

**HETA 92-128-2241
JULY 1992
TINA AND ANGELA'S NAIL SALON
SPRINGDALE, OHIO**

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I. Summary

In response to a request from the Springdale Health Department in Springdale, Ohio, representatives from the National Institute for Occupational Safety and Health (NIOSH) conducted an industrial hygiene evaluation of exposures to chemicals used during the application of sculptured nails. The request stated that an adjacent business in the same building had complained of a "terrible odor" emanating from the nail salon. No health effects were noted on the request.

Bulk samples of liquids and powders used to sculpture nails were collected and analyzed qualitatively by gas chromatography/mass spectrometry. Based on these results, personal and area air sampling was conducted in the nail salon for methyl and ethyl methacrylate, acetone, and benzene. No methyl methacrylate or benzene vapors were detected. Low concentrations of ethyl methacrylate (ranged from non-detected to 7 parts per million [ppm]) and acetone vapors (6 and 10 ppm) were detected. There are no occupational exposure criteria for ethyl methacrylate; however, *Patty's Industrial Hygiene and Toxicology* suggests that industrial hygiene recommendations for methyl methacrylate can be applied to ethyl methacrylate. All exposures were below the NIOSH Recommended Exposure Limit (REL) time-weighted average (TWA) criteria of 100 ppm for methyl methacrylate and 250 ppm for acetone.

An inspection of the heating and cooling system serving the salon indicated that there was no provision for the mechanical introduction of outside air to the salon. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) recommends that 25 cubic feet per minute (cfm) of outside air be supplied to beauty salons.

Several chemicals (methacrylates, acetone) used in nail salons emit vapors having low odor thresholds. Under certain conditions these odors can be detectable in adjacent businesses. However, concentrations of these vapors, as measured on the day of the NIOSH survey, do not constitute a health hazard to the workers and customers at Tina and Angela's Nail Salon or to adjacent businesses. Recommendations to prevent the migration of vapors from the salon to adjacent businesses can be found in Section VII of this report.

KEYWORDS: SIC 7231 (Beauty shops or salons), sculptured nails, artificial nails, ventilation, methyl methacrylates, ethyl methacrylates, acetone, benzene

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II. Introduction

On January 31, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Springdale, Ohio Health Department to evaluate exposures to chemicals used during the application of artificial sculptured nails. The request stated that another business in the same building had complained of a "terrible odor" emanating from the nail salon. In response to the request, NIOSH investigators conducted site visits on February 11, 1992, February 24, 1992, and April 14, 1992. No health effects were noted on the request.

III. Process Description

One or two nail manicurists work in Tina and Angela's Nail Salon at any given time, and approximately five to twelve sets of nails may be completed on a typical day. A full set of nails may take up to an hour or more to complete. In many cases, the customer may only request a polishing and "touch-up," or repair of one or two nails. These procedures take considerably less time.

Before a sculptured nail can be applied, old color coats are removed and the natural nail surface is filed to create a rougher surface for better adhesion of the new nail. The natural nail surface is then sanitized with isopropanol, and an acrylic primer is applied, which also promotes better adhesion.

A removable form is then attached to the fingernail, over which the sculptured nail is formed. The nail is formed entirely with a small brush applicator, which is dipped first into a liquid monomer, then dipped into a powder polymer containing a peroxide accelerator. The nail technician then forms the nail into the general shape before curing (hardening) takes place.

Further refined shaping takes place after curing by filing. The nail is strengthened with thin fiberglass fabric. Cuticle oil is usually applied, and the nail is buffed. A base coat of primer is applied, followed by one or two color coats and a clear protective coat.

The nail manicurist sits on one side of a small table opposite the customer. Nail sculpturing is performed approximately 1 to 2 feet below the sculptor's breathing zone. During this time, both the manicurist and customer are exposed to any organic vapors and methacrylate dust generated from filing. The manicurist keeps the containers of nail liquid (about 30 ml) covered as much as possible.

Tina and Angela's Nail salon is located in a single story brick building along with several other businesses. It is heated by a baseboard heating system located along one of the walls. An air conditioner has been installed in the south wall of the salon (it does not have an outside air intake). The salon does not have a mechanical ventilation system, and the windows in the salon can not be opened. Fire walls reportedly separate the nail salon from other businesses (there was no common ceiling plenum).

The salon uses an Environmental Air System® recirculating floor unit to "filter" vapors in the air (it was not known when the carbon bed had last been changed). The flow rate through the unit was unknown.

IV. Industrial Hygiene Investigation

A. *Bulk Sample Collection*

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Bulk samples of Alpha 9® liquid, NSI Nail® liquid, Alpha 9 Laser Bond Resin®, and NSI powder® were collected on February 24, 1992. These bulk samples were analyzed qualitatively by gas chromatography/mass spectrometry (GC/MS). This analytical technique allows many components of chemical mixtures to be individually identified. The liquid bulk samples were analyzed directly without any sample preparation. The bulk powder was extracted with carbon disulfide, which was then analyzed. All analyses were performed using a 30 meter DB-1 capillary column. The Material Safety Data Sheets (MSDS) were also available.

B. *Air Sampling Methodology*

Although Tina and Angela's Nail Salon employees and customers had not complained of health problems, they agreed to cooperate with the investigation by allowing NIOSH investigators to collect personal and area samples while nail sculpturing was performed. Some of the occupants of adjacent businesses reported detecting transient nail salon odors. Air sampling was not conducted in the adjacent businesses, because no nail salon odors were noted during our visit (one business was closed, so the level of odor there could not be determined).

Air sampling for methyl and ethyl methacrylate was performed according to the NIOSH method 2537.¹ The methacrylate air samples were collected with XAD-2 solid sorbent tubes (SKC #226-30-06) using low flow Gilian air sampling pumps at flow rates of 20 to 100 milliliters per minute (ml/min). Following sampling, the sorbent tubes were stored on dry ice until analysis. In the laboratory, the samples were desorbed in 1.0 milliliter (ml) carbon disulfide (contained 1.0 microliter benzene as an internal standard) and analyzed in a gas chromatograph using a flame ionization detector (FID).

One full-shift personal sample was collected from the only nail manicurist working on the day of the NIOSH visit (there were five customers over the course of the day). Additionally, one full-shift area sample and eight short-term area samples were collected on the table where the nail sculpturing was performed. The area samples were located as close as possible (12 to 20 inches) to the work of the manicurist.

Air sampling for acetone and benzene was performed according to NIOSH method 1300 with modifications.¹ Two full-shift area samples were collected near the table where the nail sculpturing was conducted. The samples were collected on coconut charcoal tubes (SKC #226-01) at a flow rate of 100 ml/min using low flow Gilian air pumps. The samples were desorbed in 1.0 ml carbon disulfide (contained 1.0 microliter n-hexane as an internal standard) and analyzed in a gas chromatograph using a FID.

V. Evaluation Criteria

The primary sources of environmental evaluation criteria for the workplace are the following: 1) NIOSH Recommended Exposure Limits (RELs), 2) the Occupational Safety and Health (OSHA) Permissible Exposure Limits (PELs), and 3) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs).^{2,3,4} The OSHA standards may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH RELs, by contrast, are based primarily on concerns relating to the prevention of occupational disease.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a

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substance over the course of a normal 8- to 10-hour workday. Some substances have a short-term exposure limit (STEL) or ceiling (C) values where there are recognized toxic effects from high short-term exposures. Environmental evaluation criteria are intended to protect workers continually exposed up to 40 hours/week for a working lifetime without experiencing adverse health effects.

Not all workers will be protected from adverse effects even if their exposures are maintained below the evaluation criterion. A small fraction may experience health effects as a result of individual susceptibility, a medical condition, or hypersensitivity (allergy). In addition, some substances may act in combination with other workplace exposures to produce health effects, even if the occupational exposures are controlled to a limit set by the evaluation criteria. Some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Inadvertent oral ingestion can occur occasionally. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available. In evaluating the exposure levels and the recommendations found in this report, it should be noted that industry is legally required to meet those limits specified by an OSHA PEL.

A. *Methacrylates*

Although methyl methacrylate was banned by the U.S. Food and Drug Administration (FDA) in 1974 for use in all nail products, there are still many nail products that contain this chemical.^{5,6,7,8} Methyl methacrylate was banned because it caused severe irritation (including dystrophy of the nails) and allergic contact dermatitis in both manicurists and customers. Many manufacturers of artificial nail products have substituted ethyl or n-butyl methacrylate as the main component.⁹ However, these methacrylates have also been associated with allergic contact dermatitis.¹⁰

Overexposure to methyl methacrylate vapor may cause irritation of the nose, throat, and eyes. The exposure limit was established to prevent complaints of eye and upper respiratory tract irritation, which have been noted at concentrations of 170 - 250 ppm.¹¹ High concentrations may cause central nervous system depression and unconsciousness.¹² Contact with the skin can cause dermatitis. Headaches and pain in the extremities have been reported from exposure to the vapor. In addition, handlers of methyl methacrylate-containing cement have developed parathesias in the fingers. The NIOSH REL for methyl methacrylate is 100 ppm as a TWA up to 10 hours per day.² The OSHA PEL and ACGIH TLV for methyl methacrylate vapor is 100 ppm as an 8-hour TWA.^{3,4}

There are no occupational criteria for ethyl methacrylate. However, there is evidence that ethyl methacrylate is toxicologically similar to methyl methacrylate.^{9,13} *Patty's Industrial Hygiene and Toxicology* suggests that industrial hygiene recommendations for methyl methacrylate can also be applied to the ethyl homologue.¹⁴ Both methyl and ethyl methacrylate are highly flammable. The odor threshold for methyl methacrylate is approximately 0.2 ppm.¹⁵

B. *Acetone*

Exposure to acetone can cause irritation of the eyes, nose, and throat. Repeated skin contact can cause dermatitis. At high concentrations, acetone can cause narcosis and central nervous system (CNS) depression. Acetone is highly flammable and volatile.^{11,16}

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The NIOSH REL for acetone is 250 ppm as a TWA up to 10 hours per day.² The OSHA final rule limits and ACGIH TLV are 750 ppm as an 8-hour TWA, and 1000 ppm as a STEL.^{3,4} The odor threshold for acetone is approximately 2 ppm.

C. *Benzene*

In rats, chronic inhalation or oral administration of benzene produced cancers of the liver, mouth and Zymbal gland. Subchronic inhalation of benzene by rats produced decreased white blood cell counts and decreased bone marrow cell activity. In humans, chronic exposure to benzene has produced irreversible injury to the blood-forming organs;¹² case reports and epidemiologic studies indicate a leukemogenic effect in humans.¹⁷ Acute exposures to higher concentrations of benzene can cause irritation of the mucous membranes and CNS effects.¹¹

NIOSH considers benzene a potential occupational carcinogen. The NIOSH REL for benzene is 0.1 ppm as an 8-hour TWA with a 1 ppm ceiling.² The ACGIH considers benzene a "suspected human carcinogen" and has established a TLV of 10 ppm as an 8-hour TWA (no STEL); however, it has proposed changing the designation to "confirmed human carcinogen" and lowering the TLV to 0.1 ppm. The OSHA PEL is 1 ppm as an 8-hour TWA with a 5 ppm STEL.^{3,4}

D. *Ventilation*

The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) has published recommended building ventilation design criteria for different types of commercial facilities, including beauty shops. ASHRAE Standard 62-1989, "Ventilation for Acceptable Indoor Air Quality,"¹⁸ recommends outdoor air supply rates of 25 cubic feet per minute per person (cfm/person) for beauty shops. ASHRAE also recommends controlling emission sources. Due to the volatility of the chemicals used in a salon, the nail operation would probably be a significant emission source.

VI. Results and Discussion

A. *Bulk Samples*

The major component of the bulk samples (NSI® and Alpha-9® nail liquids) was ethyl methacrylate; a dimethyl toluidine isomer and traces (less than 0.5%) of methyl methacrylate were also detected.

The Alpha-9® Laser Bond Resin consisted primarily of methacrylic acid. Small amounts of an unknown aromatic nitrogen compound and octabenzene were also detected.

According to the Material Safety Data Sheet (MSDS), the NSI nail powder contains methyl and ethyl methacrylate polymer, benzoyl peroxide, and titanium dioxide. The carbon disulfide extract of the powder, analyzed by GC/MS, indicated numerous compounds, with ethyl methacrylate as a major component. Other substances which were analyzed included benzene, methyl methacrylate, benzoic acid, biphenyl, various unidentified aliphatic esters, diethyl phthalate, benzenethiol, diphenyl sulfide, and phenyl benzoate. The presence of benzene is likely an artifact produced during the GC/MS analysis. This was confirmed by air samples which were analyzed for benzene (see discussion below).

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B. *Ethyl and methyl methacrylate*

All air samples for methyl methacrylate vapor were non-detected. The limit of detection (LOD) and limit of quantitation (LOQ) were 0.02 and 0.065 mg/sample, respectively. Based on the volume of air sampled, this equates to a LOD ranging from approximately 0.8 to 3.6 ppm methyl methacrylate.

For ethyl methacrylate, the full-shift personal sample and five of the nine area samples were below the LOD (see Table 1). Three area samples were between the LOD and the limit of quantitation (LOQ), and only one area sample was above the LOQ at a concentration of 7 ppm ethyl methacrylate.

C. *Acetone*

The two area air samples had low levels of acetone (10 and 6 ppm). These concentrations of acetone were well below all of the evaluation criteria (250 ppm TWA - NIOSH, 750 ppm - ACGIH and OSHA). The LOD and LOQ for acetone were 0.01 and 0.033 mg/sample, respectively.

D. *Benzene*

No benzene vapor was detected on the two area samples. The LOD and LOQ were 0.001 and 0.0033 mg/sample, respectively. Based on the volume of air sampled, this equates to a LOD of approximately 0.01 ppm.

VII. Recommendations

Many of the chemicals (methacrylates, acetone) used in nail sculpturing emit vapors which have very low odor thresholds. It is no wonder that adjacent businesses may detect the odor on occasion. However, these vapors, as measured on the day of the NIOSH survey, do not constitute a health hazard to the workers or customers at Tina and Angela's Nail Salon or to adjacent businesses. The most likely potential hazard is contact dermatitis from skin exposure to methacrylates and other chemicals used in the salon.

The following recommendations are offered to reduce the potential spread of odors from the nail salon and provide a more pleasant working environment in the salon.

1. Tina and Angela's Nail Salon should consider installing a mechanical ventilation system that provides 25 cfm/person outside air, as recommended by ASHRAE. The total quantity of outside air should be based on the maximum number of customers and employees expected in the salon at any given time.
2. To control odor complaints from customers and occupants of adjacent businesses, Tina and Angela's Nail Salon could consider installing a properly designed exhaust ventilation system (perhaps a downdraft system). An exhaust ventilation system would also maintain a slight negative pressure in the salon relative to adjacent areas to prevent the spread of the odor. NIOSH can provide further guidance if such a system is being considered.

The Environmental Air Systems® recirculating floor unit used to "filter" vapors is not likely to be very effective because of the low air flow rate through the unit. Furthermore, the unit may not remove vapors effectively unless the charcoal bed is changed on a regular basis.

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3. The walls (up to the roof) separating the nail salon from adjacent businesses should be inspected and any gaps should be repaired to reduce the migration of odors.
4. Eating and drinking in the nail salon should not be permitted since unintentional contact of methacrylate-containing nail liquids on the lips or face could cause allergic contact dermatitis. Smoking should not be permitted because many of the chemicals used in the nail salon are very flammable.

VIII. References

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1. Tina and Angela's Nail Salon
2. Springdale Health Department
3. Occupational Safety and Health Administration, Region V
4. NIOSH Region IV

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1
 Air Sampling Results for Ethyl Methacrylate
 Tina and Angela's Nail Salon
 Springdale, Ohio
 April 14, 1992
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| Sample Type | Sample No. | Flow Rate (ml/min) | Sample Time (minutes) | Concentration (ppm) |
|-------------------|------------|-----------------------|--------------------------|------------------------|
| Personal | M1 | 20 | 321 | ND (LOD = 1) |
| Area (Cust. #1) | M2 | 50 | 46 | [4] |
| Area | M3 | 100 | 46 | 7 |
| Area (Cust. #2) | M7 | 50 | 44 | ND (LOD = 4) |
| Area | M8 | 100 | 44 | [2] |
| Area (Cust. #3,4) | M9 | 50 | 62 | ND (LOD = 2) |
| Area | M10 | 100 | 62 | [1] |
| Area (Cust. #5) | M11 | 50 | 27 | ND (LOD = 5) |
| Area | M12 | 100 | 27 | ND (LOD = 2) |
| Area | M4 | 20 | 317 | ND (LOD = 1) |

The area samples were collected as close as possible to the manicurist (12 to 20 inches away from the work).

ND = non-detected

LOD = limit of detection

Values in brackets indicate quantities between the LOD and LOQ. These values should be interpreted with caution, because of unknown accuracy and precision of the analytical method at these low concentrations.

Limit of Detection (LOD) = 0.03 mg/sample

Limit of Quantitation (LOQ) = 0.072 mg/sample