manufacture of equipment (IHS Markit 2016). MMA producers use 50 to 60 percent of their production mainly for PMMA resins and surface coatings. The United States is reported to be the largest MMA consumer in the world. MMA consumption is predicted to grow at an average annual rate of 3 percent from 2015 to 2020 (IHS Markit 2016). The global market for MMA is expected to exceed 4.8 million metric tons (10.6 billion pounds) by 2020 (Global Industry Analysts Inc. 2016).

### 1.3.1 Use of MMA in Personal Care Products

MMA is used in some professional and retail nail polishes, gel nail products, and acrylic nails. In cosmetics, MMA polymerizes to PMMA to help fill in wrinkles and provides a gliding application (FutureDerm 2011). PMMA also provides hydration as a lubrication enhancer in cosmetics (FutureDerm 2011).

Cosmetic products including nail products produced or distributed for retail sale to consumers for their personal care are required to bear an ingredient declaration according to the Fair Packaging and Labeling Act (FPLA) (21 C.F.R. § 701.3 2018). Retail product ingredients may be listed on the folding carton or box wrapping if the immediate container is packaged. Therefore, customers purchasing retail products may or may not see the ingredients if the folding carton or box wrapping has been removed when they are purchasing the products. Cosmetic products that are not typically distributed for retail sale (e.g., nail products used by professionals on customers at their work places) are exempt from ingredient declaration requirement and these products are not sold to consumers at professional establishments or workplaces (FDA 2018a).

Because product labeling is inconsistent and new requirements have yet to take effect, DTSC has been unable to determine the extent to which formulations of nail products intended for professional salon use differ from those intended/packaged for retail sale. Starting in 2020, professional products will be required to list chemical ingredients (see section 5.1 for details of California Assembly Bill 2775 (2018)). Professional salon products versus retail home use products containing MMA may or may not have similar product formulations.

***MMA in Acrylic Nails***

Outside of California, MMA is still legal for use in the preparation of acrylic nails in salons. In California, MMA has been replaced by ethyl methacrylate (EMA), although some California salons may continue to illegally use MMA to prepare acrylic nails.

After polymerization of MMA to PMMA, PMMA may depolymerize to release MMA or unreacted, residual MMA may be present within and on the final product.

The following scenario is based on legal use of MMA-containing acrylic nail products at home. Natural fingernails are first cleaned, degreased, and etched to increase the adhesion of the acrylic nails (Nails Magazine 1991; Woolf and Shaw 1998). Next, methacrylic acid is applied to the natural nail surface as a primer. Liquid MMA is then mixed with a powder of methacrylate esters and PMMA (Becker et al. 2011). During the application process, MMA polymerizes on the natural nail surface to form the acrylic nail. PMMA powder contains a heat sensitive initiator (typically benzoyl peroxide). The heat of the room and heat of client’s hand are sufficient to start the polymerization reaction of MMA on the natural nail surface in the presence of daylight (Becker et al. 2011; Erdmann et al. 2001). In the application of acrylic nails, PMMA is used as an inert carrier for MMA to polymerize on the nail surface (Becker et al. 2011). PMMA also serves as a thickening agent for placement and shaping of liquid MMA, by creating a powder slurry on the nail surface during the acrylic nail process (Becker et al. 2011). The Cosmetic Ingredient Review Panel concluded that, after polymerization of MMA to PMMA, there is a possibility of depolymerization of PMMA to release MMA or unreacted, residual MMA being present within and on the final product (Quint 2013).

The polymerization of MMA occurs on the nail protein (i.e., keratin). Keratin has amine, carboxyl, thiol, and hydroxyl functional groups, that can form active sites where MMA can bond and polymerize. The functional groups of keratin favor polymerization reaction of MMA to PMMA (Martínez-Hernández et al. 2003); thus, MMA can strongly bond to the natural nail and polymerize on the nail surface during the application of acrylic nails. After the polymerization process is completed, up to 1.5 percent of the MMA may remain unreacted in acrylic nail products according to the Nail Manufacturers Council report (Becker et al. 2011). Exposure to methacrylate monomers including MMA during the acrylic nail application process may cause allergic contact dermatitis in people receiving acrylic nail services (Arora and Tosti 2017). In addition, methacrylate monomers including MMA may cause sensitization when the monomers are not completely polymerized during acrylic nail services (Arora and Tosti 2017).

***MMA in Gel Nail Products***

Gel nail products are reported to contain MMA (Quint 2013). MMA and PMMA are typically pre-mixed with an initiator and stabilizer (typically hydroquinone); the polymerization reaction is initiated by photo-bonding with the person’s hand placed under UV radiation (Erdmann et al. 2001). In gel nail products, MMA is used to enhance cross-linking and to reduce viscosity (Schoon and Baran 2017).

***MMA in Nail Polishes***

The Environmental Working Group’s (EWG) Skin Deep Cosmetics Database reported 24 nail polishes contain MMA as an ingredient (EWG 2019). Moreover, Mintel’s Global New Products Database identifies 4 MMA-containing nail polishes that have been introduced to the U.S. retail market, and 19 worldwide, since 2010 (Mintel 2018). However, Mintel and EWG’s databases include only retail nail products. Therefore, there could be professional MMA-containing nail polishes being sold in the market. Nail polishes containing MMA are applied to natural nails in daylight and air dried on the natural nail. DTSC does not have information on the function of MMA in nail polishes.

### **1.3.2** Other uses of MMA

***Industrial Use***

The primary use of MMA is to produce a variety of resins and plastics. In the presence of heat, MMA polymerizes to PMMA, which is widely used for producing acrylic polymers (IHS Markit 2016). PMMA has high transparency, strength, and durability. In 2014, U.S. PMMA production was 214.6 kilotons, and 55 percent of this PMMA was used to make:

* extruded sheets for light-emitting diode (LED) screens,
* decorative interiors,
* solar panels,
* building facades, and
* visual marketing communication displays (Grand View Research 2015).

Additional applications of PMMA are summarized in Table 1.

MMA is also combined with other acrylates to make surface coating resins, lacquers, and emulsion polymers (EC 2002).

*Table 1. Applications of PMMA (Global Industry Analysts Inc. 2016)*

| acrylic sheets | leather coatings | floor polishes |
| --- | --- | --- |
| acrylic moldings | paper coatings | textile finishes |
| extrusion powders | inks | mobile phone screens |
| plumbing fixtures | adhesives | television and video equipment |
| outdoor lighting | sealants | liquid crystal display screens and monitors |

***Medical and Dentistry Use***

MMA is polymerized to PMMA and used in prosthetic devices and dialyzers (i.e., artificial kidneys) for hemodialysis for kidney patients (Becker et al. 2011). PMMA is also used as ceramic filler for tooth fillings or cement for hip and knee replacements (IARC 1994; NTP 1986; U.S. EPA 1998), in orthotic shoe inserts (NIOSH 1982), and in soft contact lenses (EC 2002).

***Other Cosmetic Use***

MMA is crosslinked with glycol dimethacrylate and used in cosmetics as a film former (to promote water resistance and product longevity) and a thickening agent (to increase viscosity) (Becker et al. 2011). MMA is also polymerized to PMMA which acts as a lubrication enhancer in cosmetics to help fill in wrinkles and provides a gliding application (FutureDerm 2011). The Personal Care Products Council reported PMMA is used in 892 different cosmetic products including 304 eye products, 369 makeup products (including 60 lipsticks), and 198 other types of leave-on products (Becker et al. 2011).

# 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.

## 2.1 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 2. Physical and chemical properties of methyl methacrylate (MMA) monomer (HSDB 2010)*

|  |  |
| --- | --- |
| Property | Value |
| Color | Colorless |
| Physical state | Liquid |
| Molecular weight | 100.13 g/mol |
| Density at 25 °C | 0.9337 g/cm3 |
| Melting point | -47.55 °C |
| Boiling point | 100.5 °C |
| Vapor density | 3.45 (air = 1) |
| Vapor pressure at 25 °C | 38.5 mm Hg |
| Henry's law constant at 25 °C | 3.2 x 10-4 atm.m3/mol |
| Heat of vaporization at 100.5 °C | 36.0 kJ/mol |
| Odor | Acrid, fruity, sulfur-like, sweet, and sharp |
| Odor threshold in air | 0.05 or 0.21 ppm |
| Water solubility at 20 °C | 1.57 x 104 mg/L |
| Solubility | Soluble in methyl ethyl ketone, tetrahydrofuran, esters, chloroform, and aromatic and chlorinated hydrocarbons. Miscible with ethanol, ethyl ether, and acetone. |
| Log octanol-water partition coefficient (Log Kow) | 1.38 |
| Log organic carbon-water partition coefficient (Log Koc) | Estimated range 0.95 to 2.0 |
| Surface tension | 0.028 N/m at 20 °C |
| Autoignition temperature | 435 °C (815 °F) |
| Flashpoint | 10 °C (50 °F; open cup) |
| Lower explosive limit (LEL) | 1.7 % by volume in air |
| Upper explosive limit (UEL) | 8.2 % by volume in air |
| Conversion factor ppm (v/v) to mg/m3 in air | 1 ppm = 4.1 mg/m3 |

## 2.2 Fate and Transport

### 2.2.1 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 2 in section 2.1 for physicochemical properties.

The majority of MMA (98 percent) is emitted to air, and small amounts are released into water and soil (Government of Canada 1993) as a result of MMA’s physicochemical properties. MMA readily biodegrades in water (EC 2002) and has a short half-life in the atmosphere (WHO 1998). MMA released from nail products is not expected to bioconcentrate (WHO 1998) or bioaccumulate (EC 2002).

MMA does not bind strongly to soil; therefore, it may migrate through soil and into groundwater (Almazán-Sánchez et al. 2014; Australian Government 2016). While MMA can migrate into groundwater (Almazán-Sánchez et al. 2014), DTSC does not anticipate that MMA-containing nail products contribute significantly to this exposure pathway. In summary, MMA is not persistent in the environment and is degraded in air (its primary release media), as well as water bodies, and is not expected to accumulate in soil (WHO 1998).

***Air***

Based on an estimated vapor pressure of 38.5 mm Hg at 25 °C and as a function of MMA’s physical properties, MMA readily volatilizes into the ambient atmosphere (HSDB 2010; WHO 1998). MMA has a short half-life in the atmosphere, estimated as less than 5 hours in summer to a few days in winter as reported in Toronto, Canada (Government of Canada 1993). Vapor-phase MMA degrades in the atmosphere by reacting with photochemically produced hydroxyl radicals, with an estimated half-life of 21 hours (EC 2002). Vapor-phase MMA also degrades by reacting with atmospheric ozone, with an estimated half-life of 1 day (EC 2002). MMA is not expected to degrade by direct photolysis (Government of Canada 1993).

***Soil***

MMA is expected to have high mobility in soil, based on its estimated log Koc values of 0.95 to 2.0 (HSDB 2010). Due to its high vapor pressure (38.5 mm Hg at 25 °C) and weak adsorption to soil, MMA is expected to volatilize rapidly from soil (WHO 1998) and readily migrate into groundwater (Almazán-Sánchez et al. 2014). A study of the biodegradation of nonvolatilized MMA in soil by microorganisms showed that the majority of MMA in soil was degraded within 28 days (EC 2002; HRC 1993).

***Water***

MMA is water soluble (1.57 x 104 mg/L) and can volatilize from water when it is exposed to air, as indicated by the Henry’s law constant of 3.2 x 10-4 atm.m3/mol. The log Kow value of 1.38 indicates MMA’s affinity for water compared to organic matter found in soils or sediment (HSDB 2010).

Hydrolysis of MMA is not significant at neutral or acidic pH (Government of Canada 1993). The hydrolysis half-life of MMA significantly decreases when moving from neutral (pH 7) to basic environments (pH > 7) as indicated by estimated half-life values of 3.9 years at pH 7 and 14.4 days at pH 9 (Ellington et al. 1987; Government of Canada 1993; Howard 1989; Howard 1991). These estimates were confirmed experimentally, with findings of a hydrolysis half-life of 143 minutes (2.4 hours) at pH 11 and 1,600 days (4.4 years) at pH 7 (Archer 1990; EC 2002).

Biodegradation of MMA appears to contribute significantly to the removal of MMA from the aqueous environment under aerobic conditions (Douglas and Bell 1992; EC 2002; Sasaki 1978). The aqueous aerobic degradation half-life of MMA is estimated as 1 to 4 weeks (Howard 1989; WHO 1998).

A log Kow of 1.38 and an estimated bioconcentration factor of 3 indicates that MMA has a low likelihood to bioconcentrate in the fatty tissues of aquatic organisms (Government of Canada 1993; HSDB 2010).

### 2.2.2 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.

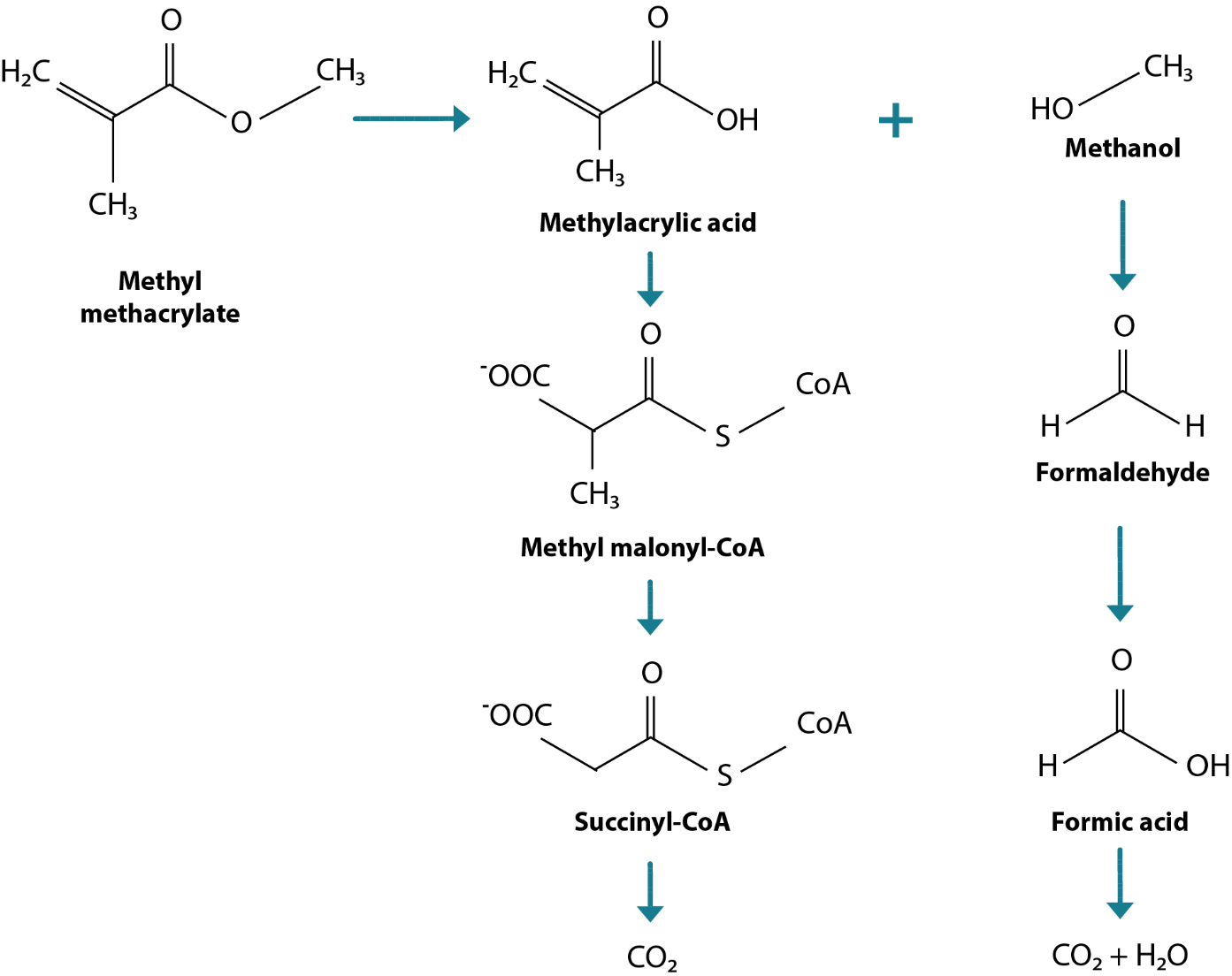
***Metabolism***

As reported in a review by Borak et al. (2011), the reactivity of MMA is responsible for its toxicity as an irritant and a sensitizer. The electrophilic index value for MMA is low (0.85) compared to known respiratory sensitizer chemicals (Borak et al. 2011); thus, MMA is not considered as a strong respiratory sensitizer.

Formaldehyde and methanol form during MMA metabolism in mammals. Formaldehyde and methanol are also Candidate Chemicals.

The metabolism of MMA yields the intermediate methacrylic acid, which is reported to cause respiratory irritation and cytotoxicity (i.e., toxicity to cells) (Borak et al. 2011). Formaldehyde and methanol also form during MMA metabolism in mammals. Formaldehyde is a Candidate Chemical (DTSC 2018), and the International Agency for Research on Cancer (IARC), National Toxicology Program (NTP), and Office of Environmental Health Hazard Assessment (OEHHA) identify it as a carcinogen (IARC 2012; NTP 2016; OEHHA 1988). Methanol is also a Candidate Chemical (DTSC 2018a), and OEHHA identifies it as a developmental toxicant on the Proposition 65 list (OEHHA 2012).

The main pathway for MMA metabolism in mammals is shown in Figure 3. MMA is converted by serum esterase-catalyzed hydrolysis to methacrylic acid and methanol (a developmental toxicant).[[6]](#footnote-7) Methacrylic acid is transformed to methyl malonyl-coenzyme A (CoA) and then to succinyl-CoA. Succinyl-CoA enters the citric acid cycle, oxidizes, and forms carbon dioxide (CO2). Methanol is transformed to formaldehyde (a carcinogen) then to formic acid. Formic acid breaks down into CO2 and water (H2O) (Borak et al. 2011; Corkill et al. 1976; U.S. EPA 1998). A second metabolic pathway for MMA is conjugation with glutathione that occurs spontaneously and enzymatically yielding thioethers and mercapturic acids (Borak et al. 2011). In an *in vitro* study, the half-life of MMA in human blood, following serum esterase-catalyzed hydrolysis, was estimated to be 20 to 40 minutes (Corkill et al. 1976; U.S. EPA 1998).

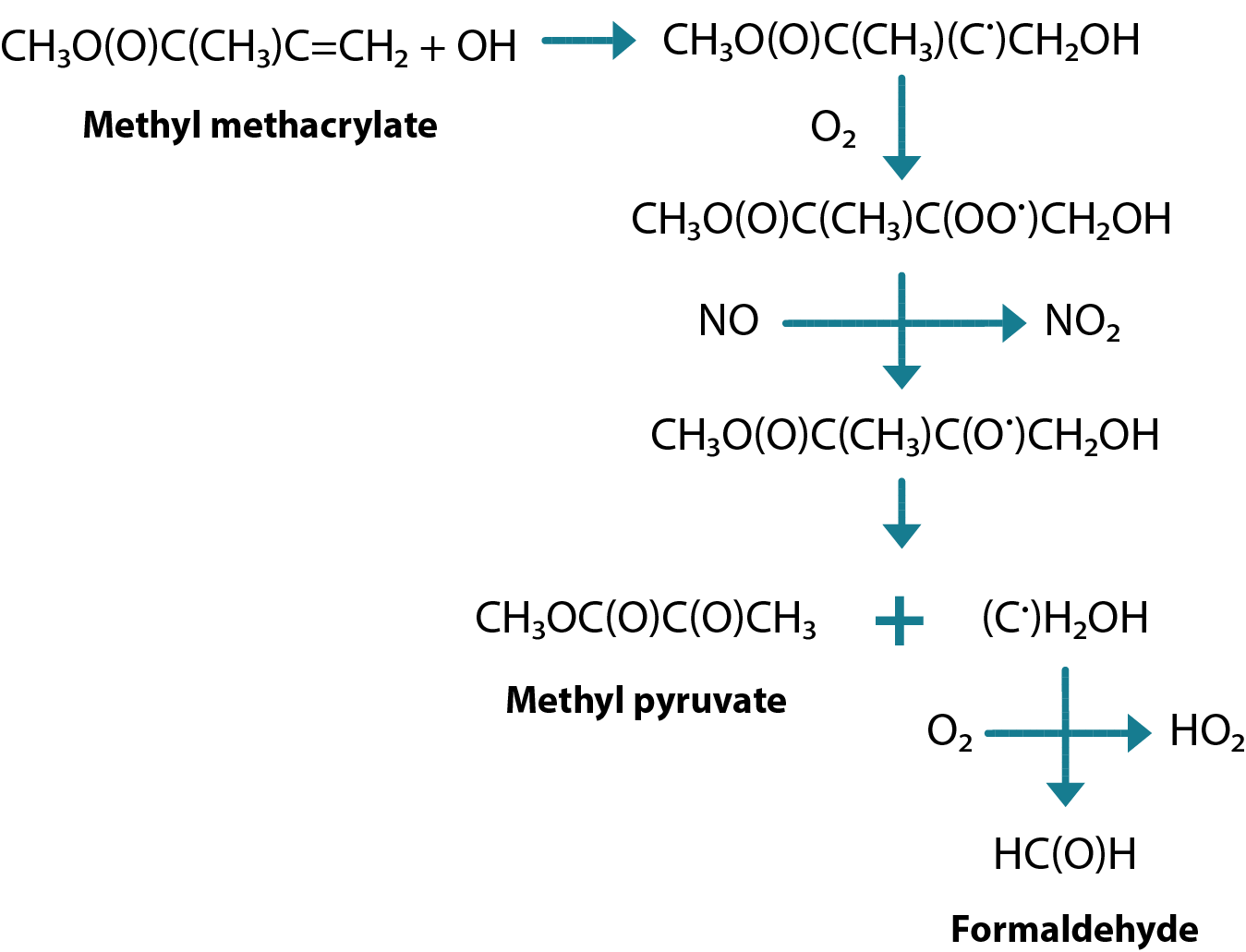


*Figure 3. Main pathway for MMA metabolism in mammals (Borak et al. 2011).*

***Reaction of MMA in Air***

MMA is mainly released to ambient air and breaks down to pyruvic acid, methyl pyruvate, epoxides, and formaldehyde in air within a couple of days (Australian Government 2016). MMA reacts with hydroxyl radicals in ambient air and produces methyl pyruvate and formaldehyde (Blanco et al. 2008).

The proposed reaction mechanism of MMA with hydroxyl radicals is shown in Figure 4 (Blanco et al. 2008). One of the products formed in this reaction is formaldehyde. As noted above, formaldehyde is a Candidate Chemical (DTSC 2018), and IARC, NTP, and OEHHA identify it as a carcinogen (IARC 2012; OEHHA 1988).



*Figure 4. The proposed reaction mechanism for reaction of MMA with hydroxyl radicals in the air   
(Blanco et al. 2008).*

MMA can react with other volatile substances in the air, which contributes to formation of photochemical smog[[7]](#footnote-8) (Australian Government 2016). Photochemical smog is a harmful mixture of gases resulting in ground-level ozone. Exposure to photochemical smog can cause respiratory tract problems such as nose and throat irritation, coughing, painful breathing, and premature aging of the lungs in humans. Moreover, high levels of ground-level ozone can damage agricultural crops and vegetation (CCME 2011).

### 2.2.3 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.

MMA rapidly degrades across all environmental media and is not expected to accumulate in biological systems or persist in the environment (EC 2002; WHO 1998). Volatilization to air is the predominant pathway for MMA release to the environment from the use of nail products (Ford 2014).

While MMA is readily volatilized, it is not expected to be persistent in air (WHO 1998). During daylight hours, MMA readily degrades in the atmosphere by reacting with hydroxyl radicals, which results in a short, estimated half-life of 21 hours (EC 2002). Further, vapor-phase MMA also degrades by reacting with atmospheric ozone, with an estimated half-life of 1 day (EC 2002).

As reviewed by EC (2002), biodegradability tests show that MMA readily biodegrades in water. The biodegradation of MMA in soil by microorganisms depends on pH, cation exchange capacity, and organic carbon content of the soil. One study indicated that the majority of non-volatilized MMA was biodegraded by soil microorganisms within 28 days (EC 2002).

MMA has a longer half-life in water than in air, which leads to a higher estimated relative proportion in water than air (WHO 1998). The bioaccumulation of MMA in fish is negligible (WHO 1998). MMA does not bind strongly to soil or sediment particles; therefore, MMA can readily migrate into groundwater (Almazán-Sánchez et al. 2014; Australian Government 2016; EC 2002).

## 2.3 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 the Office of Environmental Health Hazard Assessment’s (OEHHA) Green Chemistry Hazard Trait regulations (California Code of Regulations, Title 22, Chapter 54).[[8]](#footnote-9) These include exposure potential, toxicological, and environmental hazard traits.

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

In the 1970s, the FDA received reports of injuries – including dermatitis, fingernail damage, and nail deformity – resulting from exposure to MMA in nail products. In response, the FDA removed nail products containing 100 percent MMA from the market through court proceedings (FDA 2017b).

The FDA received injury reports of dermatitis, fingernail damage, and nail deformity due to MMA exposure from nail products and removed nail products containing 100 percent MMA from the market.

MMA is a recognized skin sensitizer and can cause severe skin irritation.[[9]](#footnote-10) Skin sensitization has been observed in animals exposed to MMA, and MMA is recognized as a skin irritant in humans with the capacity to produce sensitization in susceptible individuals (Borak et al. 2011; WHO 1998). Health Canada issued an advisory to cosmetics users of the adverse impacts of MMA, including skin rash, itching, and small oozing blisters on skin and nail beds (Government of Alberta 2003).

MMA monomer is a skin sensitizer that causes severe allergic reactions, including neuropathy,[[10]](#footnote-11) and permanent fingernail loss (Arora and Tosti 2017; Fisher 1980b). MMA used in acrylic nails is known to cause contact dermatitis, skin infection around the fingers, and brittle, peeling nails (Freeman et al. 1995). Eyelid and face dermatitis can be caused by airborne methacrylate dusts (Freeman et al. 1995).

Allergic contact dermatitis (ACD),[[11]](#footnote-12) swelling, nail dystrophy,[[12]](#footnote-13) and slight separation of nails from the nail bed have been reported in people with acrylic nails, particularly those made using methacrylate monomers including MMA (Arora and Tosti 2017; Chou et al. 2017; Froines and Garabrant 1986). The incidence of allergic contact dermatitis from MMA exposure has increased in nail technicians and their customers as artificial nails have become more common (Spencer et al. 2016; Zaragoza-Ninet et al. 2016).

Dermatitis caused by MMA in nail products is demonstrated by multiple case studies:

* Le et al. (2015) described the cases of three nail technicians who experienced hand dermatitis including rashes and painful cracking of skin after applying acrylic and gel nail products; all three tested positive for allergic reactions to monomers, such as MMA and ethyl methacrylate.
* Rajan et al. (2016) reported that 21 of 53 occupational cases of acrylate allergy were from use of nail-related cosmetics, and 51 percent of 908 patients exhibited allergy to MMA, as indicated by skin patch test results.
* Kieć-Świerczyńska et al. (2017) performed surveys and patch tests of nail technicians in 150 nail salons in Poland, and nail technicians reported ocular, nasal, respiratory, and skin irritation upon exposure to methacrylates. This study reported that acrylic nail products containing methacrylates showed higher percentage of skin and mucosal irritation compared to non-acrylic products (Kieć-Świerczyńska et al. 2017).
* A 31-year-old nail technician developed occupational hand eczema upon exposure to methacrylate monomers and showed positive patch test results to MMA (Zheleva and Darlenski 2015). The nail technician’s condition improved when she was off work and was advised to change her occupation by her physician (Zheleva and Darlenski 2015).
* Erdmann et al. (2001) described cases of dermatitis in nail salon workers following acrylic nail application. In one case, a 26-year-old female nail technician who had been applying acrylic nails over a three-year timeframe developed dermatitis of her nail folds and fingertips (Erdmann et al. 2001). In another case, a 52-year-old female nail technician developed dermatitis affecting her fingertips, nail folds, and eyelids, and noticed that her face and neck were irritated after filing acrylic nails of clients (Erdmann et al. 2001). Both nail technicians were found to be hypersensitive to MMA as proven by skin patch tests (Erdmann et al. 2001).
* Freeman et al. (1995) described the case of a 53-year-old female who developed blisters, red skin, edema (i.e., fluid buildup which causes swollen tissue), and dermatitis on her fingertips and around her nail folds after having acrylic nails applied. She had a positive reaction to MMA in skin patch testing (Freeman et al. 1995).
* A 31-year-old female who applied acrylic nails for 18 months developed nail fold dermatitis, and she was positive for MMA reaction in skin patch testing (Freeman et al. 1995).
* Fisher et al. described the cases of four patients who became sensitized to MMA. All four individuals, who were exposed to liquid MMA monomer and polymethyl methacrylate polymer in sculptured artificial nails, reported contact dermatitis and other nail toxicity including pain, swelling, and discoloration (Fisher et al. 1957). They developed brittle nails, skin infections, subungual pain, dermatitis, and/or had their nails separate from the nail beds (Fisher et al. 1957).

Other MMA-containing products have also been linked to dermatitis:

* A 51-year-old female who wore hearing aids developed dermatitis in her external auditory canals. The body of the hearing aids was made with MMA and she was positive for MMA reaction in skin patch testing (Marshall et al. 1978).
* A series of reports concerning surgeons or nurses exposed to MMA in bone cement describe contact dermatitis and paresthesia (i.e., burning or prickling sensation) of the finger tips (Darre et al. 1983; Fisher 1979; Fries et al. 1975). Swelling, redness, pain, and a burning or prickling sensation of the fingers have also been reported in similar exposure scenarios (Fisher 1980a; Fisher 1980b).
* Dental personnel and orthopedic surgeons developed contact dermatitis after working with MMA (Scolnick and Collins 1986).
* Kanerva et al. (1993) describe the cases of four patients, a dentist and three dental technicians who developed allergic contact dermatitis from working with dental prostheses; all four subjects demonstrated an MMA allergy as shown by positive skin patch tests.
* Similar reports of contact dermatitis with positive skin patch test reactions to MMA have been reported by multiple authors describing other exposure scenarios (Conde-Salazar et al. 1986; Grimalt and Romaguera 1975; Marshall et al. 1978; Meding and Ringdahl 1992; Nealey and Del Rio).

Other occupational case studies also demonstrate that MMA is a skin sensitizer:

* Dental workers who experienced skin sensitization from MMA exposure showed positive skin patch tests for MMA allergy (Farli et al. 1990; Guerra et al. 1993; Kanerva et al. 1988; Kanerva et al. 1989).
* A 31-year-old female who worked as a nurse showed skin sensitivity and skin redness when she was exposed to orthopedic cement used for total hip replacement. The orthopedic cement contained 97 percent MMA, and symptoms of skin redness and skin sensitivity disappeared when she was off work (Scolnick and Collins 1986).

Skin irritation and sensitization from MMA exposure have also been demonstrated in animal studies:

* Rabbits exposed to high concentrations of MMA on the skin displayed evidence of skin irritation and sensitization (U.S. EPA 1998). Repeated exposure of human volunteers confirmed this observation (Cavelier et al. 1981).
* Betts et al. (2006) demonstrated that MMA has the potential to induce skin sensitization in mice.
* Guinea pigs developed strong skin irritation when exposed to MMA (NTP 1986).
* Borak et al. (2011) summarized multiple skin sensitization studies in guinea pigs and mice after exposure to MMA.

Methacrylates have a high degree of cross-sensitivity; exposure to one type of methacrylate can sensitize a person to other methacrylate compounds (Arora and Tosti 2017). For example, when someone has a tendency to develop contact dermatitis from MMA in acrylic nails, a hypersensitivity reaction may develop when exposed to MMA from a different source, such as a dental crown (Arora and Tosti 2017). One case reported that a dentist, with decades of experience, developed dermatitis after the application of acrylic nails with MMA and her dermatitis resolved after removing the artificial nails, but returned when she resumed her work in dentistry and was exposed to methacrylate monomers at work (Arora and Tosti 2017; Macedo et al. 1995). In another case, a woman with long-term acrylic nail use developed allergic contact dermatitis due to methacrylate sensitivity. After having a temporary dental crown placed on a tooth, she developed erythema (i.e., skin reddening), swelling, and itching of the mouth and lips; and, thus showed cross-sensitivity to methacrylates from dental materials. This same woman also later developed a rash along her vulva, perineum, and inner thighs after using incontinency pads which had polyacrylates listed as an ingredient (Arora and Tosti 2017; Giroux and Pratt 2002).

Additionally, the Cosmetic Ingredient Review Panel concluded that after polymerization of MMA to PMMA, there is a possibility of unreacted residual MMA being present within and on the final product. This residual MMA migrates out and can cause allergic contact dermatitis (Quint 2013).

***Respiratory Toxicity*** (California Code of Regulations title 22, section 69403.15)

The California Air Resources Board (CARB) identifies MMA as a toxic air contaminant[[13]](#footnote-14) based on its respiratory toxicity (CARB 2011). MMA inhalation is known to cause respiratory irritation, and respiratory system toxicity forms the basis for health protective thresholds established by both the United States Environmental Protection Agency (U.S. EPA) and the World Health Organization (WHO). MMA is a nose, throat, and respiratory irritant (Government of Alberta 2003). The U.S. EPA derived an inhalation reference concentration (RfC) of 0.7 mg/m3 for MMA following assessment of several key animal studies, and the WHO has relied upon the same data to derive a tolerable inhalation concentration of 0.2 mg/m3 (U.S. EPA 1998; WHO 1998). MMA is identified as an occupational asthmagen by the Association of Occupational and Environmental Clinics (AOEC) (Quint et al. 2008). However, MMA is not listed as an occupational asthmagen by the American Conference of Governmental Industrial Hygienists (ACGIH), the United Kingdom Health and Safety Commission (UK HSC), or the Centers for Disease Control and Prevention (CDC)’s National Institute for Occupational Safety and Health (NIOSH). This difference in designation of MMA as an occupational asthmagen is likely due to regulatory agencies having different criteria in identifying and controlling exposures to substances that cause occupational asthma (Quint et al. 2008).

Respiratory tract irritation has been observed in workers following short-term peak MMA exposures (e.g., MMA concentrations continued to increase above 1000 parts per million (ppm) for 10 to 20 minutes after mixing bone cement) (Borak et al. 2011).

MMA has been linked to occupational asthma in nail technicians.

Further, MMA has been linked to occupational asthma in nail technicians:

* In nail technicians, worsening of pre-existing asthma, new-onset asthma, and rhinitis have been observed (Arora and Tosti 2017; Bigambo 2017; Roche et al. 2008).
* Two female nail technicians, who were sensitized to methacrylate monomers, both developed cough, nasal congestion, wheezing, and shortness of breath; after exposure to acrylic nails at work (Arora and Tosti 2017; Sauni et al. 2008).
* One case study conducted from 1996 to 2001 reported six of nine occupational asthma cases in beauticians were attributed to acrylate-containing acrylic nail applications (Kwok et al. 2014).

MMA exposure has been inconclusively linked to asthma in other occupations:

* As reviewed in Borak et al. (2011), 19 case reports described workers exposed to MMA in which their clinical symptoms included asthma, laryngitis (i.e., inflammation of the vocal cords), and hypersensitivity pneumonitis (i.e., inflammation of lung tissue). However, these workers were exposed to mixtures of chemicals along with MMA, and it is unclear that occupational asthma was solely related to MMA exposure (Borak et al. 2011).
* Several case studies reported respiratory symptoms in humans including chest tightness, difficulty breathing, coughing, and wheezing from occupational exposure to MMA (Lozewicz et al. 1985; Pickering et al. 1986; Savonius et al. 1993; U.S. EPA 1998).

Studies are inconclusive on whether MMA is a respiratory sensitizer:

* Lozewicz et al. (1985) described respiratory sensitization associated with MMA exposure in a dental assistant and a railway cable joiner.
* A case report of delayed asthmatic response following exposure to MMA also indicates MMA may be a respiratory sensitizer (Pickering et al. 1986).
* Several larger reports and studies have evaluated the potential for MMA-related respiratory sensitization with no confirmatory results (EC 2002; Jedrychowski 1982; Jedrychowski and Fonte 1984; Lindemann 1991; Monroe et al. 1981; U.S. EPA 1998).

Multiple inhalation studies in animals demonstrate that MMA is a respiratory tract irritant:

* Prolonged exposure to MMA results in adverse lung effects, including edema (i.e., fluid buildup which causes swollen tissue), discharge of blood, and tissue death (Aydin et al. 2002).
* Aydin et al. (2002) showed that MMA exposure directly affects the olfactory epithelium[[14]](#footnote-15) of nasal turbinates (i.e., side walls of the inside of the nose) and the lungs of rats. In this study, rats exposed to 1,000 ppm MMA for 6 hours per day, 5 days per week for 4 weeks, developed bronchopneumonia (i.e., inflammation in the bronchi), interstitial pneumonia, hemorrhage, or complete or partial lung collapse, emphysema (i.e., shortness of breath caused by damaged sacs of lungs), and edema in lungs (Aydin et al. 2002).
* Chan et al. (1988) also observed inflammation and deterioration of the olfactory epithelium of MMA-exposed male and female rats as well as inflammation, hyperplasia,[[15]](#footnote-16) and cytoplasmic inclusions[[16]](#footnote-17) in the respiratory epithelium,[[17]](#footnote-18) and deterioration of the olfactory epithelium in male and female mice.
* Pulmonary edema, emphysema, and complete or partial lung collapse were previously reported in a rhesus monkey that was exposed accidentally to MMA (Aydin et al. 2002; Kessler et al. 1977).
* In animal studies performed on mice, rats, dogs, and hamsters, MMA-induced respiratory irritation and cell toxicity were demonstrated. High dose MMA inhalation exposure was toxic to tissue inside the nasal cavity, leading to inflammatory cell infiltration,[[18]](#footnote-19) tissue deterioration and withering, and other abnormal tissue changes (Borak et al. 2011; Chan et al. 1988; Hext et al. 2001; Mainwaring et al. 2001).
* As reviewed in Tansy and Kendall (1979), the appearance of focal lesions of the tracheas of rats and frogs demonstrated respiratory irritation after MMA exposure.
* Hazleton Laboratories (1979) observed deterioration of the olfactory epithelium in rats following MMA exposure. Rats in all exposure groups (low, middle, and high-exposure groups were exposed to mean MMA concentrations of 25, 99.79, and 396.07 ppm, respectively) exhibited rhinitis[[19]](#footnote-20) and inflammation of the nasal tissues; the authors did not find a clear exposure-response trend. Hazleton Laboratories concluded that this lack of dose-dependence indicated the results may not be treatment-related (Hazleton Laboratories 1979). When stored tissue samples from this study were re-examined later, due to initial study did not examine low and middle dose exposed nasal tissues, dose-dependent inflammation of tissue in the respiratory tract and severe damage to nasal cells were observed; U.S. EPA used the published results to derive a RfC for MMA inhalation (Lomax 1992; U.S. EPA 1998).

***Reproductive and Developmental Toxicity*** (California Code of Regulations title 22, sections 69402.5 and 69402.3)

CARB designates MMA as a toxic air contaminant and identifies reported pregnancy complications in female workers and sexual disorders in both sexes chronically exposed to MMA (CARB 1997).

Developmental toxicity in the form of early fetal death, reduced fetal weight, and altered crown-rump length[[20]](#footnote-21) were noted in mice, and the doses administered were also toxic to the mothers in the study (Nicholas et al. 1979). Failed pregnancies and skeletal abnormalities were seen in rat offspring exposed to MMA via inhalation, yet the dose was also maternally toxic (ICI 1977; U.S. EPA 1998). Study data supports the potential for MMA developmental toxicity at doses that are maternally toxic.[[21]](#footnote-22) Rats exposed to 16 percent MMA in drinking water for 8 months showed a 60 percent increase in their testosterone levels, thus MMA interfered with the testosterone hormonal equilibrium (Fakhouri et al. 2008a). Seven out of ten male rats exposed to 32 percent MMA in drinking water for 8 months showed partial seminal vesicle atrophy (i.e., degeneration of tube-like glands in the male reproductive system), suggesting this could be a direct effect of MMA on testosterone levels or its possible action on other organs involved in testosterone metabolism (Fakhouri et al. 2008b).

***Neurotoxicity*** (California Code of Regulations title 22, section 69403.11)

CARB designates MMA as a toxic air contaminant and identifies symptoms including headaches, paresthesia, fatigue, sleep disturbances, and irritability following chronic MMA exposure (CARB 1997). MMA can cause drowsiness, dizzy spells, and trembling of hands (Government of Alberta 2003).

Short term exposures to MMA in the workplace, in both the manufacturing and use of the chemical, have resulted in reported nervous system toxicity. Headaches and sweating were reported in a case of a worker mixing methyl methacrylate in the manufacture of cables (Lozewicz et al. 1985). General peripheral neuropathy[[22]](#footnote-23) has been reported following MMA exposures in dental technicians after other potential causes were ruled out (Donaghy et al. 1991; Sadoh et al. 1999).

Other central nervous system (CNS) symptoms have been reported after MMA exposure. Karpov (1953) reported that workers exposed to MMA in the range of 25-75 ppm developed irritability, headache, fatigue, and loss of appetite. Another study indicated that worker exposure to 4 ppm MMA may result in loss of appetite and nausea (Blagodatin et al. 1976). Workers exposed to MMA have reportedly developed memory loss, sleep disturbance, lightheadedness, difficulty concentrating at work, and other CNS symptoms (Bigambo 2017; Blagodatin et al. 1976; Dobrinskij 1970; Raines 1957).

***Ocular Toxicity*** (California Code of Regulations title 22, Section 69403.12)

MMA is an eye irritant (Government of Alberta 2003). Studies show eye irritation in rabbits occurs after repeated MMA exposure (Castellino and Colicchio 1969; Cavelier et al. 1981). Direct injection of high concentrations of MMA into the anterior chamber of the eye produced significant toxicity such as corneal edema,[[23]](#footnote-24) corneal neovascularization,[[24]](#footnote-25) iris atrophy,[[25]](#footnote-26) and cataract formation[[26]](#footnote-27) (Holyk and Eifrig 1979).

## 2.4 Related Chemicals and Their Adverse Impacts

### 2.4.1 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.

A home exposure study conducted in Sweden showed acrylate or methacrylate-containing ultraviolet (UV)-curing nail polishes (i.e., UV gel) that may include MMA as an ingredient caused severe skin reactions and allergic contact dermatitis in 7 consumers between the ages of 15 to 41 (Dahlin et al. 2016). Although the acrylate concentrations were not provided on the UV-curing polishes used by consumers, it has been reported that acrylate or methacrylate concentrations can be above 90 percent for the UV-curing polishes that were being sold for home use (Dahlin et al. 2016). In addition, 65 consumers including nail technicians who used these methacrylate-containing nail polishes at home and in salons reported hand eczema, itching and pain in the fingers, permanent nail damage, and eczema on the lips, throat, and around the eyes due to incomplete curing of UV-curing nail polish by UV LED lamp (Dahlin et al. 2016). Further, another study showed allergic contact dermatitis and pain in fingers in 4 female patients between ages of 35 to 65 years old that applied UV gel nail polish kits for home use. This study showed 3 out of 4 patients were patch tested positive for methacrylates including MMA and all 4 patients were tested positive for acrylates (Gatica-Ortega et al. 2018).

Although there are limited home exposure studies in literature, numerous salon indoor air and salon worker exposure studies are available in literature. Since nail products that may contain MMA are used both in salons and at home, salon exposure studies will be helpful to estimate exposure from MMA-containing products at home.

Despite the MMA ban, salon owners can still purchase MMA from nail supply stores. High MMA concentrations were detected at a salon that was offering artificial nail services on the test day.

Nail salon workers are chronically exposed to several different chemicals simultaneously. A 2019 study by Lamplugh et al. measured personal exposures of salon workers to MMA with concentrations in the range of 70 to 1100 parts per billion (ppb) in 2 out of 6 salons; which exceeded the RfC for MMA (approximately 171 ppb) in several measurements (Lamplugh et al. 2019).

Another 2019 study conducted in New York, New Jersey, and Philadelphia nail salons collected personal chemical exposure measurements from 100 salon workers at 25 nail salons; at 24 of the 25 nail salons, MMA was detected with mean concentrations in the range of 0.049 to 21.52 ppm and a mean value of 39.45 ppm which exceeded the RfC for MMA (approximately 0.171 ppm) in several measurements (Ma et al. 2019; U.S. EPA 1998). This study reported a mean MMA concentration of 941.25 ppm at 1 of the 25 salons tested, which was an exceptionally high concentration compared to the other 24 salons tested (Ma et al. 2019). The salon with the 941.25 ppm MMA concentration was offering application of artificial nail services on the test day, which required the use of acrylic monomer that contains MMA (Ma et al. 2019). This study reported that, despite the MMA ban in New York and New Jersey, MMA was still detected in these salons. According to the survey conducted in this study, salon owners reported MMA can still be purchased from Colorado nail supply stores despite the MMA ban in Colorado (Lamplugh et al. 2019). A study conducted in 7 Boston nail salons with 10 nail technicians measured MMA concentrations of maximum 0.51 ppm with an average concentration of 0.046 ppm in technicians’ breathing zone and maximum 0.63 ppm with an average concentration of 0.05 ppm in salon indoor air (Ceballos et al. 2019). This study claimed the sources of MMA detected in salons were nail polishes, gel polishes, and acrylic nail products (Ceballos et al. 2019).

A 2011 study of California nail salons demonstrated that MMA volatilizes from nail products to indoor air by measuring an average MMA concentration of 0.54 ppm (2.2 mg/m3) in indoor air. This study also measured a total concentration of volatile organic compounds (VOCs) (e.g., toluene, ethyl acetate, and isopropyl acetate) ranging from 3 to 25 mg/m3 (Quach et al. 2011). Nail salon workers in this study reported a range of health problems, including headaches and eye, nose, and throat irritation (Quach et al. 2011). Further, a study of Los Angeles nail salons (Nguyen 2016), conducted after MMA was banned in salons, reported average concentrations of acetone, isopropyl alcohol (IPA), and MMA as much as six times higher than those measured in other nail salon indoor air studies in Alameda County, California (Quach et al. 2011) and Salt Lake City, Utah (Alaves et al. 2013). Moreover, nail salons in Los Angeles that did not operate mechanical ventilation systems during data collection had much higher VOC concentrations (Nguyen 2016). See Table 3.

*Table 3. Average VOC concentrations from indoor air studies of nail salon studies which   
used various types of ventilation.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Study | MMA  (ppm) | Acetone (ppm) | IPA  (ppm) | Ventilation Type |
| (Nguyen 2016) | 3.37 | 17.50 | 4.59 | No mechanical ventilation |
| (Quach et al. 2011) | 0.54 | 3.10 | 0.82 | Table ventilator or table or ceiling fan |
| (Alaves et al. 2013) | 0.87 | 6.10 | 0.77 | Direct exhaust ventilation (e.g., ceiling fans or downdraft nail table) |

Methacrylates including MMA and nail glue that are used in the preparation of acrylic nails and UV gels weaken the natural nail and deform the nail bed (Arora and Tosti 2017). When MMA is applied to the natural nail, MMA attaches to the functional groups (i.e., amide, carboxyl, sulfhydryl, and hydroxyl groups) on the nail protein (i.e., keratin) (Martínez-Hernández et al. 2003; Misra et al. 1991). Thus, the bonding of MMA on the nail protein may cause the deformation of nail bed during the application of acrylic nails and UV gels that contain MMA as an ingredient.

Acrylic nail tips can be attached to the natural nail with the application of nail glue (Arora and Tosti 2017). Nail glues contain ethyl cyanoacrylate, hydroquinone, or organic sulfonic acid (Arora and Tosti 2017). Nail glue causes degradation of the nail matrix leading to roughness and loss of uniformity of the nails (Arora and Tosti 2017). Nail glue also diminishes the amount of silicon and aluminum in the nail, decreasing the brightness and hardness of the nail (Pinteala et al. 2017). The strong bonding of MMA to the natural nail bed may cause the nail bed to be removed under extreme pressure, and there is a potential for nail infections to occur from breaking of the natural nail (BBC 2014).

Both MMA and the nail glue used to apply acrylic nails are potentially flammable (see Table 1 in section 2.1) (Kelemen et al. 2016; NJDOH 2002b). Artificial nails burn to completion once ignited; even when the source of ignition is removed, a burning acrylic nail is difficult to extinguish (Vanover et al. 1999). In one case study a 64-year-old female’s acrylic nail caught fire when she lit her cigarette, causing a full-thickness burn along her thumb that required debridement and reconstruction (Arnaout et al. 2016). Moreover, nail glue used with acrylic nails can react exothermically with cotton clothing, due to the cellulose and extensive hydroxyl groups in the cotton (Arora and Tosti 2017). In one documented case, nail glue fell on cotton pants, exothermically reacting with cellulose and hydroxyl groups in the cotton; the cotton pants reached temperatures above 60 °C (140 °F), which is hot enough to cause skin damage (Kelemen et al. 2016). Three case reports documented full thickness burn of inner thighs and legs when 11, 15, and 16 year-old girls accidentally spilled nail glue on their cotton pants during artificial nail application (Kelemen et al. 2016).

### 2.4.2 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.

## 2.5 Populations That May Be Harmed by the Candidate Chemical

### 2.5.1 Human populations and non-human 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 2.3, section 2.4, section 3.2, and section 3.3 for additional information.

MMA has the potential to contribute to or cause adverse impacts to humans. Some of the retail nail products used at home may contain MMA; therefore, nail product consumers, who include children and pregnant women, may be exposed to MMA at home. In addition, some populations are chronically exposed to MMA, such as nail industry workers and some sensitive subpopulations are exposed to MMA, such as pregnant women, fetuses, infants, children, and adolescents. Despite the MMA ban in salons in California, nail industry workers may be exposed to MMA from retail products brought into salons by customers. Further, they may be exposed to MMA as a result of depolymerization of PMMA to release MMA or MMA as a residual from PMMA-containing nail products.

Nail salon customers, nail product consumers, and their fetuses, infants, and children may potentially be exposed to MMA from nail products both at home and in salons. Nail salon customers and nail product consumers may experience inhalation, dermal, and/or oral MMA exposure. Infants and children who accompany their parents to work at nail salons, or who use nail products themselves at home or in salons may also be exposed to MMA in nail products.

### 2.5.2 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 MMA from nail products include nail industry workers, pregnant women (including their fetuses), infants, children, and adolescents.

Infants and children are especially vulnerable to MMA exposure from nail products if they use nail products themselves or accompany their parents to work at a nail salon. They are a sensitive subpopulation because of 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, as 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 to infants and children and increased likelihood or severity of adverse impacts.

Nail product consumers, who include children and pregnant women, may be exposed to MMA at home. Wu et al. in 2010 found in California, 45 percent of girls 5 years old and younger use nail polish, and this increases to 79 percent for girls over 5 (Wu et al. 2010). In this study, nail product use by parents and children in the same household suggested 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). A survey conducted among pregnant women in New York City in 2003 through 2006 reported that 69 percent of the participants claimed use of nail products at some point throughout their pregnancy (Just et al. 2010). Some of these retail nail products used at home may contain MMA, however DTSC does not have sales volume data or home exposure data for retail nail products containing MMA in California.

In an older study of exposure cases recorded in the National Electronic Injury Surveillance System from 1991 through 1993, Woolf et al. reported that 769 exposure cases were related to artificial nail preparations that may have included MMA as an ingredient, and 54.7 percent of the emergency department visits involved children younger than 6 years old (Woolf and Shaw 1998). Fifty-nine percent of these artificial nail preparation exposures were dermal, 19 percent were ingestion, and 6 percent were ocular and dermal. Eighty nine percent of the nail product exposures occurred at the child’s own home from acrylate-containing retail products which may have included MMA as an ingredient (Woolf and Shaw 1998). Acrylic nail products, nail polishes, and gel nail products that contain MMA are still being sold in both retail stores and local beauty supply stores in California as shown by the Environmental Working Group’s (EWG) Skin Deep Cosmetics Database and Safety Data Sheets (SDSs) received from San Francisco Department of Environment (EWG 2019; SF Environment 2017b). Therefore, nail product consumers including sensitive subpopulations such as pregnant women and children that use these MMA-containing products are exposed to MMA in California.

A study showed acrylate or methacrylate containing UV-curing retail nail polishes that may contain MMA as an ingredient with concentrations of acrylates and methacrylates that can be above 90 percent were being sold for home use in Sweden (Dahlin et al. 2016). In this study, 7 out of 8 consumers between ages of 15 to 41 were patch-tested positive that applied these acrylate or methacrylate-containing nail polishes at home reported severe skin reactions and showed allergic contact dermatitis to acrylate or methacrylate-based ingredients in the nail polish (Dahlin et al. 2016). In addition, 65 consumers including nail technicians who used these acrylate or methacrylate-containing nail polishes at home and in salons, respectively; reported hand eczema, itching and pain in the fingers, permanent nail damage, and eczema on the lips, throat, and around the eyes (Dahlin et al. 2016). Another study performed in Spain showed allergic contact dermatitis, pain in fingers, and eczema in 3 out of 4 female patients between ages of 35 to 65 who applied UV gel nail polish kits for home use and patients were patch-tested positive for methacrylates including MMA and all 4 patients were tested positive for acrylates (Gatica-Ortega et al. 2018). These retail nail products may be available online for purchase in California and these studies showed methacrylate-containing products that may include MMA as an ingredient can cause potential significant and widespread adverse impacts.

There are no age limits on the sale or use of retail nail products, and they are not labeled with information on reducing exposure potential.

Methacrylate-containing nail products that may contain MMA as an ingredient are sold at retail stores for consumers who may be exposed to MMA at home from product application (Gatica-Ortega et al. 2018). These exposures may be exacerbated by relatively poor ventilation in homes. In addition, consumers applying home-use nail products are not trained in industrial hygiene practices designed to reduce workplace exposure to chemicals and may apply the products frequently, since doing so is more convenient and affordable than visiting a salon (Gatica-Ortega et al. 2018).

There are no age limits on the sale or use of retail nail products and these products are not labeled with information on reducing exposure potential. Nail products are often purchased by adolescents who may understand the exposure risks even less than adults (Dahlin et al. 2016; Gatica-Ortega et al. 2018). Based on these factors, Sweden has banned the sale of methacrylate-containing nail polishes and has reported these products to the other members of the European Commission for safety evaluation (Dahlin et al. 2016). Gatica-Ortega et al. (2018) recommended that the European Commission must take action to prohibit methacrylic monomers in home-use cosmetic products, including nail products.

Although MMA is banned from nail salons in California and many other states, MMA continues to be detected in salon indoor air (see section 3.3.1), which means nail salon workers and customers continue to be exposed. The sources may include legally purchased retail products brought in by customers, illegal professional products brought in from other states or countries, and PMMA-containing products containing either residual MMA or MMA resulting from depolymerization of PMMA. In aggregate, exposure to MMA from nail products, both legal and illegal, has the potential to cause significant and widespread harm.

In California, chemical exposure of nail industry workers is an environmental justice issue. A large majority of nail salon workers are people of color and of lower socioeconomic status (Ford 2014; Nails Magazine 2017; U.S. Census Bureau 2012). Ninety percent of all nail salons in California are minority-owned, and 68 percent are Vietnamese-owned (U.S. Census Bureau 2012). Between 59 and 80 percent of California nail salon workers are women of Vietnamese descent (Quach et al. 2008). Nail salon workers often 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). They often have longer workdays and workweeks compared to employees in other sectors (Quach et al. 2008).

California’s nail industry workforce is comprised of approximately 130,000 licensed nail technicians (DCA 2017). Nail salon workers may have daily exposure to MMA, as indicated by MMA detected in salon indoor air in California and elsewhere (see section 3.3.1). For instance, according to the survey conducted by Lamplugh et al. in 2019, salon owners reported that MMA can still be purchased from Colorado nail supply stores despite the MMA ban in Colorado (Lamplugh et al. 2019). Moreover, Ma et al. measured MMA in 25 nail salons in New York, New Jersey, and Philadelphia in 2019 despite the MMA ban in New York and New Jersey (Ma et al. 2019). Further, MMA may be present as a residual in PMMA-containing products. Therefore, nail industry workers are a sensitive subpopulation that may be impacted by exposure to MMA in nail products. Some nail technicians work while pregnant, putting their fetuses at risk of MMA exposure (see section 2.3 of this document for studies describing MMA-related developmental toxicity.) (Ford and Scott 2017). Reportedly, 97 percent of U.S. nail technicians are female and many are of childbearing age (Nails Magazine 2017).

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. The nail salon workers surveyed were predominantly Vietnamese, female, and generally worked long hours and were exposed to chemicals from nail products including MMA and others. Health effects reported included musculoskeletal disorders, respiratory symptoms, skin problems, and headaches (Roelofs et al. 2008). In addition to a higher incidence of specific health problems, a recent study suggests that nail technicians experience a faster deterioration of their overall health compared to controls as a result to chronic exposure to low levels of VOCs (Grešner et al. 2017).

# 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.

## 3.1 Presence and Use Patterns of the Product

### 3.1.1 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 or amount of sales generated, or information on the targeted customer base.

***Retail Products Formulated with MMA***

Approximately 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). Annual sales of various nail products from June 2015 to May 2016 from U.S. retail outlets exceed $1 billion per year (Drug Store News 2016). Acrylic nail product sales were almost 13 percent and nail polish sales were 49 percent of total nail product sales in U.S. (Drug Store News 2016). Acrylic nail products, nail polishes, and gel nail products that contain MMA are sold in both retail stores and local beauty supply stores (EWG 2019; SF Environment 2017b). The Environmental Working Group’s (EWG) Skin Deep Cosmetics Database lists 24 nail polishes containing MMA as an ingredient (EWG 2019). The U.S. EPA’s Chemical and Product Categories (CPCat) database shows two acrylic nail products containing MMA as an ingredient (U.S. EPA 2017). Mintel’s Global New Products Database identifies four MMA-containing nail coatings and acrylic nail products introduced to the U.S. retail market, and 19 worldwide, since 2010 (Mintel 2018). Mintel and EWG’s databases include only retail nail products (not intended for professional use) and Mintel’s data is limited to products under $25. Therefore, there may be a greater number of MMA-containing nail products available for purchase in California.

Various databases list nail products containing MMA for sale in retail and beauty supply stores in California.

Gel polishes have been associated with professional nail salons, but retail gel products intended for home use are also available. 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). Because these products are not intended for use in salons (where MMA is banned), they can legally be sold even if they contain MMA.

***Salon Products That May Contain Residual MMA***

Products intentionally formulated with MMA are not the only potential source of exposure to the chemical from nail products. Unreacted, residual MMA may also be present in polishes, enamels, and UV gels that contain PMMA as an ingredient (Becker et al. 2011; Quint 2013). The Nail Manufacturers Council reported that PMMA-containing products may contain unpolymerized MMA up to 1.5 percent of the total PMMA content in the product (Becker et al. 2011). A Cosmetic Ingredient Review Expert Panel safety assessment by Becker et al. (2011) found 351 PMMA-containing polishes and enamels with PMMA concentrations ranging from 0.7 to 20 percent and 137 other nail products with PMMA concentrations of 30 percent (Becker et al. 2011). According to Mintel’s Global New Product Database, 23 new PMMA-containing nail products were introduced to U.S. market within the last five years (Mintel 2018). PMMA-containing products are legal to use in California salons. However, if the level of residual MMA in these products is consistent with those reported in the studies cited above, the products could significantly contribute to MMA exposure in salons where they are used.

***Illegal Use of MMA-Containing Products***

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 acrylic nails, and 82 percent offer nail art (Nails Magazine 2015).

The focus of this document is on products whose sale and use are legal in California – primarily retail products intended for home use. However, despite the ban on MMA in professional nail salons, the chemical continues to be detected in indoor salon air, where it may expose workers and customers. Some of this MMA may be attributable to legally purchased products (e.g., retail products brought into salons by customers or MMA present as a residue in professional salon products). However, some nail salons have continued to illegally use MMA for acrylic nails due to its low cost (FDA 2017b). In 2011, one gallon of MMA cost $9 to $22; whereas, one gallon of ethyl methacrylate (EMA), a common chemical substitute for MMA, cost $189 to $219 (Roberts 2011). While it is challenging to quantify illegal purchases of MMA, it is clear that intentional, illegal use of MMA-containing products in salons may contribute to aggregate exposure of salon customers and workers and increase the potential for adverse impacts.

### 3.1.2 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 1.2, section 1.3, and section 3.1.1 for additional information.

Use of nail products containing MMA at home and in salons has the potential to expose nail product consumers, nail technicians and other salon workers, and nail salon patrons to MMA. Nail technicians who work with MMA-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. DTSC does not have data for the use frequency of MMA-containing products at home.

Parents use nail products on their children or parental use patterns influence their children’s nail product use and their consequent exposure. to chemicals.

In a 2010 study, data on use patterns of 30 personal care product types were collected from 604 households in Northern and Central California. 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. The frequency of professionally applied and self-applied nail polish uses for adult females and child participants is shown in Table 4 (Wu et al. 2010).

*Table 4. 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) User % | Nail Polish (Professional) User % |
| Adult < 55 | 374 | 53 | 81 |
| Adult > 55 | 99 | 39 | 77 |
| Child < 5 | 185 | 45 | No data |
| Child > 5 | 31 | 79 | No data |

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

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

\*\*\*In this study, 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.

\*\*\*\*User percentages reflect the total of self and professional use.

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, and professional nail polish use frequency for females with children was 81 percent (Table 4) (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 5 years old and younger and 79 percent of girls over 5 years old used nail polish (Table 4) (Wu et al. 2010). This study showed a correlation between use of nail products among parents and children in the same household, suggesting that either 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 their consequent exposure to chemicals from the products (Wu et al. 2010).

### 3.1.3 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.

MMA exposure can occur from sources other than nail products including industrial, medical, dentistry, and cosmetic uses discussed in section 1.3. Occupational exposure to MMA has been documented in dentistry workers (i.e., dentist, dental and prosthesis technicians), surgeons and surgical assistants, nurses, monomer and polymer production workers, plastics manufacturing workers, fiberglass and graphic printing industry workers, painting and coating workers, acrylic sheet manufacturing workers, and nail technicians who apply acrylic nails (IARC 1994; Ramos et al. 2014). Other populations that may be exposed to MMA include patients with knee or hip implants, dental fillings, intraocular lenses,[[27]](#footnote-28) artificial nail users, and users of other cosmetic products (e.g., eye, makeup, and leave-on products) that contain PMMA with residual MMA. Cosmetic products can contain unpolymerized MMA at concentrations up to 1.5 percent and intraocular lenses, and other products may contain unpolymerized MMA up to 1 percent (Becker et al. 2011; IARC 1994).

MMA continues to be used in a range of nail products available in California (Quach et al. 2011; Quach et al. 2013). According to Mintel’s Global New Products Database, four MMA-containing nail coating products have been introduced into the U.S. retail market since 2010 (Mintel 2018). The U.S. EPA’s Chemical and Product Categories (CPCat) database lists two MMA-containing acrylic nail products with unknown concentrations (U.S. EPA 2017). Safety data sheets (SDSs) for some of these products list MMA concentrations above 95 percent (Quint 2013). MMA is also found in nail coating products (EWG 2019; Mintel 2018); the Environmental Working Group’s (EWG) Skin Deep Cosmetics Database identifies 24 nail polish products containing MMA as an ingredient (EWG 2019). According to SDSs, methacrylate monomers (which may include MMA) are ingredients in UV gel nail products at concentrations ranging from 5 percent to 50 percent (Quint 2013; SF Environment 2017a).

Home users and salon customers who are exposed to MMA from nail products may also be exposed to MMA from other sources. For example, dental workers may also paint their nails with MMA-containing polish or visit salons for acrylic nail services. Golbabaei et al. (2005) reported direct exposure measurements of more than 300 mg/m3 (73 ppm) MMA. In a study of dental workplaces in Canada, MMA concentrations up to 9.7 ppm (40 mg/m3) were reported (Nayebzadeh and Dufresne 1999). In a study of chemicals associated with 3D printers in Switzerland, MMA was detected as 37 percent of the total VOC concentration measured (Steinle 2016). Another study in Switzerland identified methacrylate, a breakdown product of MMA, in urine from a series of dental technicians at up to 373 nmol/mmol of creatinine (Rajaniemi et al. 1989). In addition, nail technicians who use more than one MMA-containing nail product in a workday may experience aggregate exposure to MMA.

## 3.2 Potentially Exposed Populations and Product-Use Scenarios

**3.2.1 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, children, adolescents, and pregnant women (and their fetuses) (Ford 2014; Wu et al. 2010). 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). Annual sales of various nail products from May 2015 to May 2016 from U.S. retail outlets exceed $1 billion per year (Drug Store News 2016) (see section 3.1.1 for additional information). Some of the retail nail products used at home may contain MMA, therefore nail product consumers, who include children and pregnant women (and their fetuses), may be exposed to MMA at home. Moreover, there are chronically exposed populations to MMA, such as nail industry workers, and their children who may accompany their parents to work, and the fetuses of pregnant workers. Despite the MMA ban in salons, nail industry workers may be exposed to MMA from retail products brought into salons by customers. Further, they may be exposed to residual MMA or MMA resulting from depolymerization of PMMA from PMMA-containing products.

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). U.S. nail industry workers are mostly low-income, women of color, and non-native English-speaking women of childbearing age (Ford 2014; Nails Magazine 2017). 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 5).

*Figure 5. Demographic makeup of nail salon customers (Nails Magazine 2017).*

### 3.2.2 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 2.4, section 2.5, section 3.1, section 3.3, section 3.4, and section 3.5 for additional information.

Use of nail products containing MMA at home and in salons has the potential to expose nail product consumers, nail technicians and other salon workers, and nail salon patrons to MMA. Nail technicians who work with MMA-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).

When methacrylate-containing nail products are sold for home use, consumers that self-apply the nail products at home may be exposed to MMA (Gatica-Ortega et al. 2018). In addition, home environments may have poor ventilation while applying methacrylate-containing nail products, which would be expected to increase the exposure potential to MMA.

Consumers who apply retail nail products at home are not trained and apply the products frequently; therefore, the exposure potential of the general public may be same or higher than the salon workers.

Consumers who apply retail nail products at home are not trained and apply the products more frequently at home, since doing so is more convenient and affordable than visiting a salon for nail services (Gatica-Ortega et al. 2018). Therefore, the exposure potential of the general public may be the same or higher than the salon workers (Gatica-Ortega et al. 2018). Moreover, there are no minimum age requirements, information on exposure risks, or control of home use nail product purchases, and these products are being purchased by adolescents who may understand the exposure risks even less than adults (Dahlin et al. 2016; Gatica-Ortega et al. 2018).

Inhalation is an important exposure route for both nail product consumers and nail salon workers who use MMA-containing products at home and in salons (Ford 2014). When nail products that contain MMA are opened to allow for application, MMA volatizes into the indoor air and is breathed in by nail product users or nail technicians and their customers.

Building parameters, air exchange rates, ventilation, weather conditions, seasonal variations (Gresner et al. 2016), and the use of personal protective equipment (OSHA 2017; Quach et al. 2012; Quach et al. 2013) all affect MMA exposure potential. Ventilation, in particular, is a critical factor in determining indoor air conditions and potential exposure to workers and consumers. While adequate ventilation reduces worker exposure, some salons do not have sufficient ventilation (Goldin et al. 2014; NYSDOH 2016). Roelofs and Do (2012) showed that many salons in the Boston area did not have adequate ventilation. Respiratory problems from chemical exposure are made worse by inadequate ventilation in salons (Marlow et al. 2012).

The average nail salon is a single room with 1 to 10 work stations 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, increasing potential exposure to the chemicals these products contain (Yang and Han 2010). Further, nail salons tend to be small spaces (a mean area of 512 square feet in California) with inadequate ventilation, which increases the magnitude of potential inhalation exposure (Quach et al. 2011).

Nail salon workers and their clients are exposed to MMA during the application of acrylic nails. The duration of this exposure depends on the type of application (full set vs. fill-in vs. repair). The preparation time for a full set of acrylic nails (i.e., applying liquid MMA and powder mixture to the entire natural nail) is approximately 40.4 minutes; for fill-ins (i.e., when natural nail grows out, it is necessary to fill-in the base of the nail with liquid MMA and powder mixture) the time required is approximately 17.4 minutes; repairing a broken acrylic nail takes only a few minutes (Froines and Garabrant 1986). MMA exposure can also occur when the MMA-containing nail products are left uncapped, left soaking on cotton pads, and when dust is generated from acrylic nail filing (Ford 2014).

While inhalation is the primary exposure route for MMA in nail products, people may also be exposed to MMA dermally via nail product application (EC 2002; Ford 2014; Froines and Garabrant 1986; WHO 1998) and accidental spillages, and orally from accidental ingestion, and hand-to-mouth behavior such as nail biting (Rister 2016). Further, there is exposure potential to MMA from unpolymerized MMA that may still be present after artificial nails have been cured (Arora and Tosti 2017). Nail product users and nail technicians have reported acrylate-associated allergic contact dermatitis. While other occupational groups may also experience dermal MMA exposure, nail salon workers are the most affected occupational group, representing 80 percent of cases of occupational allergic contact dermatitis (DeKoven et al. 2017; Ramos et al. 2014).

As noted previously, nail salon workers often work long hours and may be exposed to multiple MMA-containing nail products simultaneously. As mentioned in section 3.1.2., the median nail technician works 36 or more hours per week and services 16 to 20 customers per week (Nails Magazine 2017). Ten percent of nail technicians service 36 or more customers per week (Nails Magazine 2017). While the average nail technician applies only five acrylic sets per week (Nails Magazine 2015), nail technicians are continuously exposed to MMA vapors and dust in indoor salon air, which is generated when they file acrylic artificial nails (LoSasso et al. 2001; Quach et al. 2011).

## 3.3 Exposures to the Candidate Chemical Throughout the Product Life Cycle

**3.3.1 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 3.2.2 for additional information.

Studies have documented the presence of MMA in nail salons’ indoor air, demonstrating potential exposure to workers, patrons, and visitors (Quach et al. 2011; Quach et al. 2013). Quach et al. (2011) measured MMA in three California nail salons at an average concentration of 0.54 ppm (2.2 mg/m3). Another study analyzed the concentration of volatile organic compounds over eight hours in salon indoor air for the 12 randomly selected nail salons in Salt Lake City, Utah. In this study, MMA was detected in indoor air samples in 7 out of 12 (58 percent) salons tested (Alaves et al. 2013).

After MMA was banned in salons in California, Nguyen (2016) measured indoor air VOC concentrations at eight Los Angeles nail salons and reported that individual (e.g., acetone, isopropyl alcohol, and MMA) and total VOC concentrations were four to six times higher than concentrations measured in other nail salon indoor air quality studies due to not operating a mechanical ventilation system during data collection. This study found a significant positive correlation between the MMA concentration and the total VOC concentration (R > 0.97, p < 0.0001). Further, this study found a significant positive correlation (R ≥ 0.87, p < 0.01) between the occurrence of acrylic nail services and total VOC concentrations (including MMA as one of the VOCs) measured in salon indoor air. This study also showed that the number of gel nail services were significantly correlated (R>0.70, p<0.05) with concentrations of MMA and other VOCs in salon indoor air (Nguyen 2016).[[28]](#footnote-29)

MMA was banned in Colorado by the Colorado Office of Barber and Cosmetology Licensure in 2018 (CDORA 2018). Despite the MMA ban in Colorado in 2018, Lamplugh et al. (2019) measured personal exposures of salon workers to MMA with concentrations in the range of 70 to 1100 ppb in 2 out of 6 salons; which exceeded the RfC for MMA (approximately 171 ppb) in several measurements. According to the survey conducted in this study, salon owners reported that MMA can still be purchased from Colorado nail supply stores despite the MMA ban in Colorado (Lamplugh et al. 2019).

Despite the MMA ban in New York and New Jersey, MMA was detected in 25 nail salons located in New York, New Jersey, and Philadelphia in the range of 0.049 to 21.52 ppm with a mean value of 39.45 ppm at 24 out of 25 salons and one out of 25 salons measured mean MMA concentration as 941.25 ppm (Ma et al. 2019), which exceeded the RfC for MMA (approximately 0.171 ppm) in several measurements (U.S. EPA 1998).

Another study showed that nail salons performing services including acrylic nail services had significantly higher concentrations of total VOCs (11,000 ppb) than salons that were not performing any nail services (600 ppb) (Goldin et al. 2014). However, Zhong et al. (2019) performed a VOC exposure study in 17 nail salons in Michigan and detected MMA in salon indoor air at concentrations ranging from 100 to 36,000 µg/m3 in 15 of the 17 nail salons (88 percent) tested. In this study, MMA was not detected in the tested nail products; thus, emission sources of MMA in salon indoor air is unknown (Zhong et al. 2019).

In an older study, Froines and Garabrant (1986) evaluated manicurists’ exposure to MMA at eight nail salons in Los Angeles during artificial nail application. While nail technicians prepared artificial nails, air samples were collected in their breathing zones using passive samplers. MMA was detected at a mean intermittent exposure that ranged from 9.1 to 47.6 ppm (37 to 195 mg/m3), with an average of 20.3 ppm (83 mg/m3) and peak exposure as high as 137 ppm (562 mg/m3). The eight-hour time-weighted average (TWA) MMA exposure in these salons was calculated to be 5.3 ppm (21.7 mg/m3) (Froines and Garabrant 1986; IARC 1994). Peters et al. (2007) measured MMA at eight-hour TWA concentrations ranging from 1.80 to 5.74 ppm (7.37 to 23.5 mg/m3) in nail salons in Brisbane, Australia (Peters et al. 2007).

### 3.3.2 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 3.2, section 3.3.1, section 3.3.3, section 3.4, and section 3.5 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 MMA during the manufacture of nail products, this evaluation of MMA in nail products is focused on exposure to nail industry workers and nail product consumers.

### 3.3.3 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 3.2, section 3.3.1, section, 3.3.2, section 3.4, and section 3.5 for additional information.

A variety of nail products contain MMA, including nail polishes and other coatings and acrylic nail products (EWG 2019; Mintel 2018; U.S. EPA 2017).

The most significant routes of MMA exposure for nail product users and nail salon workers are inhalation and dermal contact (EC 2002; Ford 2014; WHO 1998).

Nail product use is popular in the U.S. and California. Approximately 105.41 million women in the United States used nail polish or other nail products in 2017 (Statista 2017a). Annual 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).

Retail stores sell millions of nail products to consumers annually (Drug Store News 2016), and consumers are potentially exposed to MMA when they apply and remove MMA-containing nail products. Acrylic nail products, nail polishes, and gel nail products that contain MMA are sold in retail stores and local beauty supply stores (EWG 2019; SF Environment 2017b). Even after the FDA removed products containing 100 percent MMA from the market through court proceedings, some nail salons continue to illegally use MMA for acrylic nails due to its low cost (FDA 2017b). Some artificial nail products contain MMA concentrations of 95 percent (SDS, USIC Inc. 2012). Nail salon customers may also bring MMA-containing products into nail salons.

UV gels and gel polishes are among the nail products that may contain MMA. Some UV gels are reported to contain a mixture of methacrylates with concentrations of 5 to 50 percent that may include MMA as an ingredient (SDSs, CND 2008).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 acrylic nails. 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. Ten percent of women who apply nail polish at home report that they use gel polish (Romanowski 2015). 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. U.S. at-home gel polish sales revenue in 2012 totaled $25 million and is expected to grow in subsequent years (Brookman 2013).

Further, 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 MMA-containing nail products are opened or applied, and the concentration of MMA present in these products. Nail industry workers may be exposed to MMA-containing products daily, potentially several times per day, and multiple times per week. A study at two Florida nail salons found that nail technicians spent approximately 24 percent of the total time of acrylic nail service procedure working with liquid monomer, which included work with MMA (Marty 2007). 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 MMA. This may result in a greater exposure over an occupational lifetime.

Factors affecting indoor air dynamics also contribute to concentrations of MMA 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 MMA 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 MMA 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 which do not remove finer particles (Bennett et al. 2012).

Even with adequate ventilation, salons with several nail technicians performing services simultaneously can have elevated levels of VOCs in salon 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 MMA. 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 3.5.2) (Cal/OSHA 2018).

## 3.4 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 MMA do not meet either of these criteria; therefore, this section does not apply.

## 3.5 Factors That May Mitigate or Exacerbate Exposure to the Candidate Chemical

**3.5.1 Containment of the Candidate Chemical within the product**

*Reference: SCP regulations 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 coatings and acrylic nails are formulated mixtures of chemicals that include MMA. Due to its high vapor pressure, MMA readily volatilizes at ambient and room temperatures, and it is potentially released from nail products during product use and end-of-life.

### 3.5.2 Engineering and administrative controls that reduce exposure concerns

*Reference: SCP regulations sections 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.

Cosmetic products including nail products do not need FDA approval prior to sale in the U.S. market (FDA 2017a). Therefore, the FDA recommends the following to reduce nail product exposure during home use of nail products:

1. apply nail products in areas with good air circulation (i.e., ventilation);
2. do not let any person or pet ingest nail products, as some nail product ingredients can be harmful if swallowed;
3. read labels for nail product ingredients to avoid using products containing harmful ingredients; and
4. follow label instructions when applying nail products (FDA 2017).

Further, exposure to nail product vapors can be minimized by turning on a bathroom or other room exhaust fan or opening windows during use, and leaving the room after you have applied them (Beyond Toxics 2018).

Occupational exposures to harmful substances should be addressed via a well-documented hazard control methodology widely accepted by industrial hygiene professionals and safety organizations. NIOSH recommends the following hierarchy of controls to protect workers from hazards, in order of preference:

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 personal protective equipment (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. Engineering controls can also be effective, especially when combined with administrative controls and PPE. 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).

Due to factors discussed previously, nail salon workers are likely to experience greater and more frequent exposures to MMA than workers in most surgical, dental, or industrial settings (LoSasso et al. 2001). 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 (LoSasso et al. 2001; Quach et al. 2011).

It is crucial that nail salons implement adequate engineering controls to reduce chemical exposure. Proper ventilation reduces nail salon worker exposure to airborne chemicals (NYSDOH 2016), while poor ventilation during use of nail products can be an important risk factor for adverse health effects (Aydin et al. 2002). A study of salon indoor air to measure VOC concentrations was conducted in Los Angeles nail salons (Nguyen 2016) after MMA was banned in salons. These salons that did not operate mechanical ventilation systems during data collection had as much as six times higher VOC concentrations, including MMA, than those measured in other nail salon indoor air studies in Alameda County, California (Quach et al. 2011) and Salt Lake City, Utah (Alaves et al. 2013) (see section 2.4.1).

NIOSH and the U.S. Occupational Safety and Health Administration (OSHA) recommend proper ventilation systems as an engineering control to reduce exposure to MMA and other chemical vapors and the dust created while filing/buffing acrylic nails (NIOSH 1999; OSHA 2012). However, many salons lack 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 breathings 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 carbon dioxide (CO2) levels exceeding 800 ppm, suggesting that these salons had 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 MMA and other VOCs. 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 2017a);
* using less toxic products (OSHA 2012; Quach et al. 2012);
* reading product labels and SDSs 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[[29]](#footnote-30) (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 OSHA Respiratory Protection Standard 29 C.F.R. 1910.134, which has certain requirements including training and fit testing. Further, employers must evaluate the appropriate cartridges for the job, provide cartridges to workers, and inform workers how and when to change cartridges (OSHA 2017).

While proper use of appropriate PPE can reduce MMA exposure from nail products, nail salon owners may not provide such PPE; their use 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 rarely use gloves and masks, and 32 percent never do. (White et al. 2015). Moreover, customers including pregnant women, their fetuses, and children that receive nail services do not wear PPE and are at risk of being exposed to MMA.

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 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 MMA exposure. MMA can penetrate through nitrile, neoprene, vinyl, and latex gloves; thus, none of these glove types is appropriate when working with MMA-containing products (Gosavi et al. 2010; Ursberg et al. 2016). Thicker polyethylene gloves could provide better protection; however, they are not suitable for nail technicians’ fine work (Ursberg et al. 2016). 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). A 2015 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[[30]](#footnote-31) to improve nail salon safety and health statewide in California (DTSC 2018b). DTSC’s HNSR program guidelines include training topics for salon workers such as use of PPE; adopting safer products; safe chemical handling, transfer, storage, and disposal; and implementing proper ventilation (DTSC 2018b). While better, more consistent training of salon staff may reduce MMA exposures to nail salon workers and their clients, the potential for exposure exists even in salons that have implemented such training programs.

# Adverse Waste and End-of-Life Effects

*Reference: SCP Regulations sections 69503.2(b)(1)(B) and 69501.1 (a)(8).*

DTSC is most concerned about MMA exposures during the use phase. While MMA in discarded nail products can be released to the environment, the products are often packaged in relatively small containers, limiting the amount of MMA released from an individual product. MMA released from disposed nail products is expected to be diluted in ambient air or in wastewater and degraded by the processes discussed in section 2.2.1. Consequently, DTSC is not basing its proposal on this factor.

# 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.

## 5.1 Other Relevant Factors Not Identified by the Regulation

In the U.S. and Europe, market trends are moving toward minimizing or eliminating the use of certain chemicals in nail products. The use of MMA has been restricted in the U.S. and Europe due to severe cases of contact dermatitis associated with MMA. Many products with more than 90 percent MMA have been recalled in Europe, and use of nail products containing MMA is not allowed in U.S. nail salons and cosmetology schools (BBC 2015; FDA 2017b; SGS 2014).

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 2018). 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 2018).

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 & Safety Code, Section 25257.2)**

* Includes incentives for businesses to use less toxic nail polishes and polish removers and to improve ventilation.
* Calls upon DTSC to publish guidelines for cities and counties to implement voluntary local healthy nail salon recognition (HNSR) programs, including a list of chemicals that should not be used by salons seeking HNSR program recognition.

**AB 2025 (2015-2016) – Barbering and Cosmetology: Labor Law Education Requirements (amended Business & Professions Code, Sections 7312, 7314, 7314.3,** **7337, 7347, and 7389)**

* Provides provisions for improved education and language access for salon workers.

**AB 2437 (2015-2016) – Barbering and Cosmetology: Establishments: Posting Notice (Bus. & Prof. Code, Section 7353.4)**

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

**AB 2775 (2018) – Professional cosmetics: labeling requirements (amended Health and Safety Code, Section 110371)**

* Requires manufacturers to disclose ingredients on the labels of professional cosmetics. The law makes the violation of its provisions a crime.
* Authorizes the California Department of Public Health to require cosmetic labels to list ingredients for professional cosmetics. Professional cosmetic products manufactured on or after July 1, 2020 and available for sale in California must have a label affixed on each container that satisfies all the labelling requirements.

## 5.2 Key Data Gaps

In this Profile, DTSC has documented the continued use of MMA in retail nail products as well as MMA’s hazard traits and potential exposure scenarios. We have determined that exposure to MMA from these products, alone or in combination with exposures from products formulated with PMMA that may contain residual MMA and from illegal use of MMA-containing products in salons, has the potential to contribute to, or cause, significant or widespread adverse impacts in the public and in salon workers. This Profile summarized MMA’s potential adverse impacts and DTSC acknowledges that addressing several data gaps would enable us to better estimate the extent and magnitude of these potential adverse impacts:

* the typical frequency and duration of application of acrylic nails and other MMA-containing retail nail products at home;
* relative MMA exposure level and frequency during at-home use versus in salons;
* the number of nail products containing MMA available in California; and
* the proportion of pregnant women and children who receive professional nail services versus applying nail products at home.

## 5.3 Conflicting Studies

DTSC has not identified studies that conflict with the information that is the basis for this proposal.

# 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 MMA through normal use of nail products may contribute to or cause significant or widespread adverse impacts to Californians, including sensitive subpopulations such as pregnant women and their fetuses, infants, children, adolescents, and nail industry workers. This determination is based on the hazard traits associated with MMA, MMA’s volatility (HSDB 2010), and the potential for inhalation exposures during use of retail nail products that contain the chemical. We have also determined that legally sold retail nail products have the potential to contribute to adverse impacts in nail salons, based on data showing measured MMA levels in salon air samples.

Exposure to MMA through use of nail products may contribute to or cause significant or widespread adverse impacts to Californians.

Nail products are very popular in the U.S. Approximately 105.41 million U.S. women used nail polish or other nail products in 2017 (Statista 2017a), and annual 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, sales of nail polishes alone exceeded $741 million (or 204 million products sold) at chain drug stores, supermarkets, discount stores, and club and dollar stores (Drug Store News 2016).

Acrylic nail products, nail polishes, and gel nail products intentionally formulated with MMA are sold in retail stores and local beauty supply stores (EWG 2019; SF Environment 2017b). Both the Environmental Working Group’s (EWG) Skin Deep Cosmetics Database (EWG 2019) and Mintel’s Global New Products Database (Mintel 2018) identify MMA-containing nail polishes for retail sale in the U.S. Gel nail products are also reported to contain MMA (Quint 2013).

While not intentionally added, MMA may also be present as a residual at significant concentrations in professional nail products formulated with PMMA or as a result of depolymerization of PMMA to release MMA, including polishes, enamels, and UV gels (Becker et al. 2011; Quint 2013). In a Cosmetic Ingredient Review Expert Panel safety assessment, Becker et al. (2011) reported 351 polishes and enamels contained PMMA at concentrations of 0.7 to 20 percent and 137 other nail products contained PMMA at concentrations of 30 percent (Becker et al. 2011). The Nail Manufacturers Council reported that PMMA-containing products may contain residual unpolymerized MMA up to 1.5 percent of the total PMMA content in the product (Becker et al. 2011). Mintel’s Global New Product Database reported 23 PMMA-containing nail products were introduced to U.S. market within the last five years (Mintel 2018), and EWG’s Skin Deep Cosmetics Database reported 52 PMMA-containing nail products (EWG 2019).

In some cases, nail salons may be using illegal MMA-containing products procured outside of California. For instance, in a 2019 survey by Lamplugh et al., salon owners reported that MMA can still be purchased from Colorado nail supply stores despite an MMA ban in that state (Lamplugh et al. 2019). In addition, MMA was detected in New Jersey and New York nail salons despite the MMA ban in these states in a 2019 study conducted by Ma et al. (Ma et al. 2019). Another source of MMA detection in salon indoor air could be MMA-containing retail nail products (e.g., polishes, gels products, and acrylic nails sold legally for home use) may be brought into salons by customers for professional technicians to apply.

While DTSC is unable to determine the relative contributions of illegally-used products to the levels of MMA detected in salon air, we have concluded that nail products legally sold in California have the potential to expose workers to MMA and, potentially, to contribute to significant or widespread adverse impacts. DTSC is not basing this proposal solely on products the use of which is prohibited in California.

Users of retail nail products, including children and pregnant women, may also be exposed to MMA. Wu et al., found that 45 percent of girls younger than 5 years old use nail polish, and this increases to 79 percent for girls over 5 years old (Wu et al. 2010). The authors found 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 (Wu et al. 2010). Therefore, children are exposed to chemicals in nail products directly from using the products on themselves or indirectly by inhaling chemical vapors released from products when their parents are applying the products.

Consumers that self-apply acrylate or methacrylate-containing nail products that may contain MMA as an ingredient at home are not trained on the safe use of these products and apply the products more frequently at home, since doing so is more convenient and affordable than visiting a salon for nail services (Gatica-Ortega et al. 2018). DTSC believes that several factors may increase home users’ exposure risk. For instance, home environments may have relatively poor ventilation, and products are generally not labeled with information on exposure potential. There are no minimum age limits for purchasing or using MMA-containing retail nail products, and they are sometimes purchased by adolescents who may understand the exposure potential even less than adults (Dahlin et al. 2016; Gatica-Ortega et al. 2018). Therefore, the exposure potential of the general public may be the same or higher than the salon workers (Gatica-Ortega et al. 2018).

The most significant routes of MMA exposure for nail product users and nail salon workers are inhalation and dermal contact (EC 2002; Ford 2014; WHO 1998). In a 2016 nail salon air monitoring study, measured concentrations of individual (e.g., acetone, isopropyl alcohol, and MMA) and total VOC concentrations were four to six times higher in eight Los Angeles nail salons not using mechanical ventilation systems than those in salons using some type of ventilation (Alaves et al. 2013; Nguyen 2016; Quach et al. 2011).

Even after the enactment of bans on MMA-containing products in nail salons in California and other states, MMA continues to be detected in salons’ air (Alaves et al. 2013; Nguyen 2016; Quach et al. 2011), sometimes at levels that exceed health-based thresholds. A study in Michigan detected MMA in the air of 88 percent of the salons tested, even after a ban in that state (Zhong et al. 2019). Another study analyzed the concentration of VOCs in the air of 12 randomly-selected nail salons in Salt Lake City, Utah; MMA was detected in indoor air of 58 percent of the nail salons tested (Alaves et al. 2013).

Lamplugh et al. (2019) performed a study to measure VOC levels in the breathing zones of nail salon workers at 6 nail salons in Colorado. In this study, despite the MMA ban in Colorado, MMA was detected at 2 of the salons that were measured in the breathing zone of Colorado nail salon workers at concentrations in the range of 70 to 1100 ppb, which exceeded the U.S. EPA RfC for MMA (~171 ppb) in several measurements (Lamplugh et al. 2019). An older air monitoring study in California nail salons measured MMA in indoor air of three salons at an average concentration of 0.54 ppm (2.2 mg/m3) (Quach et al. 2011).

Ma et al. (2019) performed a study to collect personal exposure measurements from 100 salon workers at 25 nail salons in New Jersey, New York, and Philadelphia. In this study, despite the MMA ban in New York and New Jersey, MMA was detected with concentrations in the range of 0.049 to 21.52 ppm with a mean value of 39.45 ppm at 24 out of 25 salons and one out of 25 salons measured mean MMA concentration of 941.25 ppm; this exceeded the U.S. EPA RfC for MMA (~0.171 ppm) in several measurements. The salon with 941.25 ppm MMA concentration measurement was offering application of artificial nail services on the test day, which required the use of acrylic monomer that contains MMA (Ma et al. 2019).

A study at two Florida nail salons found that nail technicians spent approximately 24 percent of the total time of acrylic nail services procedure working with liquid monomer, which included work with MMA (Marty 2007). One study showed that nail salons providing nail services including acrylic nail services had significantly higher concentrations of total VOCs (11,000 ppb) than salons that were not providing any nail services (600 ppb) (Goldin et al. 2014). Nguyen found a significant positive correlation between the occurrence of acrylic nail services and total VOC concentrations (including MMA as one of the VOCs) measured in salon indoor air. This study also showed that the number of gel nail services significantly correlated with concentrations of MMA and other VOCs in salon indoor air (Nguyen 2016).

Using MMA-containing nail products has been documented to cause adverse impacts. The primary hazard traits associated with MMA exposure are dermal toxicity and respiratory toxicity (see section 2.3).

As methacrylate-containing artificial nails have become more popular, the incidence of allergic contact dermatitis cases has increased in both nail technicians and their customers (Roche et al. 2008). Marty (2007) lists several studies that document cases of allergic contact dermatitis in workers, including nail technicians, who were occupationally exposed to MMA and ethyl methacrylate (EMA). Two recent studies in Europe documented methacrylate-containing UV gels that may contain MMA as an ingredient offered for sale in retail stores and online for home use. Consumers that applied these products reported severe skin reactions including allergic contact dermatitis; hand eczema; itching and pain in the fingers; permanent nail damage; and eczema on the lips, throat, and around the eyes (Dahlin et al. 2016; Gatica-Ortega et al. 2018). Thirty-seven of 122 patients tested by Ramos et al. (2014) demonstrated sensitization to acrylates and methacrylates. Dermatitis was observed in 37 patients and 25 of the patients (67.6 percent) were occupationally exposed, and 20 of 25 (80 percent) of the patients were nail technicians working with artificial nails (Ramos et al. 2014).

Studies of occupationally exposed workers, including dental workers and nail technicians, document cases of occupational asthma following acrylates and MMA exposure (Arora and Tosti 2017; Borak et al. 2011; Kwok et al. 2014; Marty 2007; Roche et al. 2008). Between 1996 and 2011, six out of nine reported occupational asthma cases in beauticians were attributed to acrylates (Kwok et al. 2014). In addition, a study found that the number of years employed as a nail technician and the number of hours being exposed to acrylic nails were positively correlated to reduced lung function and increased airway inflammation (Reutman et al. 2009).

In California, there are over 9,000 nail salons (Nails Magazine 2017) and approximately 130,000 licensed manicurists (DCA 2017). Chemical exposure of nail industry workers is an environmental justice issue, as a large majority are people of color and lower socioeconomic status (Ford 2014; Nails Magazine 2017). The children of nail technicians often accompany their parents to the workplace. In addition, pregnant nail technicians and their fetuses are especially sensitive to the adverse impacts of MMA exposure from nail products, as are their infants and children, due to physiological differences from adults (see section 2.5.2). Nail salon workers’ potential for exposure to MMA is exacerbated by several factors: They often work hours 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 work places often lack appropriate ventilation (Quach et al. 2008).

# 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).

## 7.1 Chemical Alternatives

### 7.1.1 Chemical Name: Ethyl Methacrylate (EMA) (CAS No. 97-63-2)

***Discussion of applicability of the chemical alternative:***

Ethyl methacrylate (EMA) has become a commonly used chemical substitute for MMA for acrylic nail preparation (Government of Western Australia 2017; Roberts 2011) since the FDA’s ban on MMA’s use in acrylic nail products (FDA 2017b). Liquid EMA monomer is mixed with polymerized EMA powder, and this mixture polymerizes on the nail surface to form acrylic nails (Reutman et al. 2009). The concentration of EMA in legal acrylic monomers ranges from 70 percent to 90 percent (Nails Magazine 2017).

As mentioned in section 1.3, EMA is more expensive than MMA; in 2011, one gallon of MMA cost $9 to $22, whereas one gallon of EMA cost $189 to $219 (Roberts 2011). Notwithstanding FDA’s ban some nail salons continue to choose MMA over EMA due to its lower cost (Roberts 2011).

Occupational exposure limits, including an OSHA permissible exposure limit (PEL), have not been established for EMA (Cal/OSHA 2018; NJDOH 2002a; OSHA 2018). Nevertheless, NJDOH recommends implementing engineering controls, including local exhaust ventilation and respirators, to reduce exposure to EMA vapors (NJDOH 2002a).

***Readily available hazard trait information****:*

In April 2012, the Methacrylate Producers Association Inc. (MPA) issued a statement that methacrylic acid (MAA) and its esters including MMA, EMA, n-butyl methacrylate (nBMA), isobutyl methacrylate (iBMA), and 2-ethylhexyl methacrylate (2-EHMA) in unreacted liquid monomer form are not appropriate for use in artificial nail products (MPA 2012). The statement cites the corrosivity and skin sensitization properties of these chemicals in urging the FDA to ban their use in cosmetic products (MPA 2012).

Acute EMA exposure can cause abdominal pain, nausea, vomiting, and diarrhea (OSHA 2006), as well as eye, skin, and respiratory irritation (ECHA 2018) (see section 2.4.2). Acute exposure to EMA vapors can cause dizziness, light-headedness, and fainting (OSHA 2006) as well as occupational asthma and allergic contact dermatitis (Marty 2007). The Cosmetic Ingredient Review Panel recommends avoiding skin contact when applying EMA because of its allergenic and skin sensitization properties (FDA 2017b). EMA and MMA have similar results in skin patch tests for methacrylate sensitization (MPA 2012). EMA exposure including nail salons may cause mild cognitive and neurosensory changes (Marty 2007).

EMA is a flammable liquid and a fire hazard (NJDOH 2002a; OSHA 2006). Vapor and air mixtures of EMA are explosive, and vapors can polymerize and block air vents (NIOSH 2014).

## 7.2 Non-Chemical alternatives

### 7.2.1 Discussion of applicability of the non-chemical alternative

Not applicable.

# 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 MMA as a Priority Product nor with any subsequent regulation that may result for such listing.[[31]](#footnote-32)

## 8.1 U.S. Food and Drug Administration

The U.S. Food and Drug Administration (FDA) is authorized by the Federal Food, Drug, and Cosmetic Act (FDCA) to oversee the safety of food, drugs, and cosmetics (FDA 2016). 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 2016).[[32]](#footnote-33)

The FDA banned the sale of nail products containing 100 percent MMA after receiving complaints of injury resulting from their use.

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 2016). As noted earlier, the FDA took action to ban sale of nail products containing 100 percent MMA in the early 1970s, after receiving multiple complaints of injury resulting from their use (FDA 2017b).

### 8.1.1 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 2018b). The FDCA defines cosmetics as "articles intended to be 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 2016). 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.

### 8.1.2 Fair Packaging and Labeling Act

The Fair Packaging and Labeling Act (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).

The specific labeling requirements for cosmetic products are detailed 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. § 701.3 2018). Cosmetic products that are not typically distributed for retail sale (e.g., nail products used by professionals on customers at their work places) are exempt from this requirement and these products are also not sold to consumers at professional establishments or workplaces (FDA 2018a).

## 8.2 U.S. Environmental Protection Agency

* MMA 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 2018). Under Section 8, TSCA requires reporting and recordkeeping 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 EPA, except in situations where EPA has been adequately informed of such information (40 C.F.R. § 716.120 1994).
* MMA is listed as a hazardous air pollutant under the Clean Air Act (42 U.S.C. § 7412 1999).
* MMA 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. § 63 2006).

## 8.3 California Division of Occupational Safety and Health

MMA is listed as a hazardous substance by the California Division of Occupational Safety and Health (DOSH), also known as Cal/OSHA (DIR 2016). Pursuant to Cal/OSHA’s hazard communication regulations, employers must “… provide information to their employees about the hazardous chemicals to which they may be exposed, by means of a hazard communication program, labels and other forms of warning, safety data sheets, and information and training” (DIR 2016).

MMA is listed as an airborne contaminant (Cal/OSHA 2018). Cal/OSHA has set the following exposure limits to protect workers who are occupationally exposed to MMA:

* The permissible exposure limit [[33]](#footnote-34) (PEL) for gas or vapor is 50 ppm (205 mg/m3) of air by volume at 25 °C and 760 mm Hg pressure (Cal/OSHA 2018).
* The short term exposure limit [[34]](#footnote-35) (STEL) for gas or vapor is 100 ppm (410 mg/m3) of air by volume at 25 °C and 760 mm Hg pressure (Cal/OSHA 2018).

## 8.4 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.

MMA is prohibited in California Board of Barbering and Cosmetology licensed establishments.

BBC has notified licensees and consumers that use of MMA is prohibited in BBC licensed establishments (BBC 2015).

MMA is listed as a prohibited hazardous substance:

“No establishment or school shall:

(a) Have on the premises cosmetic products containing hazardous substances banned by the U.S. Food and Drug Administration for use in cosmetic products.

(b) Have on the premises methyl methacrylate monomer and/or methylene chloride.

(c) Use a product in a manner that is disapproved by the FDA, Occupational Safety and Health Administration or EPA.” (16 CCR§ 989) (BBC 2015).

This regulation does not prevent the sale of retail nail products containing MMA in California; therefore, it does not overlap with this proposed regulation.

## 8.5 California Air Resources Board

MMA is designated by the California Air Resources Board (CARB) to be a toxic air contaminant pursuant to Health and Safety Code Section 39657 (17 CCR§ 93001) (CARB 2011).

## 8.6 Other States

Many states have banned professional cosmetic use of MMA (MPA 2012). A list of these states and a summary of the scope of their bans are provided in Appendix 2.

# Acronyms and Abbreviations

**Abbreviations used in this document**

ACD allergic contact dermatitis

ACGIH American Conference of Governmental Industrial Hygienists

ACH acetone cyanohydrin

AOEC Association of Occupational and Environmental Clinics

ATSDR Agency for Toxic Substances and Disease Registry

BBC Board of Barbering and Cosmetology

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

C.F.R. Code of Federal Regulations

CNS central nervous system

CoA Coenzyme A

CO2 carbon dioxide

CPCat Chemical and Product Categories

DCA Department of Consumer Affairs

DIR Department of Industrial Relations

DTSC Department of Toxic Substances Control

EC European Commission

ECHA European Chemicals Agency

2-EHMA 2-ethylexyl methacrylate

EMA ethyl methacrylate

EWG Environmental Working Group

FDA Food and Drug Administration

FDCA Federal Food, Drug, and Cosmetic Act

FPLA Fair Packaging and Labeling Act

GISO General Industry Safety Orders

GPC Global Product Classification

H2SO4 sulfuric acid

HSDB Hazardous Substances Data Bank

HVAC heating, ventilation, and air conditioning

H2O water

IARC International Agency for Research on Cancer

iBMA isobutyl methacrylate

ICI Imperial Chemical Industries

IPA Isopropyl Alcohol

IRIS Integrated Risk Information System

LED light-emitting diode

LEL lower explosive limit

LEV local exhaust ventilation

MAA methacrylic acid

MMA methyl methacrylate

MPA Methacrylate Producers Association Inc.

N95 Masks NIOSH-approved filtering facepiece respirators

nBMA n-butyl methacrylate

NCBI National Center for Biotechnology Information

NHCS U.S. Census Data and Simmons National Consumer Survey

NH4HSO4 ammonia bisulfate

NIOSH National Institute for Occupational Safety and Health

NJDOH New Jersey Department of Health and Senior Services

NOAA National Oceanic and Atmospheric Association

NTP National Toxicology Program

NYSDOH New York State Department of Health

OEHHA Office of Environmental Health Hazard Assessment

OSHA Occupational Health and Safety Administration

PEL Permissible Exposure Limit

pH potential hydrogen

PMMA polymethyl methacrylate

PPE personal protective equipment

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

RfC Inhalation Reference Concentration

RIVM National Institute for Public Health and the Environment

SCP Safer Consumer Products

SCV source capture ventilation

SDSs safety data sheets

SF Environment San Francisco Department of Environment

STEL short term exposure limit

UEL upper explosive limit

UK HSC United Kingdom Health and Safety Commission

U.S. United States

U.S. EPA United States Environmental Protection Agency

USIC, Inc. U.S. International Chemist Inc.

UV ultraviolet

VOC volatile organic compound

WVE Women's Voices for the Earth

**Units**

atom/cm3 atom per cubic centimeter

atm atmosphere

atm·m3/mol atmosphere times cubic meter per mol

°C degrees Celsius

°F degrees Fahrenheit

ft2 square feet

ft3 cubic feet

g gram

g/cm3 gram per cubic centimeter

g/day gram per day

g/mol gram per mol

kg kilogram

kJ/mol kilojoule per mol

Koc organic carbon-water partition coefficient

Kow octanol-water partition coefficient

l/kg liter per kilogram

m meter

m/s meter per second

m3 cubic meter

mm Hg millimeter of mercury

mg/L milligram per liter

mg/m3 milligram per cubic meter

mmol millimole

ng/L nanogram per liter

nm Nanometer

nmol Nanomole

N/m Newton per meter

ppb parts per billion

ppm parts per million

radical/cm3 radical per cubic centimeter

v/v volume/volume

μg microgram

µg/g microgram per gram

μm micrometer

µg/L microgram per liter

µg/m3 microgram per cubic meter

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40 C.F.R. § 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

**Report Preparation:**

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# Appendix 2 - U.S. States Which Have Banned MMA in Professional Cosmetics

|  |  |  |  |
| --- | --- | --- | --- |
| State | Statutory or Regulatory Language | Statue or Regulation | Reference |
| Alabama | "No licensee shall use methyl methacrylate or any other product considered poisonous or unsafe." | Alabama Administrative Code 250-X-3.02(5) | (Alabama Administrative Code 250-X-3.02(5) 2017) |
| Arizona | "An establishment shall not have on the premises cosmetic products containing hazardous substances banned by the U.S. Food and Drug Administration (FDA) for use in cosmetic products, including liquid methyl methacrylate monomer and methylene chloride…" | Arizona Administrative Code, Title 04,  Chapter 10, Section R4-10-112(M)(1) | (Arizona Administrative Code § R4-10-112(M)(1) 2017) |
| Arkansas | "Cosmetologist and manicurist shall not use Liquid Methyl Methacrylate (MMA) Monomer" | Arkansas State Board of Health  Rule 11 (E) | (Arkansas State Board of Health Rule 11 (E) 2016) |
| California | "No establishment or school shall:  (a) Have on the premises cosmetic products containing hazardous substances banned by the U.S. Food and Drug Administration for use in cosmetic products.  (b) Have on the premises methyl methacrylate monomer and/or methylene chloride.  (c) Use a product in a manner that is disapproved by the FDA, Occupational Safety and Health Administration or EPA." | California Code of Regulations, Title 16, Section 989 | (BBC 2015) |
| Colorado | "Licensees are specifically prohibited from using the following: . . . Methylmalonic acid or Methacrylate Liquid Monomers, (MMA)…" | Colorado Code of Regulations,  Title 4, Section 731-1:8.1(B)(2) | (Colorado Code of Regulations § 731-1:8.1(B)(2) 2018) |
| District of Columbia | "A person may not use or possess methyl methacrylate liquid monomer (MMA) in a salon of any type in the District of Columbia." | District of Columbia Municipal Regulations,  Title 17, Chapter 17-37, Section 3718.18(c)(1) | (District of Columbia Municipal Regulations § 3718.18(c)(1) 2017) |
| Delaware | "Electric nail files and electric drills shall not be used on natural nails. The use of methyl methacrylate (MMA) is prohibited. No licensee, school or shop shall use or permit the use of MMA." | Delaware Administrative Code, Title 24, Chapter 5100, Section 16.3 | (Delaware Administrative Code § 16.3 2017) |
| Florida | "It is unlawful for any person to…: In the practice of cosmetology, use or possess a cosmetic product containing a liquid nail monomer containing any trace of methyl methacrylate (MMA)." | Florida Statutes, Title XXXII, Chapter 477, Section 477.0265(1)(g) | (Florida Statutes § 477.0265(1)(g) 2018) |
| Illinois | "The use of nail products or the distribution of nail products containing monomer Methyl Methacrylate (MMA) is prohibited." | Illinois Administrative Code, Title 68, Chapter VII, Section 1175.115(b)(16) | (Illinois Administrative Code § 1175.115(b)(16)) |
| Iowa | "No [cosmetology] salon or school shall have on the premises cosmetic products containing substances which have been banned or otherwise deemed hazardous or deleterious by the FDA for use in cosmetic products," including "any product containing liquid methyl methacrylate monomer." | Iowa Administrative Code, Chapter 63, r. 645-63.18(1) | (Iowa Administrative Code r. 645-63.18(1) 2016) |
| Kentucky | "No instructor, student, cosmetologist, or nail technician shall: … Use on any patron a liquid nail enhancement product containing monomeric methyl methacrylate, also known as dental acrylic monomer, for the purpose of creating artificial nail enhancements in the practice of cosmetology and nail technology." | Kentucky Revised Statutes, Chapter 317A,  Section 317A.130(1)(e) | (Kentucky Revised Statutes § 317A.130(1)(e) 2018) |
| Louisiana | "Prohibited equipment and substances. No beauty shop, salon or cosmetology school shall permit the use of and no individual licensed by the board shall use the following in the performance of cosmetology… nail enhancement products containing methyl methacrylate (MMA) monomer." | Louisiana Administrative Code, Title 46, Part XXXI, Chapter 7, Section 701(R)(3) | (Louisiana Administrative Code § 701(R)(3) 2018) |
| Maryland | "A person may not use or possess methyl methacrylate liquid monomer (MMA) in a beauty salon in this State." | Code of Maryland, Business Occupations and Professions,  Title 5, Subtitle 6, Section 5-608.1(a) | (Code of Maryland § 5-608.1(a) 2018) |
| Michigan | "A student, apprentice, or licensee shall not do any of the following… Use or possess methyl methacrylate monomers.” | Michigan Administrative Code,  R 338.2179g (1)(a) | (Michigan Administrative Code R 338.2179g (1)(a) 2018) |
| Mississippi | "No product containing the ingredient methyl methacrylate (MMA) can be used in any manicuring or pedicuring procedure. All products must be correctly labeled, and manufacturer’s data sheets for any nail product must be readily available for review by any agent of the Board of Cosmetology." | Mississippi State Board of Cosmetology Rules and Regulations, Chapter 7, Rule 7.15(H) | (Mississippi State Board of Cosmetology Rules and Regulations Rule 7.15(H) 2017) |
| Missouri | "No cosmetology licensee shall provide any cosmetology services that involve the use of any liquid product containing methyl methacrylate (MMA)." | Missouri Code of State Regulations, Title 20,  Section 2085-11.020(2)(J) | (Missouri Code of State Regulations § 2085-11.020(2)(J) 2013) |
| Montana | "Possession or use of the following items is prohibited… methyl methacrylate monomers for artificial nails…." | Administrative Rules of Montana, 24.121.1517(3)(d) | (Administrative Rules of Montana § 24.121.1517(3)(d) 2015) |
| New Hampshire | "A licensee shall not… Apply methyl methacrylate (MMA) monomer on a person, or have MMA available for use in the facility" | New Hampshire Code of Administrative Rules Bar, 302.07(g)(1) | (New Hampshire Code of Administrative Rules Bar 302.07(g)(1) 2018) |
| New Jersey | "A licensee, licensed shop, or school of cosmetology and hairstyling shall not utilize any product that contains methyl methacrylate monomer." | New Jersey Administrative Code, Title 13, Chapter 28, Subchapter 3, Section 13:28-3.4(a) | (New Jersey Administrative Code § 13:28-3.4(a) 2012) |
| New Mexico | “Prohibitions… for the purpose of performing services under the Act, no licensee shall buy, sell, or use, or apply to any person liquid monomeric methyl methacrylate (MMA)." | Code of New Mexico Rules, Title 16, Chapter 34, Part 7, Section 16.34.7.9(D)(3) | (Code of New Mexico Rules § 16.34.7.9(D)(3) 2018) |
| New York | "No owner or operator of an appearance enhancement business shall knowingly… Sell, use or apply to any person monomeric methyl methacrylate…" | New York General Business Law, Article 27, NY GEN BUS, Section 404-a(1)(a) | (New York General Business Law § 404-a(1)(a) 2018) |
| North Carolina | “Licensees or students shall not use or possess in a cosmetic art school or shop any of the following… Methyl Methacrylate Liquid Monomer, a.k.a. MMA…" | North Carolina Administrative Code, 21 NCAC, 14H.0401(c)(1) | (North Carolina Administrative Code 14H.0401(c)(1) 2018) |
| Ohio | “No individual shall do any of the following… Use or possess a liquid nail monomer containing any trace of methyl methacrylate (MMA)." | Ohio Administrative Code, 4713.14(M)(3) | (Ohio Administrative Code 4713.14(M)(3) 2016) |
| Oklahoma | "Each licensee shall be knowledgeable of product ingredients. If not listed on the product, the manufacturer should be contacted for content information. The use of methyl methacrylate (MMA) is prohibited." | Oklahoma Administrative Code, Title 175, Chapter 10,  Section 175:10-7-14(f) | (Oklahoma Administrative Code § 175:10-7-14(f) 2012) |
| Rhode Island | "The possession and/or use of any cosmetic nail preparation containing methyl methacrylate (MMA) shall be prohibited." | Rhode Island Administrative Code, Title 216, Chapter 40, Subchapter 05, Part 4, Section 4.7.6(B)(17) | (Rhode Island Administrative Code § 4.7.6(B)(17) 2018) |
| South Dakota | "A salon or booth may not use the following products… Liquid monomer nail products containing methyl methacrylate monomers (MMA)…" | Administrative Rules of South Dakota, Article 20:42, Chapter 20:42:04, Section 20:42:04:08.01(1) | (Administrative Rules of South Dakota § 20:42:04:08.01(1) 2017) |
| Tennessee | "No establishment or school shall have on the premises cosmetic products containing hazardous substances which have been banned by the U.S. Food and Drug Administration (FDA) for use in cosmetic products, including, but not limited to, liquid methyl methacrylate. No product shall be used in a manner that is disapproved by the FDA." | Tennessee Rules and Regulations, Chapter 0440-02, Section 0440-02-.17(1) | (Tennessee Rules and Regulations § 0440-02-.17(1) 2018) |
| Texas | "Licensees may not use any of the following substances or products in performing cosmetology services… Methyl Methacrylate Liquid Monomers, a.k.a., MMA…"  "For the purpose of performing services authorized under the Act, no licensee shall buy, sell, use, or apply to any person liquid monomeric methyl methacrylate (MMA)." | Texas Administrative Code, Title 16, Part 4, Chapter 83, Section 83.112(a)(1); Section 83.113(c) | (Texas Administrative Code § 83.112(a)(1) 2012; Texas Administrative Code § 83.113(c) 2006) |
| Utah | "Unlawful conduct includes… using or possessing a solution composed of at least 10% methyl methacrylate on a client…" | Utah Code, Title 58, Chapter 11a, Part 4, r. 58-11a-502(4) | (Utah Code r. 58-11a-502(4) 2017) |
| Washington | "No establishment or school may have on the premises cosmetic products containing hazardous substances which have been banned by the U.S. Food and Drug Administration for use in cosmetic products. Use of 100% liquid methyl methacrylate monomer and methylene chloride products are prohibited. No product must be used in a manner that is disapproved by the U.S. Food and Drug Administration." | Washington Administrative Code, Title 308, Chapter 308-20, Section 308-20-110(15) | (Washington Administrative Code § 308-20-110(15) 2017) |
| Wisconsin | "Licensees may not use methyl methacrylate monomer, commonly referred to as MMA in liquid form, and may not use any cosmetic or nail product formulated with MMA as one of its ingredients." | Wisconsin Administrative Code, Chapter Cos 2, Section Cos 2.03(9) | (Wisconsin Administrative Code § Cos 2.03(9) 2012) |

1. California Code of Regulations, title 22, Division 4.5, Chapter 55, Article 3 [↑](#footnote-ref-2)
2. California Code of Regulations, title 22, section 69503.2(a) [↑](#footnote-ref-3)
3. California Code of Regulations, title 22, section 69503.7 and Article 5 (Alternatives Analysis) [↑](#footnote-ref-4)
4. <https://calsafer.dtsc.ca.gov/> [↑](#footnote-ref-5)
5. A monomer is a molecule that can be bonded to other identical molecules to form a polymer. [↑](#footnote-ref-6)
6. Serum is the human blood component that does not include the blood clotting proteins. Esterase is an enzyme that is found in serum. [↑](#footnote-ref-7)
7. Photochemical smog is a haze formed through a chemical reaction of sunlight, nitrogen oxides, and volatile organic compounds in the atmosphere. Flint D (2018) What Causes Photochemical Smog? In. https://sciencing.com/causes-photochemical-smog-6159455.html Accessed February 2018 [↑](#footnote-ref-8)
8. <https://govt.westlaw.com/calregs/Browse/Home/California/CaliforniaCodeofRegulations?guid=I6E0E45C032A411E186A4EF11E7983D17&originationContext=documenttoc&transitionType=Default&contextData=(sc.Default)> [↑](#footnote-ref-9)
9. Skin sensitization is when an immunological response occurs following previous exposure to a substance and results in an inflammatory skin reaction. Skin sensitization may or may not result in an allergic reaction upon initial contact with a chemical. However, once skin sensitization develops, intense skin responses may occur even at low chemical concentrations. ISTAS Database in cooperation with European Trade Union Institute (ETUI), Sensitizers (2012) http://www.istas.net/risctox/en/iframe/index.asp?idpagina=612. Accessed August, 2018. [↑](#footnote-ref-10)
10. Neuropathy includes weakness, numbness, and pain from nerve damage, usually in the hands and feet. Mayo Clinic (2017) Peripheral neuropathy. In. https://www.mayoclinic.org/diseases-conditions/peripheral-neuropathy/symptoms-causes/syc-20352061 Accessed July 2018 [↑](#footnote-ref-11)
11. Allergic contact dermatitis (ACD) occurs when skin has contact with a chemical that one is allergic to. It can take a few days for immune system to recognize the chemical and skin reactions may appear several days after the actual exposure. National Eczema Association (2018) Contact Dermatitis. In. https://nationaleczema.org/eczema/types-of-eczema/contact-dermatitis/ Accessed August, 2018 [↑](#footnote-ref-12)
12. Nail dystrophy is poor nail formation as a result of trauma or infection including nail discoloration, detachment of nail bed, and dry, brittle, or splitting nails. Naildystrophy.com (2018) Nail Dystrophy: The Cause of Brittle, Peeling & Fragile Nails. In. http://naildystrophy.com/ Accessed February 2018 [↑](#footnote-ref-13)
13. “Toxic air contaminant” means an air pollutant which may cause or contribute to an increase in mortality or in serious illness, or which may pose a present or potential hazard to human health. Health and Safety Code – HSC 39655. http://leginfo.legislature.ca.gov/faces/codeBillCrossRef.xhtml?sectionNum=39655&lawCode=HSC. Accessed October 2019. [↑](#footnote-ref-14)
14. The olfactory epithelium is specialized epithelial tissue inside the nasal cavity that is involved in smell. [↑](#footnote-ref-15)
15. Hyperplasia is an increase in the amount of organic tissue that results from rapid cell proliferation (i.e., increase of the number of cells). [↑](#footnote-ref-16)
16. Cytoplasmic inclusions consist of abnormally folded proteins and are a symptom of a considerable number of human disorders. Zatloukal K, Stumptner C, Fuchsbichler A, Janig E, Denk H (2004) Intermediate Filament Protein Inclusions Methods in Cell Biology. vol 78. Academic Press, p 205-228. [↑](#footnote-ref-17)
17. Respiratory epithelium is a type of ciliated epithelial tissue found lining most of the respiratory tract, where it serves to moisten and protect the airways. [↑](#footnote-ref-18)
18. Inflammatory cell infiltration is “when inflammatory cells such as neutrophils, eosinophils, lymphocytes, plasmacytes, macrophages and mast cells infiltrate around the blood vessels (perivascular infiltration).” Shimizu H (2007) Chapter 2: Histopathology of the Skin. Shimizu's Textbook of Dermatology. p 33. [↑](#footnote-ref-19)
19. Rhinitis is inflammation and swelling of the mucous membrane of the nose characterized by a runny nose and stuffiness. [↑](#footnote-ref-20)
20. Crown-rump length is the measurement of the length of human or animal embryos and fetuses from the top of the head (crown) to the bottom of the buttocks (rump). [↑](#footnote-ref-21)
21. Developmental effects which occur even in the presence of maternal toxicity are considered to be evidence of developmental toxicity, unless it can be unequivocally demonstrated on a case by case basis that the developmental effects are secondary to maternal toxicity. Developmental effects that are observed at maternally toxic doses should not be automatically discounted. Moreover, classification shall be considered where there is a significant toxic effect in the offspring, e.g., irreversible effects such as structural malformations, embryo/fetal lethality, or significant post-natal functional deficiencies. OSHA, Health Hazard Criteria, Appendix A, Section 1910. https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1200AppA. Accessed October 2019. [↑](#footnote-ref-22)
22. Peripheral neuropathy, caused by nerve damage, often results in weakness, numbness, and pain usually in the hands and feet. [↑](#footnote-ref-23)
23. Corneal edema is the abnormal swelling of the cornea due to fluid accumulation leading to blurred or clouded vision. [↑](#footnote-ref-24)
24. Corneal neovascularization is the in-growth of new blood vessels in the cornea. [↑](#footnote-ref-25)
25. Iris atrophy is the development of distorted areas of degeneration or holes in the iris. [↑](#footnote-ref-26)
26. Cataract is a cloudy or opaque area in the normally clear lens of the eye. [↑](#footnote-ref-27)
27. Intraocular lenses are lenses implanted in the eye to treat cataracts or myopia. [↑](#footnote-ref-28)
28. Pearson Correlation coefficient (R): “R” ranges from -1.0 to +1.0. The closer R is to +1 or -1, the more linearly the two variables are related. If R is closer to +1, it means that as one variable gets larger the other gets larger. If R is closer to -1, it means that as one gets larger the other gets smaller. If R is zero, then there is no linear relationship. Probability (p) value: “p” value indicates whether correlation coefficient is significantly different from zero. If p ≤ 0.05, then correlation coefficient is significantly different from zero and the correlation coefficient is called statistically significant. If p > 0.05, then the correlation coefficient is not different from zero and the correlation coefficient is not statistically significant. [↑](#footnote-ref-29)
29. 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. [↑](#footnote-ref-30)
30. DTSC published the [Healthy Nail Salon Recognition Program Guidelines](https://dtsc.ca.gov/wp-content/uploads/sites/31/2018/10/AB2125-HNSR-Program-Guidelines.pdf) in April 2018. [↑](#footnote-ref-31)
31. Safer Consumer Products regulations do not apply to a consumer product that the Department determines is regulated by one or more federal and/or California state regulatory programs, and/or applicable treaties or international agreements with the force of domestic law, that, in combination (Section 69501(b)(3)(A)). <https://govt.westlaw.com/calregs/Document/I8C1641B016D911E39FBEC451F3D23076?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)> Accessed November 2019. [↑](#footnote-ref-32)
32. “Adulterated” cosmetics refers to product composition violations: whether they result from ingredients, contaminants, processing, packaging, or shipping and handling FDA (2016) 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 October 2017 . [↑](#footnote-ref-33)
33. Defined in subsection (b) of section 5155 of title 8 of the California Code of Regulations as the “… maximum permitted 8-hour time-weighted average concentration of an airborne contaminant.” [↑](#footnote-ref-34)
34. Defined, in part, in subsection (b) of section 5155 of title 8 of the California Code of Regulations as a “… 15-minute time-weighted average exposure which is not to be exceeded at any time during a workday….” [↑](#footnote-ref-35)