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Ethyl methacrylate and methyl methacrylate exposure among fingernail sculptors

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Ethyl Methacrylate and Methyl Methacrylate Exposure among Fingernail Sculptors

by

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Dedication

This thesis is dedicated to my parents, Phillip and Marianne Marty, with love. You have always believed in me, pushed me to succeed, and supported me in all my scholastic endeavors and I truly thank you both.

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ABSTRACT

Fingernail sculptors may be exposed to ethyl methacrylate and methyl methacrylate in their workplace. The literature suggests that these chemicals may cause sensitization in individuals who are exposed to sufficient quantities. Cases of occupational asthma and allergic contact dermatitis have been reported among persons who work with these chemicals. Little personal exposure data exists on nail technicians' exposures to these chemicals, especially ethyl methacrylate. The literature suggests that the industrial hygiene practices used for methyl methacrylate also be applied to ethyl methacrylate since more is known about methyl methacrylate. Previous exposure studies have revealed relatively low exposures to these chemical. There are no U.S. occupational exposure limits for ethyl methacrylate.

The objectives of this study were to measure nail sculptors' exposure to ethyl methacrylate and/or methyl methacrylate vapors in their personal breathing zone, describe the interior lay-out of the nail salon in relation to where the chemical vapors were generated, and quantify the volume of air supplied by the HVAC. This study was designed to further characterize and quantify nail technicians' exposures to ethyl methacrylate and methyl methacrylate.

Two nail salons were identified as study sites. A total of five fingernail sculptors volunteered to participate. Personal sampling pumps and activated charcoal media were used to collect organic vapors in the personal breathing zones of the participants. The samples were collected for an entire work shift and analyzed by gas chromatography with dual flame ionization detection, per a modified OSHA 7 Protocol.

The 8-hour time weighted averages ranged from < 1 – 31 parts per million of ethyl methacrylate and <1 – 5.2 parts per million methyl methacrylate. These levels were similar to those already reported in the literature. These levels were below any U.S. occupational exposure level in place or suggested. Local exhaust ventilation appeared to make a difference, as did natural ventilation. The results of this study strongly suggested that methyl methacrylate was used at one salon despite a ban on its use in nail products.

INTRODUCTION

Nail technicians may be exposed to the chemicals ethyl methacrylate (EMA) and/or methyl methacrylate (MMA) during the application of acrylic liquid used in the sculpting of artificial nails. Acrylates are a class of chemicals that include methacrylates, both EMA and MMA (Bisesi, 2001). The various acrylate monomers generally exist in a liquid form. These monomers can undergo polymerization to form products that range from hard, solid plastics to emulsion polymers (Bisesi, 2001). Methacrylates are used in surgical organ repair, contact eye lenses, surgical and dental cement, artificial nail products, and for other applications (Bisesi, 2001). Nail technicians' exposures to EMA and/or MMA may lead to the development of skin and respiratory disorders (Thorne, 2001). These disorders may lead to decreased quality of life and may even be life threatening. Unfortunately, little information exists on nail technicians' personal exposure to these chemicals and even less information exists on the prevalence of the disorders associated with chronic exposure. This study was designed to further characterize and quantify nail technicians' exposure to EMA and MMA.

Two nail salons were selected based on convenience. Volunteer nail technicians were equipped with air sampling media to measure the amounts of EMA and/or MMA in their personal breathing zone (PBZ). A task analysis of each nail technician's work activity was performed. The nail salon's dimensions and lay-out, including positions of the manicure tables, any windows and exits, and the heating, ventilating, and air

conditioning system's (HVAC) diffusers and returns were measured and drawn. The salon's HVAC system was also assessed to determine the air flow within the salon. This information will add substantially to the limited information that exists on this topic.

Chronic exposures to EMA and MMA can lead to serious health problems. Little personal exposure data exists on nail technicians' exposures to these chemicals. Because previous studies have not included some of the objectives contained in this study, this research was unique. The research did have its limitations. The study design only provided a snapshot of the data collected on one day. The information captured only applied to the conditions encountered on the day the exposure assessment was performed. It may not apply to other nail salons and it may not predict other nail technicians' exposures. However, the research design did provide needed information on nail technicians' exposures to EMA and MMA and under what conditions these exposures occurred. This study therefore provided a valuable source of information that furthers the previous research on this topic.

Purpose

The purpose of this research was to quantify nail technicians' exposures to EMA and MMA vapors and characterize the conditions under which these exposures occurred. Specifically, the objectives of this research were:

1. To quantify and describe nail technicians' exposures to EMA and MMA vapors;
   a. The concentration of EMA and/or MMA vapors breathed by nail technicians was determined.
   b. The number of clients seen on the day of sampling was determined.
   c. The duration of the nail technicians' work shift was determined.
   d. The percentage of the time spent working with the liquid methacrylate was determined.

2. To describe the interior lay-out of the nail salon in relation to where the chemical vapors were generated;
   a. The interior dimensions of the nail salons were measured and the interior volumes were determined.
   b. The locations of the manicure tables were determined in relation to windows, exits, and heating, ventilating, and air conditioning (HVAC) diffusers and returns.

3. To quantify the volume of air supplied by the nail salons' HVAC system;
   a. The number of air changes per hour was determined.
   b. The HVAC system was qualitatively assessed for evidence of fresh air introduction.

LITERATURE REVIEW

MMA,$C_5H_8O_2$, has a molecular weight of 100.13, a boiling point of 101 C, a relative vapor density (Air = 1) of 3.45, and a vapor pressure of 40 mm Hg at 25˚ C (Bisesi, 2001). MMA has an odor threshold of less than 0.4 parts per million (ppm) (ACGIH, 2001) and is immediately dangerous to life and health (IDLH) at a concentration of 1000 ppm and above (NIOSH, 2005). The odor threshold and IDLH for EMA were not available. EMA, $C_6H_{10}O_2$, has a molecular weight of 114.14, a boiling point of 117˚ C, a relative vapor density (Air = 1) of 3.94 (Bisesi, 2001), and a vapor pressure of 21 mm Hg at 20˚ C (Haz Map, 2007).

EMA, on the molecular level, has only one CH_2 group more than the MMA molecule. Because the EMA molecule is slightly heavier, the chemical has an increased boiling point, vapor density, and a decreased vapor pressure. Both chemicals are monomers and rapidly polymerize (Bisesi, 2001).

Nail technicians working in nail salons may be exposed to EMA and/or MMA monomers during the application of acrylic liquid for the sculpting of artificial nails. Exposure may result from physical contact between the chemical and the skin or through inhalation of the chemical vapors. Persons exposed to these chemicals may develop irritation at the site of exposure. Persons exposed to these chemicals may also develop an immune mediated response in the organs exposed resulting in organ sensitization (Thorne, 2001). Sufficient skin contact may cause dermal sensitization resulting in a

condition known as allergic contact dermatitis (Thorne, 2001). Sufficient inhalation of the vapors may cause an immune mediated asthmatic response known as occupational asthma (Thorne, 2001). The signs associated with these conditions usually subside when the exposure is removed (Thorne, 2001). These conditions can be serious since sensitized individuals may have reactions to even the most minute amounts of these chemicals (Thorne, 2001).

Prior to 1975, MMA was used as the primary monomer in the liquid acrylic (Jackson, 1999). The Food and Drug Administration subsequently banned MMA for use in nail products due to reports of several cases of severe allergic contact dermatitis associated with its use (Fisher and Baran, 1991). Some literature suggests MMA may still be used due to its relatively inexpensive price, $20-$60/gallon compared to EMA at approximately $200/gallon, as well as a lack of regulatory oversight (Jones, 2003).

Toxicology

EMA and MMA can cause health problems when persons are exposed to sufficient amounts of these chemicals. The main routes of exposure are by direct skin contact and through inhalation of the chemical's vapors (Bisesi, 2001). Both chemicals are irritating to the skin, eyes, and mucus membranes (Bisesi, 2001). Both can cause allergic contact dermatitis (Bisesi, 2001; Kanerva *et al*, 1992; Kanerva *et al*, 1997, Van Der Walle *et al*, 1982; Condé-Salazar *et al*, 1986; Condé-Salazar *et al*, 1988) and persons sensitized to one acrylate may show cross-sensitization to other acrylates (Fisher, 1980). Cases of occupational asthma have been associated with exposure to MMA vapors (Lozewicz *et al*, 1985; Pickering *et al*, 1986; Marez *et al*, 1993; Piirila *et al*, 1998; Jedrychowski,

1982); some cases have also been associated with EMA exposure (Spencer *et al*, 1997; NIOSH, 1999; Estill *et al*, 2000). The National Institutes of Health lists both chemicals as respiratory sensitizers (Haz-Map, 2004). The literature surrounding the allergic potential of MMA and EMA is controversial, as highlighted in "The sensitization potential of methyl methacrylate and ethyl methacrylate (Jackson, 1999)", "Hazards of ethyl methacrylate (Estill *et al*, 2000)", "Response (Jackson, 2000)", and the "Amended final report on the safety assessment of ethyl methacrylate (Cosmetic Ingredient Review, 2002)", although it seems more so for EMA. These issues are discussed further.

Health Effects Associated with Exposure

The literature suggests that both EMA and MMA are dermal sensitizers; although the extent to which has been debated. Allergic contact dermatitis (ACD) is a condition that results from repeated exposures to certain chemicals (Mathias, 1994). ACD is characterized by inflammation and redness of the skin that frequently is seen in areas distal from the initial site of exposure (Mathias, 1994). The development of ACD is preceded by repeated exposures that immunologically sensitize the worker (Mathias, 1994). The actual condition does not manifest itself until after the individual is sensitized. Once sensitized, the worker may show symptoms of ACD to very low levels of the offending chemical hours to days after the exposure (Mathias, 1994). Symptoms may decrease with cessation of the exposure; however, in certain individuals symptoms may persist for longer periods of time (Mathias, 1994).

Several studies have documented dermal sensitization to these chemicals in an occupational setting (See Table 1). Ten years of patch testing with (meth)acrylates

(Kenerva *et al*, 1997) revealed that between 6.5 % - 8.2 % of persons patch tested with 2 % MMA reacted positively and between 4.8 % - 10.1 % of persons patch tested with 2 % EMA reacted positively. Condé-Salazar *et al* (1986) reported that a 17-year-old woman who had been working with artificial nails developed dermatitis after 3 months. She was subsequently patch tested with a variety of compounds including EMA and MMA monomers. Both concentrations of the compounds were 10 % in petroleum. EMA yielded a "+" result after 48 hours and a "+" result after 96 hours. MMA yielded a "+" result after 48 hours and a "++" result after 96 hours; however, it was unclear what a "+" or "++" result meant in this report. ACD has also been reported among car mechanics and car assembly workers who worked with acrylic sealants (Condé-Salazar *et al*, 1988). Patch tests of six workers revealed dermal sensitivity to EMA and MMA, 83 % of cases and 50 % of cases respectively. Kanerva *et al* (1992) also reported ACD in an orthodontist. Patch testing with 2 % EMA and 2 % MMA resulted in abundant redness and swelling on the six day reading. The sensitizing potential of EMA and MMA has also been examined in a guinea pig model using the guinea pig maximization test (GPMT). In that report, Van Der Walle *et al* (1982) reported that approximately 20 % - 30 % of guinea pigs tested could be sensitized to MMA and approximately 10 % could be sensitized to EMA. Additionally, the documentation for the American Conference of Governmental Hygienists' (ACGIH) Threshold Limit Value (TLV) for MMA also called it a "potent skin sensitizer" (ACGIH, 2001). The evidence clearly shows that both EMA and MMA can cause allergic contact dermatitis.

Table 1: Allergic contact dermatitis studies associated with EMA and MMA exposure

Study	Study description	MMA Concentration	MMA Results	EMA Concentration	EMA Results
Kanerva *et al*, 1997	Patch test of 275 patients with a history of exposure to (meth)acrylates	2% w/w petroleum	7.4 % of 271 tested	2% w/w petroleum	7.4 % of 243 tested
Condé-Salazar *et al*, 1986	Patch test of a nail technician who presented with dermatitis	10% in petroleum	+ after 48 hrs ++ after 96 hrs 20 controls –	10% in petroleum	+ after 48 hrs + after 96 hrs 20 controls –
Condé-Salazar *et al*, 1988	Patch test of 6 patients who presented with dermatitis and also worked with acrylic sealants	10% in petroleum	Patient 1 – Patient 2 – Patient 3 – Patient 4 + Patient 5 ++ Patient 6 ++ 20 controls –	10% in petroleum	Patient 1 – Patient 2 + Patient 3 ++ Patient 4 ++ Patient 5 + Patient 6 ++ 20 controls –
Kanerva *et al*, 1992	Orthodontist suspected of developing occupational pharyngitis. Patch testing revealed dermal sensitivity to EMA and MMA	2% w/w petroleum	3+ 3 indicates abundant redness and swelling	2% w/w petroleum	3+ 3 indicates abundant redness and swelling
Van der Walle *et al*, 1982	Guinea pig sensitization to (meth)acrylates using the guinea pig maximization test (GPMT) and/or the Freund's complete adjuvant test (FCAT)	Varied	GPMT = 20% - 30% of animals sensitized FCAT = 25% of animals sensitized	Varied	GPMT = 10% of animals sensitized FCAT = 33% of animals sensitized

EMA and MMA can cause ACD; however, the degree to which each is a dermal sensitizer has been debated. It has been suggested that part of this debate could originate from how the studies have reported their findings; percentages have been used, descriptors such as weak or potent have been used, and symbols such as "+" have been used. The problems seem to arise when the results are interpreted across the studies. It is difficult to compare a "++" result to a result described as potent. Furthermore, the exposure strategies used in patch tests may not be typical of the exposures encountered in a work setting.

Occupational asthma, sometimes referred to as allergic occupational asthma, is a condition that results because of an increased response of the airways in the lungs to irritants encountered in the work environment (Demeter, 1990). Asthma, in general, costs the American public billions of dollars each year (Sipkoff, 2006). It is estimated that approximately 5 – 25 percent of newly diagnosed asthma cases fall within the occupational asthma definition (Sipkoff, 2006). In workers with occupational asthma, the worker is usually sensitized over a period of time to the offending irritant with no adverse reaction (Demeter and Cordasco, 1994). Once the worker is sensitized, the airway response is triggered through an immune mediated pathway (Demeter and Cordasco, 1994). Occupational asthma is also characterized by decreasing symptoms with time away from the work environment (Demeter and Cordasco, 1994). Workers with occupational asthma must have their exposures reduced since even the smallest exposures can elicit a life threatening asthma attack in which breathing can become very difficult (Sipkoff, 2006).

Several studies have documented occupational asthma associated with exposures to MMA in an occupational setting (See Table 2); however, little information exists on the association between EMA exposure and occupational asthma. Piirilä *et al* (1998) reported respiratory hypersensitivity to acrylates in dental personnel. One patient was inhalation challenge tested with MMA, resulting in a decreased forced expiratory volume (FEV_1) in one second of 6 % and a decreased peak expiratory flow (PEF) of 20 %. Marez *et al* (1993) studied workers exposed to MMA. Pre-shift and post-shift lung function tests were performed. Although post-shift/pre-shift ratios for forced vital capacity (FVC), FEV_1, and FEV_1/FVC were not statistically significant, they did find statistical significance in the post-shift/pre-shift ratios for maximum expiratory flow when 50 % of the FVC remained (MEF_{50}) and the MEF_{50}/MEF ratio, $p = 0.04$ and $p = 0.01$ respectively. In this study, MEF_{50} and MEF_{50}/MEF may have been a more sensitive indicator for obstruction in the smaller airways of the lung (Baum and Wolinsky, 1983). Pickering *et al* (1986) documented occupational asthma in an orthopedic operating theater worker. Inhalation challenge testing with MMA resulted in a 25 % decrease in FEV_1 13 hours after the challenge. Lozewicz *et al* (1985) reported a dental assistant with occupational asthma. Inhalation challenge testing with MMA provoked a similar 24 % reduction in PEF in two challenge tests conducted one week apart. Lung obstruction syndrome, a general condition that includes occupational asthma, has also been reported by Jedrychowski (1982) in workers exposed to styrene and MMA; however, the study did not isolate the effects of either compound. The evidence clearly shows that MMA can cause occupational asthma.

Table 2: Occupational asthma studies associated with MMA exposure

Study	Study description	Study findings
Piirilä *et al*, 1998	Goal of the study was to report respiratory hypersensitivity in dental personnel to acrylates. Flow-volume spirometry, skin-prick, and inhalation challenge tests were performed.	A dental nurse was symptomatic of occupational asthma. Challenge test with liquid MMA reduced Max FEV_1 by 6% and PEF by 20%. Skin-prick test was negative for MMA.
Marez *et al*, 1993	Study of 40 workers exposed to MMA for more than 5 yrs and 45 controls. Questionnaires were administered for sample selection and flow-volume spirometry was measured before and after shift.	No statistically significant findings for before shift observed/predicted spirometric measurements among the exposed group and controls. There was statistical significance in after shift/before shift ratios for MEF_{50} and MEF_{50}/MEF in the exposed group, p=0.04 and p=0.01, respectively.
Pickering *et al*, 1986	A case report of an orthopedic operating theater worker who developed work related asthmatic symptoms. Inhalation challenge tests were performed using water as a control and MMA. Flow-volume spirometry was subsequently performed	Lung function tests were normal when the worker was not working. Lung function tests were normal after inhalation challenge with water. Lung function tests were abnormal starting 6 hrs after inhalation challenge with MMA. FEV_1 was reduced 25% 13 hrs after the challenge.
Lozewicz *et al*, 1985	Case report of a dental assistant who mixed liquid MMA with powdered poly-MMA on a regular basis. Experienced chest tightness, dyspnoea, and cough after working with MMA for several yrs. Underwent two inhalation challenges with MMA one week apart. Lung function tests were performed after each challenge. "No formal control test was made."	First inhalation test provoked a 24% reduction in PEF. Second test provoked similar results. PEF measurements between the two tests showed little variation (<10%) except upon waking in the morning.
Jedrychowski, 1982	Study assessed the prevalence of lung obstruction syndrome in 454 workers exposed to styrene and MMA and 683 controls. Included area air monitoring, interviews on health status, and lung function tests.	Study found the prevalence of lung obstruction was: non-smokers or ex-smokers = 13.6% of controls and 42.4% of exposed current smokers = 21.0% of controls and 46.5% of exposed. Study did not isolate the effects of either compound

Background

Nail technicians and their customers' breathing zones are often within 2 feet of where the liquid acrylic is applied. The liquid is volatile and vapor inhalation is a concern (Sandmeyer and Kirwin, 1981). The application of liquid acrylic usually does not take place in the proximity of local exhaust ventilation. Nail technicians have the potential to be exposed to greater amounts of the chemical when applying several sets of artificial nails throughout the workday and especially when more than one nail set is being applied in the same room. Only the monomer forms of EMA and MMA are a health concern and they quickly react to form polymers (Spencer *et al*, 1997). When industrial hygiene sampling is performed, personal exposures are converted to an eight-hour workday, time weighted average (8-hr TWA) since most occupational exposure limits are based on this average (Klonne, 2003). This calculation takes into account shorter or longer workdays and assumes a 40 hour work week (Klonne, 2003). The National Institute of Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) have established a Recommended Exposure Limit (REL) and a Permissible Exposure Limit (PEL) of 100 ppm 8-hr TWA for MMA, respectively. The American Conference of Government Industrial Hygienists has recommended a Threshold Limit Value of 50 ppm 8-hr TWA; however, no established United States's occupational exposure limits (OELs) exist for EMA (NIOSH, 2005). Patty's Industrial Hygiene and Toxicology, 3rd revised ed., has recommended that the same criteria used to evaluate MMA also be applied to EMA due to their chemical similarity (Sandmeyer and Kirwin, 1981). The Netherlands's government has

recommended an OEL of 10 ppm 8-hr TWA; Sweden and the former Soviet Union have established an OEL of 11 ppm 8-hr TWA for EMA. However, this recommendation does not appear to be based on any human epidemiological evidence as they noted that very limited human data was available (Health Council of the Netherlands, 1994).

Nail technicians may work with MMA or EMA during the application of artificial nails. There are typically three scenarios in which the chemicals are used: during application of a full set of artificial nails, during a fill-in of a previously applied set of nails, or during the repair of a broken artificial nail. The time that the nail technician may work with the chemicals varies according to procedure being done with a full set generally taking the most time and a repair the least.

Related Studies

The literature suggests that available data on EMA toxicology and EMA exposure is limited and controversial (Jackson, 1999). Lowenstein (2006) suggests that a "combination of circumstances contributes to the lack of information on the topic." Roelofs (2006) suggests that small businesses, like nail salons, are not well characterized. This could be because most nail salons have less than ten employees and are not required to maintain OSHA injury and illness records (OSHA, 2000 revised). In a self-report survey, Roelofs (2006) reported that 31% of nail techs reported respiratory irritation, 18% reported breathing difficulty, and 30% reported that these symptoms declined away from work. Roelofs (2006) also reported that 79% of nail techs reported an irritating smell at work.

The goal of this research was to further characterize nail technicians' exposures to EMA and/or MMA vapors via inhalation. Knowing the extent of nail technicians' exposures to EMA and/or MMA was important because there were approximately 43,800 licensed, active nail specialist in the state of Florida alone as of November, 2005 (Board of Cosmetology, 2006). The few studies that have been conducted do not adequately document the inhalation route of exposure in this population of workers (See Table 3). The Spencer *et al* (1997) study evaluated the effectiveness of a modified, ventilated table versus a non-ventilated table. Although these researchers found low levels of EMA, 15 ppm or less TWA, they used students who lack experience and tended to have slower application rates compared to an experienced nail technician. Additionally, the Spencer *et al* (1997) study seemed to indicate that only one nail set was being applied at any one time. Perhaps more than one set could be applied by different nail technicians within the salon at any given time.

Decker and Beasley (1992) performed a NIOSH Health Hazard Evaluation (HHE) at a Springdale, Ohio nail salon. This salon had two employees, only one was working on the day of the HHE, where 5 – 12 nail sets would be completed per day. Although low levels of EMA were detected, only one of ten air samples taken was a personal breathing zone (PBZ) sample; of the area samples, only one was a full day and the other eight were short-term samples.

Almaguer and Blade (1992) performed a NIOSH HHE at a Norman, Oklahoma nail salon. Two employees were employed at this salon; however, the number of clients seen that day was unclear. They found short-term, 14 minutes or less, PBZ samples

approaching 28 ppm; however, only three PBZ samples were taken. Froines and Garabrant (1986) performed PBZ sampling in several nail salons and found nail technicians were being exposed to both EMA and MMA. Both active and passive sampling media were used; however, it was unclear when either was used. The study also lacked details regarding sampling times, number of nail technicians working at the salon, and the number of clients seen.

Hiipakka and Samimi (1987) also found that nail techs were being exposed to low levels of EMA. Interestingly, they had planned to sample on a cold winter day so as to capture the worst-case scenario; however, the weather was spring-like and the salons' windows were open. They (Hiipakka and Samimi, 1987) also noted that "considerable intersalon differences in mean personal organic vapor exposures were found to exist, in that air levels ranged from <0.1 ppm of all vapors to 46.4 ppm for isopropyl alcohol." These differences in isopropyl alcohol concentrations could serve as a surrogate for EMA variability.

The literature also suggests that even low levels of EMA can cause health problems. LoSasso *et al* (2001) concluded that exposure to even low levels of chemicals common in nail salons, including EMA, may result in mild cognitive and neurosensory changes similar to those observed among documented solvent-exposed workers in other settings. Although this study did not isolate EMA as the single cause for these health problems, it highlights the need for further research.

Table 3: Previous studies of nail technicians' exposures to EMA

Study	Study description	PBZ samples taken for EMA	Strengths	Weaknesses	EMA concentration
Spencer *et al*, 1994	The Colorado Department of Health requested NIOSH assist in the evaluation and control of nail technicians' exposures at a cosmetology school. Examined differences in exposures under conditions utilizing a modified manicure table with downdraft ventilation or an unventilated manicure table.	10 short-term w/ unvent table 8 short-term w/ vent table 3 samples > 5 hours w/ unvent table 3 samples > 5 hours w/ vent table	Established the effectiveness of modified ventilated table Included diagram of facility and location of manicure table relative to exhaust fan in wall Active sampling media used	Student nail techs lacked experience and were slower Appeared only one set of nails was being applied at any one time General ventilation and air changes per hour were not measured	Short-term PBZ w/ unvent table = 10.6 ppm GM Short-term PBZ w/ vent table = 0.8 ppm GM PBZ > 5 hours w/ unvent table = 7.0 – 12.8 ppm GM PBZ > 5 hours w/ vent table = 0.4 – 1.5 ppm GM
Hiipakka and Samimi, 1987	In-depth study that measured exposures of nail techs to organic vapors and methacrylate dust. Samples were collected in six different nail salons. Self-administered symptom questionnaires completed by nail techs and controls.	17 samples using active sampling media	Included evaluation of nail techs' symptom prevalence Revealed that regular ventilated tables do not produce enough capture velocity to reduce EMA exposure	Lacked details regarding sampling times, number of nail techs at each salon, and number of clients seen General ventilation and air changes per hour were not measured	4.5 ± 4.6 ppm mean TWA Range <0.1 to 17 ppm
Froines and Garabrant, 1986	Eight nail salons and their employees sampled for MMA, four of which were also sampled for EMA. Both active and passive sampling media were used.	25 mean intermittent samples for MMA 59 mean continuous samples for MMA 15 mean intermittent samples for EMA 32 mean continuous samples for EMA	Captured both EMA and MMA exposure Included direct reading instrumentation for est. continuous methacrylate exposure Appeared all samples taken were PBZ samples	Lacked details regarding sampling times, number of nail techs at each salon, and number of clients seen General ventilation and air changes per hour were not measured Unclear when active or passive sampling media were used	Mean intermittent exposure for MMA = 9.1 – 47.6 ppm Mean continuous exposure for MMA = 2.1 – 6.8 ppm Mean intermittent exposure for EMA = 7.0 – 18.0 ppm Mean continuous exposure for EMA = 2.4 – 9.2 ppm
Almaguer and Blade, 1992	NIOSH conducted a Health Hazard Evaluation (HHE) at the request of a nail salon owner.	3 short term Samples, 14 min or less	Qualitative evaluation of general ventilation Some IEQ parameters measured Active sampling media	Lacked details regarding numbers of clients seen Lacked long-term PBZ samples	7 min sample = 27.4 ppm 14 min sample = 16.9 ppm 37 min sample = 4 ppm* * Portion of sample was lost
Decker and Beasley, 1992	NIOSH conducted a HHE at the request of adjacent business owners who noted a" terrible smell" emanating from salon.	One long-term sample (321 mins) during which five clients were seen	Qualitative evaluation of general ventilation Active sampling media	Lacked long-term PBZ samples	PBZ sample = ND (LOD = 1 ppm) One Area sample = 7 ppm (4.6 L air)

Study Design

This research project was an industrial hygiene study of nail technicians' exposures to ethyl methacrylate and methyl methacrylate. The hypothesis of this research was that nail technicians were exposed to measurable concentrations of one or both of these chemicals; however, the research was not designed to assess the presence of any disease. The design did provide actual concentrations of nail technicians' personal exposures to EMA and MMA on the day of sampling and under what conditions these exposures occurred. This type of design was necessary since little information exists on these types of exposures.

This research project was a pilot study designed to capture nail technicians' exposures on a busy workday. Therefore, the nail salons' nail technicians were sampled on their historically busiest day of the week and arrangements were made to perform the exposure assessment based on appointment schedules and past information.

Two nail salons served as study sites, including an Asian owned salon. Having an Asian owned salon incorporated into the design was important because approximately 37 % of nail salons in the U.S. are Asian owned (EPA, 2006). Nail technicians employed by these sites were asked to volunteer as research subjects. Six to eight volunteers were expected from both sites. Only nail technicians who volunteer participated. Only nail technicians who worked with artificial nails for more than half their shift were considered. A University of South Florida Institutional Review Board (IRB) Application for Initial Review was submitted and IRB requirements were subsequently waived.

This research design had its limitations. The study design only provided a snapshot of the data collected on that day. The information captured only applied to the conditions encountered on the day the exposure assessment was performed. It does not apply to other nail salons and it may not predict other nail technicians' exposures. However, the research design did provide needed information on nail technicians' exposures to ethyl methacrylate and/or methyl methacrylate and under what conditions they occurred. This may provide important information for further assessment and research.

METHODS

Task Analysis

A task analysis of the nail application process was performed at each study site. Each nail technician was observed for at least one entire nail procedure for each type of nail procedure that they performed. These observations were performed to assess the time spent on each task of the artificial nail application process. Each nail technician was also asked to record the numbers of procedures that they performed. These task analyses were necessary for determining the proportion of time spent working with the liquid related to the total time of the procedure.

Salon Lay-Out

The two participating nail salons' interior lay-outs were drawn. The interior dimensions of the salons were measured. Placements of all manicure tables were measured from a wall to the mid-point of the table. All windows, exits, and locations of HVAC vents and return(s) were also measured and recorded. Diagrams of the salons are provided in Figures 1 and 2.

Ventilation Assessment

The nail salon's HVAC system was assessed. An Alnor Balometer (APM 150, Alnor, Skokie, Illinois), an instrument used to quantify air flow, was used to measure the air flows through the HVAC system's vents and returns. These air flow measurements were used to determine the amount of air movement within the nail salon measured in

supply air changes per hour. This measure was important in determining the time it takes to recycle one volume of inside air. The HVAC system was also assessed for evidence of outside air introduction.

Sampling Strategy

Research subjects were equipped with a Buck personal sampling pump (Basic-5, A.P. Buck Inc., Orlando, Florida) and activated coconut shell charcoal sampling media connected via Tygon tubing. The sampling apparatus was pre-calibrated and post-calibrated according to the OSHA protocol of ± 5% (OSHA, 2007). A factory calibrated mini-Buck calibrator (M-5, A.P. Buck Inc., Orlando, Florida) was used for this purpose. Nail technicians' personal breathing zones were continuously sampled at an approximate flow rate of 42 milliliters of air per minute (ml/min). Each personal sample was collected over an approximate four hour period. Two samples per nail technician were collected whenever it was possible. This flow rate and sample time should have yielded a minimum mass of the chemicals that satisfies the minimum detection limit of the analytical method, Wisconsin Occupational Health Laboratory (WOHL) Method WG006 which is based on OSHA Method 7 (See Appendix A). An area sample was collected at an approximate flow rate of 40 ml/min over the entire day in each nail salon in the area where the chemicals are stored. Additionally, an air sample was taken from a partially full liquid monomer bottle supplied by each salon. The sampling media was inserted into the one gallon bottle of the monomer and positioned approximately 3 inches from the surface of the liquid. The air space above the liquid was sampled for 15 minutes at a flow rate of 200 ml/min. These grab vapor samples from the one gallon bottles were

collected to quantify the vapor mixture at high concentrations since the sampling media would be nearly saturated. Appropriate sample blanks were also submitted for analyses. All samples were packed on ice and shipped overnight to the WOHL for analyses.

Sample Analysis

Samples were analyzed according to WOHL Method WG006, which is a modified version of the OSHA Method 7 protocols. The Wisconsin Occupational Health Laboratory developed WG006 to accommodate a variety of organic solvents including EMA and MMA. The method allowed for the sampling and analysis of both chemicals at the same time. The method used SKC Anasorb CSC (catalog # 226-01) activated coconut shell charcoal sampling media with a 20/40 mesh particle size to collect organic vapors which were subsequently desorbed with carbon disulfide and analyzed by gas chromatography with flame ionization detection. The analytes were separated by two different analytical columns, a primary and confirming column, and quantified against valid calibration curves.

WOHL Method WG006 was chosen after careful discussions with the WOHL's organic laboratory supervisor. The WOHL is an AIHA accredited laboratory and recommended this method for a few reasons. First, the WOHL reported that they did not get good recoveries of EMA from XAD-2 media using NIOSH Method 2537; although it works well for MMA. Second, the WOHL uses WG006 (modified OSHA Method 7 protocol) for the analyses of EMA and MMA with good recoveries of the analytes. The WOHL has provided documentation of multiple EMA/MMA spiked quality control samples. See Appendix B for the Desorption/QC Development Spreadsheet. Third,

WOHL Method WG006, OSHA Method 7, and the EMA specific OSHA Method PV2100 are all virtually identical in all other aspects.

RESULTS

Task Analysis

The task analysis was separated into three general steps: nail prep, work with liquid monomer, and fine finish. The nail prep consisted of removing the old nail polish, filing, trimming, and shaping the real nail, gluing the artificial nail extension on to the real nail, trimming the nail extension to an appropriate length, and roughening and priming the surface of the nail. The only difference between a full set and a fill-in was in this step, because a fill-in did not require the artificial extensions. Interestingly, a Dremel-like tool with a variable speed foot control was used in the roughening of the nail. The work with liquid monomer step consisted of the time the nail technician spent forming the artificial nail. The nail technician dipped a small brush into a small container of the liquid monomer, then into a container of powdered polymer, and then applied the mixture to the nail and formed it. During this step, the liquid container remained open the entire time and the smell of the vapors was very noticeable. The openings of the containers were approximately one and quarter inch in diameter. The fine finish step consisted of filing and shaping the artificial nail some more and smoothing the surface of the nail. The Dremel-like tool was also used in the fine finish. For the purpose of this analysis, the fine finish step ended when the costumer was sent to wash the nail dust off their hands, although the nails may have been painted after washing. These procedures were used at both locations.

Nail salon 1 had four nail technicians working on the day of sampling. Three of the four nail technicians, nail tech A, B, and D, worked six or more hours. Nail technician C worked approximately 4 hours and went home early. Nail salon 2 had two employees who worked with artificial nails; however, arrangements were made so that only one of them would perform the majority of artificial nail work on the day of sampling. Therefore, only this nail technician served as a study subject. This nail technician worked approximately nine hours on the day of sampling.

The results of the task analyses for the application of a full set of artificial nails are reported in Table 4. For the purpose of this analysis, a procedure called a back-fill, which is a major fill-in, was grouped in the full set category. This decision was made because the time spent on each task and the amount of the liquid monomer used in a back-fill was similar to a full set of artificial nails. Unfortunately, nail salon 1 performed only four such procedures on the day of sampling and none of them was observed from the beginning. Therefore, only the time spent working with the liquid monomer, 15 minutes, was captured in a task analysis of nail technician B at nail salon 1. Nail salon 2 performed three full set procedures. A task analysis of one procedure revealed that 14 minutes were spent on nail preparation, 10 minutes were spent working with the liquid monomer, and 18 minutes were spent doing the fine finish. The percentage of time spent working with the liquid monomer was 24 % of the total time of the procedure.

Table 4: Task analysis for the application of a full set of artificial nails

Site Location	Nail Technician	Nail Prep (min)	Work with Liquid Monomer (Min)	Fine Finish (Min)	Total Time for Procedure (Min)
Salon 1	B	NR	15	NR	NA
Salon 2	TTM	14	10	18	42

NR = Not recorded
NA = Not Applicable

The results of the task analyses for the fill-in of a previously applied set of artificial nails are reported in Table 5. Nail salon 1 performed 22 such procedures. Nail technicians A, B, and D were observed once from start to finish and once again during the work with the liquid monomer. Therefore, the average of each technician's time spent working with the liquid monomer was used in the overall task analyses. A task analysis of nail technician A revealed that 26 minutes were spent on nail prep, 17.5 minutes were spent working with the liquid monomer, and 17 minutes were spent on the fine finish. The percentage of time spent working with the liquid monomer was 29 % of the total time of the procedure. A task analysis of nail technician B revealed that eight minutes were spent on nail prep, six minutes were spent working with the liquid monomer, and 14 minutes were spent on the fine finish. The percentage of time spent working with the liquid monomer was 21 % of the total time of the procedure. A task analysis of nail technician D revealed that five minutes were spent on nail prep, eleven minutes were spent working with the liquid monomer, and 15 minutes were spent on the fine finish. The percentage of time spent working with the liquid monomer was 35 % of the total time of the procedure.

Table 5: Task analysis for a fill-in of artificial nails

Site Location	Nail Technician	Nail Prep (min)	Work with Liquid Monomer (Min) N=2[†]	Fine Finish (Min)	Total Time for Procedure (Min)
Salon 1	A	26	17.5	17	60.5
	B	8	6	14	28
	D	5	11	15	31
Salon 2	TTM	9	9	23	41

[†]Average of two observations

Nail salon 2 performed at least eight fill-in procedures. Task analyses of nail technician TTM revealed that nine minutes were spent doing nail prep, nine minutes were spent working with the liquid monomer, and 23 minutes were spent on the fine finish. The percentage of time spent working with the liquid monomer was 22 % of the total time of the procedure.

Table 6: Estimate of the total time spent working with the liquid monomer

Nail Technician	Full Set Procedure		Fill-In Procedure		Total time working with liquid (Min)
	# of Events	Estimated time working with liquid/Event (Min)	# of Events	Estimated time working with liquid/Event (Min)	
A	0	0	6	17.5	105
B	2	15	8	6	78
C[†]	1	12.5	2	10.9	34.3
D[‡]	1	12.5	6	11	78.5
TTM	3	10	8	9	102

[†]Time spent working with liquid monomer for both procedures estimated from averages of A - D and TTM

[‡]Time spent working with liquid monomer for full set estimated from averages of B and TTM

An estimate of each nail technician's time spent working with the liquid monomer was calculated, see Table 6. The calculations were based on the sum of total numbers of each procedure times the estimated amount of time spent working with the liquid monomer for that procedure, respectively. Since nail technician C was not observed during either procedure, the time spent working with the liquid monomer was estimated from the averages of nail technicians A, B, D, and TTM for each procedure, respectively. Since nail technician D was not observed for a full set procedure, the time spent working with the liquid monomer for this procedure was estimated from the averages of B and TTM since they were the only nail technicians who were actually observed performing this procedure. Nail technician A spent an estimated 105 minutes working with the liquid monomer during the sampling periods. Nail technician B spent an estimated 78 minutes working with the liquid monomer during the sampling periods. Nail technician C spent

an estimated 34.3 minutes working with the liquid monomer during the sampling period. Nail technician D spent an estimated 78.5 minutes working with the liquid monomer during the sampling periods. Nail technician TTM spent an estimated 102 minutes working with the liquid monomer during the sampling periods.

The work practices of the nail technicians varied considerably. At nail salon 1, it was common for the nail technicians to eat and drink at their manicure tables whereas this practice was not observed at salon 2. None of the salon 1 nail technicians used latex gloves to guard against direct chemical contact with the skin; however, the salon 2 nail technicians did. At both sites, nail debris was observed flying while clipping the nails and using the Dremel-like tool and air-borne dust was generated during the filing process. At nail salon 1, nail technician B used proper protective eye wear while nail technician A relied on corrective lenses; nail technicians C and D did not use eye protection. Nail technicians A and D did use dust masks; however, the masks did not appear to be very tight fitting. The salon 2 nail technicians did use dust masks and appeared to use them correctly; however, they did not wear protective eyewear.

Salon Lay-Out

Figure 1 shows the detailed interior lay-out of nail salon 1. This salon was 23 feet wide, 36.8 feet long, and 7.9 feet high, and the internal volume of the salon was 6686.6 cubic feet. This salon had one air handler. Five supply diffusers and one return were noted. No evidence of outside air introduction into the HVAC system was observed. The salon had one window located in the bathroom, which does not appear in the drawing, and one door. Four manicure tables were used for the purpose of applying

artificial nails. On the day of sampling, all four tables were used, labeled A, B, C, and D. Manicure tables A and B had local exhaust ventilation. Each nail technician worked at their respectively labeled manicure table.

Figure 2 shows the interior lay-out of nail salon 2. This salon was 31.6 feet wide, 34.7 feet long, and 8.3 feet high, and the internal volume of the salon was 9101.1 cubic feet. The salon's owner stated that this salon had two separate air handlers. Ten supply diffusers and three returns were noted. No evidence of outside air introduction into the HVAC system was observed. This salon had one window located in the back corner and one door. Three manicure tables were used for applying artificial nails, and none of these tables had local exhaust ventilation. On the day of sampling, only two of the tables were used, labeled M and MN. Nail technician TTM worked at the tables labeled M interchangeably. The table labeled N represents the location of area sample TTN.

Figure 1: Interior lay-out of nail salon 1 (Not to Scale)

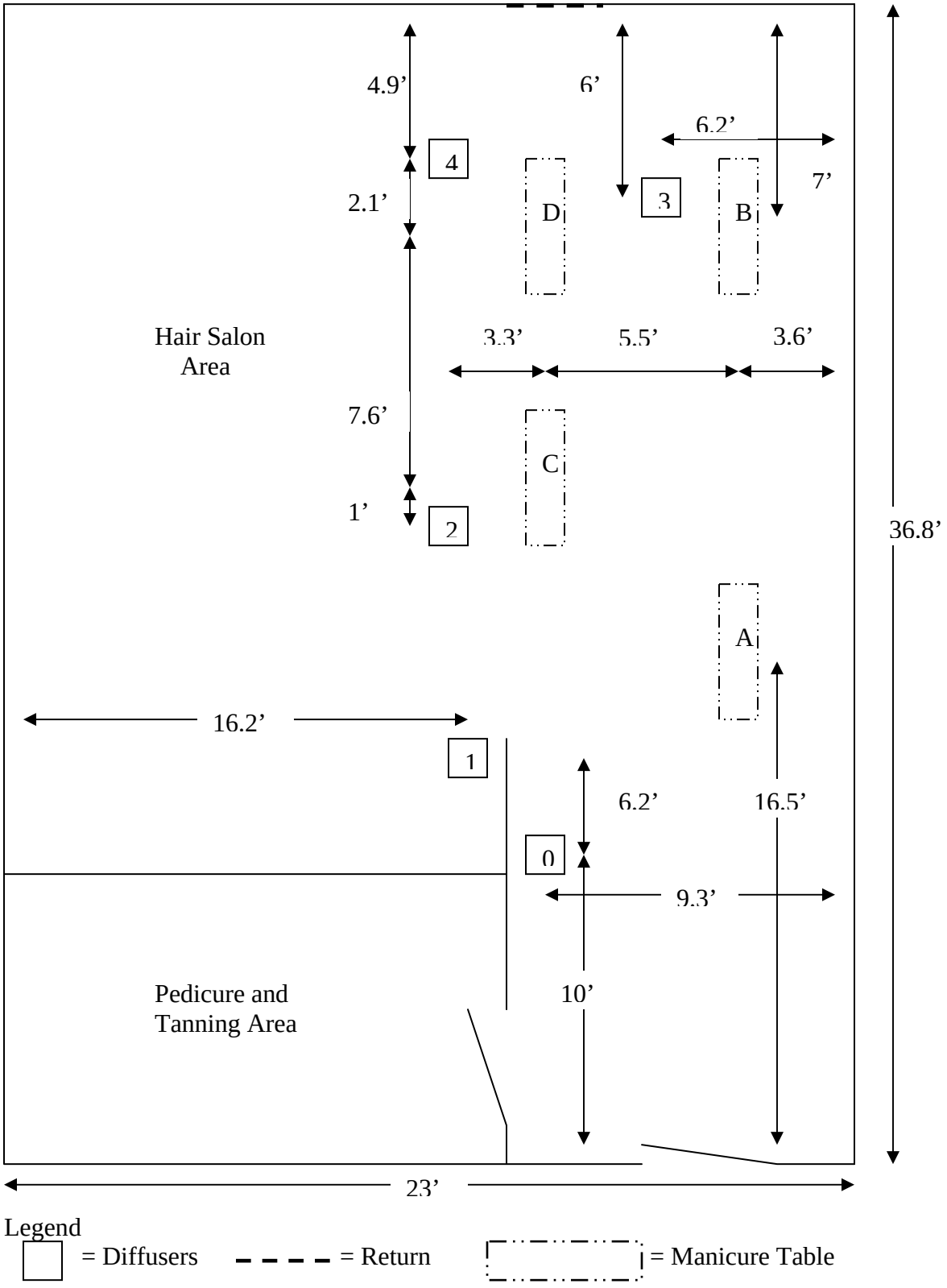
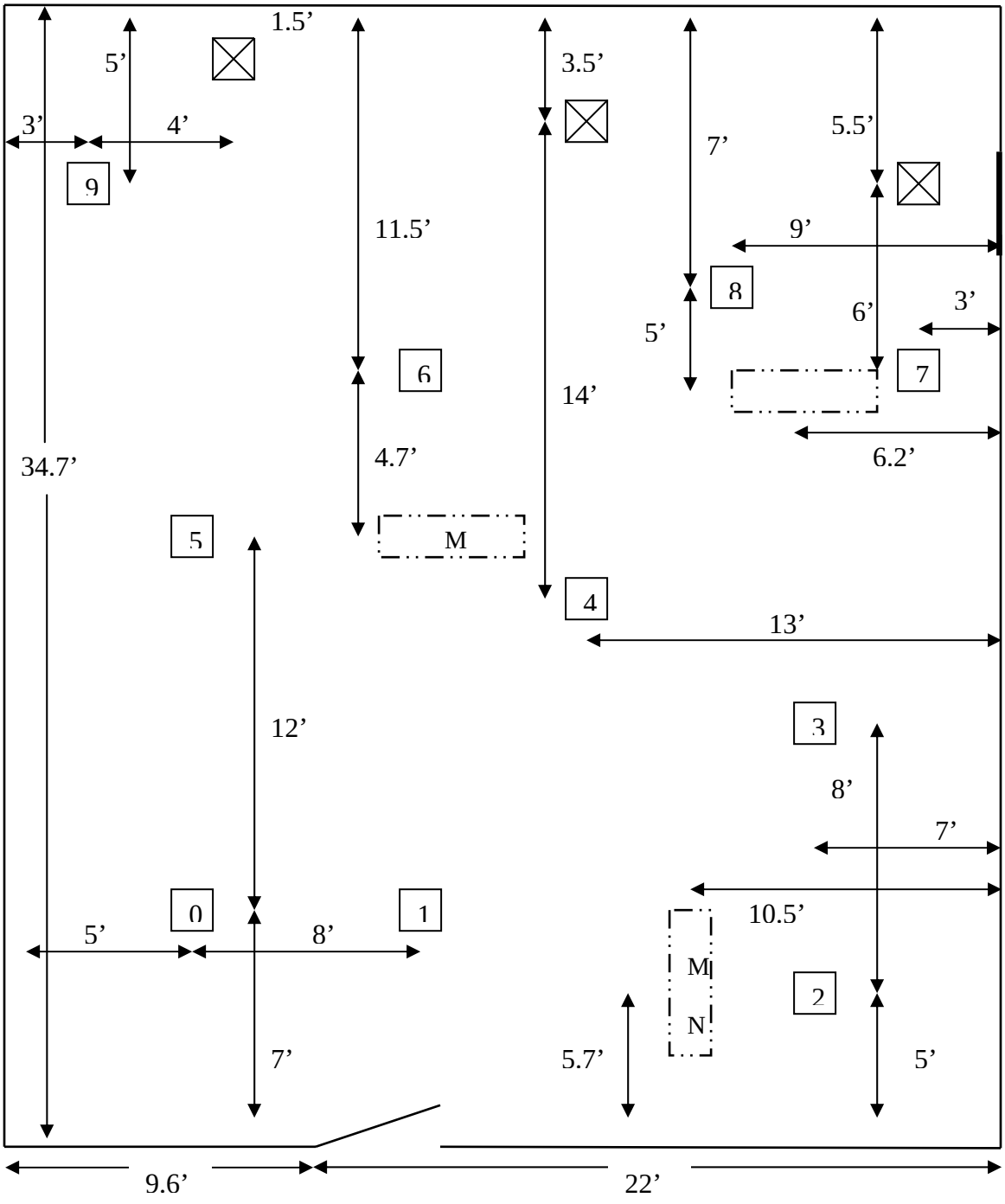


Figure 2: Interior lay-out of nail salon 2 (Not to Scale)



Legend

= Diffusers = Returns = Manicure Table

= Window

Ventilation Assessment

The HVAC systems were evaluated for the total volume of air supplied and total air returned to the units. The air flows were measured in cubic feet per minute and taken with the doors and windows open and with them closed. This evaluation took place one week prior to the exposure assessment which was necessary to minimize the inconveniences imposed had this evaluation taken place on the day of the exposure assessment. Nail salon 1 operated their HVAC system with the doors and window closed on the day of sampling. Table 7 shows the different air volumes measured through the individual supply diffusers and the return, as well as the total supply volume. Based on the internal volume of the salon and the total volume of the air supplied by the HVAC, the calculated supplied air changes per hour (ACH) were six ACH with the door and the window closed. Nail salon 2 did not operate their HVAC systems but instead opened the window and the door to provide natural ventilation. Details regarding the air volumes and the supply ACH of both salons with the doors and windows open and with them closed are included in Appendix C.

Table 7: Ventilation assessment for nail salon 1

Diffuser #	Air flow with door/window closed* (cfm)
0	120
1	137
2	137
3	178
4	92
Total Supply (cfm)	664
Total Return Volume(cfm)	713

*One door and one window

Analytical Results

Personal and area sampling were performed at nail salon 1 on Friday, February 2, 2007. The temperature and relative humidity inside this nail salon were 20.2 ° C and 60.5 %, respectively. Personal and area sampling were performed at nail salon 2 on Saturday, February 3, 2007. The temperature and relative humidity inside this nail salon were 23.4 ° C and 52.9 %, respectively. These two days were reported to be their busiest days of the week based on past information from the salons' owners.

Detectable levels of both EMA and MMA were measured in both nail salons. Information regarding personal sample designation, sample times, sample volumes, and calibration information appears in Table 8 and Appendix D. A summary of the personal sample results and 8-hour time weighted averages (TWA) appears in Table 9. The 8-hour TWA was calculated under the conservative assumption that the exposure during the unsampled time was similar to the sampled time.

Table 8: Summary of personal sample and calibration information

Location	Nail Technician	Sample Designation	Sample Time (min)	Sample Volume (Liters)	Percent Difference Pre and Post Pump Calibrations
Salon 1	A	A1	190	7.670	4.0%
		A2	198	7.478	6.7%
	B	B1	275	11.477	1.3%
		B2	258	10.780	1.5%
	C	C1	206	8.721	5.5%
	D	D1	309	12.952	2.5%
		D2	74	3.136	4.2%
Salon 2	TTM	TTM1	244	10.703	0.5%
		TTM2	217	9.508	0.7%

Table 9: Summary of personal exposures to MMA and EMA

		First Sample Period			Second Sample Period			8 - Hour TWA	
Site Location	Personal Sample	MMA (ppm)	EMA (ppm)	Time (Min)	MMA (ppm)	EMA (ppm)	Time (Min)	MMA (ppm)	EMA (ppm)
Salon 1	A	0.13	6.40	190	0.17	10.00	198	0.15	8.24
	B	0.15	8.60	275	0.15	9.90	285	0.15	9.26
	C	0.70	31.00	206	NA	NA	NA	0.70	31.00
	D	0.24	13.00	309	0.18	11.00	74	0.23	12.61
Salon 2	TTM	2.90	0.036†	244	7.7	0.041†	217	5.16	0.04†
	TTN*	2.60	0.033†	291	5.3	0.044†	218	3.76	0.04†

* Indicates an area sample taken in the vicinity of the personal breathing zone
†Less than or equal to. The analyte was detected but at a level too low to accurately quantify.

One area sample was set up in the vicinity of the chemical storage area of nail salon 1. In this case it was a small room, not shown on the salon diagram, where towels were also washed. The door to this room remained open during the sample period. The

sample period lasted from 12:13 PM until 7:38 PM for a total sample time of 445 minutes at a flow rate of 39.9 ml/min. This area sample, sample E1, yielded a concentration of 7.5 ppm for EMA and 0.14 for MMA. Analysis of a three liter sample of the vapors from the liquid monomer bottle supplied by this salon yielded a concentration of 5300 ppm of EMA and 100 ppm of MMA (see Sampling Strategy). However, these values should be considered approximate values since the EMA concentration was above the upper calibration standard of the analytical method and both samples contained analytes on the back-up section of the charcoal tube. A sample blank submitted with the nail salon 1 samples was reported below the detection limits for both chemicals. No air was sampled through this sample blank. A copy of the WOHL Analytical Laboratory Report for the nail salon 1 samples appears in Appendix E.

An area sample was attached to the light of manicure table MN at nail salon 2. This area sample was positioned directly over the work space and approximately one and a half feet from nail technician TTM's face. Two area samples were collected at this table. The first area sample, sample TTN1, was collected from 9:30 AM until 2:21 PM for a total time of 291 minutes at a flow rate of 40.1 ml/min. Sample TTN1 yielded a concentration of 2.6 ppm of MMA and approximately 0.03 ppm of EMA. The later value was only approximate because the analyte was detected but at a level too low to be accurately quantified. The second area sample, sample TTN2, was taken from 2:30 PM until 6:08 PM for a total time of 218 minutes at a flow rate of 39.8 ml/min. Sample TTN2 yielded a concentration of 5.3 ppm of MMA and approximately 0.04 ppm of EMA. The later value was considered approximate for the same reason as described

above. The TWA for these area samples, based on the time sampled, were 3.8 ppm MMA and approximately 0.04 ppm EMA.

One area sample was set up in the vicinity of the chemical storage area of nail salon 2. In this case it was a room, not shown on the salon diagram, that also contained a refrigerator and a bed. The door to this room remained closed during the sample period. The sample period lasted from 10:19 AM until 6:17 PM for a total sample time of 478 minutes at a flow rate of 39.5 ml/min. This area sample, sample TTP1, yielded a concentration of 1.1 for MMA and 0.03 ppm for EMA. Analysis of a three liter sample of the vapors from the liquid monomer bottle supplied by this salon yielded a concentration of 5400 ppm of MMA and 4.1 ppm of EMA (see Sampling Strategy). These values should be considered approximate values since the MMA concentration was above the upper calibration standard of the analytical method and both samples contained analytes on the back-up section of the charcoal tube. A sample blank submitted with the nail salon 2 samples was reported below the detection limits for both chemicals. No air was sampled through this sample blank. A copy of the WOHL Analytical Laboratory Report for the nail salon 2 samples also appears in Appendix E.

DISCUSSION AND CONCLUSIONS

The purpose of this study was to characterize nail technicians' exposures to ethyl methacrylate (EMA) and methyl methacrylate (MMA). The literature was reviewed for information regarding occupational exposure to these chemicals, the associated health effects, and more specifically, for information on nail technicians' exposure to these chemicals. This review indicated that allergic contact dermatitis and occupational asthma may be associated with chronic exposure to these chemicals. The review also indicated that nail technicians' exposures to these chemicals have not been well characterized.

This study sought to quantitatively evaluate nail technicians' personal exposure to EMA and/or MMA vapors and describe the conditions under which the exposures occurred. The breathing zones of nail technicians were sampled over the course of a workday. Additionally, a task analysis was performed to determine the total number of clients seen by each nail technician, the time spent with one client, the percentage of time spent working with the liquid monomer, and the approximate time each nail technician spent working with the liquid monomer during the sampling periods. The interiors of two different nail salons were described in detail in relation to where the artificial nail processes took place. The HVAC systems were assessed to determine the number of supply air changes per hour that could have been provided on the day of sampling with the doors and windows open and then closed. This study captured personal exposures to both chemicals and was successful in determining how and under what conditions these

exposures occurred. This information was necessary for a complete understanding of the personal exposures.

Discussion

The analytical results reported in this study appear consistent with what other studies have reported. One aspect that made this study unique was the fact that the majority of samples collected were personal. Another important aspect of this study was the completeness of the exposure assessment. Also, this study attempted to use an Asian owned nail salon and was successful in doing so. This was important because a large number of nail salons in the U.S. are Asian owned.

Detectable levels of EMA and MMA were found in air samples of nail technicians' personal breathing zones taken at the nail salon 1 site. Nail technicians at this site were mainly exposed to EMA. Personal exposures ranged from 8.2 – 31.0 ppm EMA as an 8-hour TWA. A number of variables, such as the time spent with a client, the time spent working with the liquid monomer, presence of local exhaust ventilation, and proximity to HVAC diffusers, likely contributed to the differences in personal exposures seen between nail technicians. Nail technician A was the owner of this nail salon and her total time spent performing a fill-in procedure was about twice the time that the other two nail technicians, who were task analyzed, spent on this same procedure. She conversed extensively with her clients because she likely had developed a rapport with them over time. At the same time, her workers may have worked faster so as to make more money. Interestingly, although the total time spent on this procedure was quite different, the percentage of time spent working with the liquid monomer was similar between nail

technicians at this site, approximately one-quarter to one-third of the total time of the procedure. In fact, the percentage of time working with the liquid was similar between both procedures and both sites.

It was noted in the results section that manicure tables A and B at this salon were equipped with local exhaust ventilation. This ventilation was not assessed for its effectiveness; however, both were operational. Nail technician A worked closely over the local exhaust and nail debris and dust were observed being captured. Nail technician B however did not work as closely over the local exhaust with little debris observed being picked up by the exhaust system. Initially, it was expected that there would be a larger difference between nail technician A and B's personal exposures, 8.2 ppm and 9.3 ppm, respectively. This initial expectation was based not only on the behavior of nail debris and nail dust entering the local exhaust but also on the fact that extensive nail dust was collected on nail technician B's sampling tube holder bypass. This was not observed on nail technician A's tube holder. There did, however, seem to be a difference in these individuals' exposures when compared to nail technicians C and D, who did not have local exhaust provisions. Nail technician C had an 8-hour TWA, based on an approximate three and a half hour sample time, of 31 ppm of EMA and nail technician D had a 12.6 ppm 8-hour TWA for EMA. It may be possible that the local exhaust ventilation played a role in reducing nail technician A and B's exposure.

Nail technician C at the salon 1 site who had an EMA exposure of 31 ppm had her sample collected over a period of 206 minutes. She performed only one full set and two fill-in procedures; yet her exposure was almost three times higher than the next highest

personal exposure at this salon. It may be possible that this measured exposure was in fact their personal exposure from their job; however, work practices that were not observed could have likely played a role in this higher exposure. Another possible explanation for this result was that the personal sample was tampered with, but no evidence of this was observed.

Detectable levels of EMA and MMA were measured at nail salon 2. Personal air sampling of one nail technician and an area sample set up in the vicinity of his personal breathing zone indicated that MMA was the main chemical exposure at this nail salon. Nail technician TTM's 8-hour TWA indicated a personal exposure to 5.2 ppm MMA and the area samples, TTN1 and TTN2, yielded a TWA concentration of 3.8 ppm MMA. The area sample was likely lower because the nail technician did not work solely at that particular manicure table. The results from the grab vapor sample and the personal and area samples clearly suggested that MMA was being used in this nail salon despite the FDA's ban on its use in nail products. This result was particularly surprising since the bottle that the grab vapor sample was taken from was labeled "No MMA."

Nail salon 1 operated its HVAC unit during the exposure assessment and the door and window were closed. This was not the case at nail salon 2. The door and window were open and the HVAC system was not used. A strong cross-draft through the salon was noted throughout the day. Nail salon 2 had lower personal exposures to MMA compared to the levels of EMA found at nail salon 1. It is possible that natural ventilation played a role in lowering the concentrations of airborne chemicals at nail salon 2, especially since MMA has a higher vapor pressure and more chemical vapors

should have been generated. Hiipakka and Samimi (1987) also suggested that natural ventilation could help reduce airborne chemical exposures in nail technicians.

The HVAC systems were evaluated at both sites; however, this information was only relevant to nail salon 1 where the HVAC was in operation. Both evaluations are included in Appendix C. Nail salon 1's HVAC provided six supply air changes per hour (ACH) with the door and window closed. There are no recommended air change rates provided by Burton for nail salons or beauty shops (Burton, 1995). If the light factory operations category for typical air change rates is applied to salon operations, six supply ACH seemed like a reasonable amount and possibly within the lower ranges of the recommendation (Burton, 1995). The American Society of Heating, Refrigerating, and Air-Conditioning Engineers recommends 25 cubic feet per minute of outside air per person be introduced into a beauty shop (ASHRAE, 2001). It was not clear if this recommendation was met. It was initially thought that diffuser locations and the air flows through them might influence the exposure; however, it was impossible to deduce how that interaction might have occurred.

The exposures that occurred at nail salon 1 may more closely resemble nail technicians' personal exposures in the Tampa Bay area. Most of the year it is hot and humid here and it is likely that most small businesses, like nail salons, would keep their doors and windows closed and operate their HVAC systems to keep the indoor environment comfortable. It is also likely that most nail salons would be using EMA since MMA has been banned for nail use. Although personal exposures to these chemicals are highly variable, it is likely that personal exposures would be low. The

United States does not have any Occupational Exposure Limits (OELs) for EMA. If the Occupational Safety and Health Administration's Permissible Exposure Level for MMA, which is 100 ppm for an 8-hour TWA, is applied to EMA, the exposures obtained in this study are much less than half of this value. If the American Conference of Governmental Industrial Hygienist's Threshold Limit Value for MMA, which is 50 ppm for an 8-hour TWA, is also applied to EMA, only nail technician B's exposure would have exceeded the action level, which is one-half the TLV. Interestingly though, some of the exposures obtained from nail salon 1 would have exceeded the OELs that some other nations, such as the Netherlands, Sweden, and the former Soviet Union, have recommended or established.

The nail technicians at salon 1 were not observed using gloves to protect against chemical contact with the skin. It was therefore likely some chemical contact with the skin could have occurred; although, this was not actually observed. Because direct skin contact has been associated with the development of allergic contact dermatitis (ACD), the possibility of these workers developing ACD exists. NIOSH does not recommend the use of latex gloves for this application because of the potential for chemical permeation; however, the recommended gloves made of polyvinyl alcohol or laminates of plastic films would probably not be appropriate due to the limitations in dexterity that these materials would impose (NIOSH, 2005).

Conclusion

Detectable levels of ethyl methacrylate and methyl methacrylate were both measured at two Tampa Bay area nail salons. Personal exposures ranged <1 – 31 ppm of EMA and

<1 – 5.2 ppm MMA. These levels were below any U.S. occupational exposure level in place or suggested. Local exhaust ventilation seemed to make a difference in reducing personal exposure levels. The type of general ventilation, whether HVAC use or natural, used in the salon also seemed to make a difference in exposure levels. Natural ventilation seemed to dilute the concentrations of airborne chemicals in the salon by the introduction of outside air.

The analytical results strongly suggested that MMA was being used at nail salon 2. A manufacture's bottle of liquid monomer stated that it contained "NO MMA." The possibility therefore exists that MMA substitution is occurring in some nail salons despite a ban on its use.

Task analyses of the different nail procedures resulted in considerable differences in the time it took different nail technicians to perform a procedure; however, the percentage of time spent working with the liquid monomer was similar between nail technicians and nail procedures. The time spent working with the liquid monomer varied between 20 – 35 % of the total procedure.

Recommendations for Future Research

Based on the findings from this study, the following recommendations for future research are provided. These include:

- Expand the study and select a more representative sample of nail salons in the community to better characterize personal exposure levels of EMA and/or MMA in the Tampa Bay area.

- Expand the time frame to include more personal monitoring of nail technicians at the same sites on different days.
- Conduct a cross-sectional epidemiological study that uses surveys designed to measure current health problems and personal sampling to assess the exposure.
- Conduct a prospective epidemiological study, with physiological measures, to determine what, if any, long-term health effects occur to chronic, low level exposures to EMA and MMA.
- Conduct inhalation challenge testing, coupled with spirometry and other physiological measures, of volunteer nail technicians to assess the extent of airway reactivity in this population of workers.
- Sample all nail salons in the city to determine the frequency of use of MMA.

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APPENDICES

Appendix A: OSHA Method 7

Organic Vapors (See section 4)

lethod no.:	07
latrix:	Air
)SHA PELs:	Section 4
rocedure:	Collection on charcoal, extraction with an organic solvent, and analysis by gas chromatography with flame ionization detector.
:ecommended air volume nd sample rate:	Section 4
:tatus of method:	This method has been used extensively in the OSHA Salt Lake Technical Center. With slight modification, this method is a generalized version of validated NIOSH methodology.

)ate: May 1979
ast Update: May 2000

By: Organic Methods Evaluation Branch
By: Methods Development Team

Methods Development Team
Industrial Hygiene Chemistry Division
OSHA Salt Lake Technical Center
Salt Lake City, UT 84115-1802

.. General Discussion

1.1 Background

Background information on the analytes may be obtained from a number of sources such as NIOSH Criteria Documents, chemical dictionaries and industrial hygiene manuals. Solvents are used for degreasing, for dry cleaning, and in the manufacture of many materials ranging from paints, varnishes, shellacs, and lacquers to rubber and synthetic resins. When not being used as solvents, they may function as fuels or act as chemical intermediates with or without regard to their ability to put materials into solution. Toxic effects of the analytes vary with many acting as irritants or causing narcosis, and some having more hazardous effects.

1.2 Statistical parameters

1.2.1 Each analyte included in this general procedure has a validated NIOSH method, (Ref. 5.1) and/or a validated OSHA method. One of the NIOSH validation requirements is that the

results obtained be within ±25% of the true values at the 95% confidence level at the air concentration equal to the OSHA standard. Although the OSHA evaluation procedure differs from that of NIOSH, the same validation requirements are used.

1.2.2 Refer to the validated NIOSH methods, (Ref. 5.1) for detailed information on individual analytes.

1.3 Advantages

1.3.1 The sampling device is small, portable, and involves no liquids.

1.3.2 The analysis is by a quick instrumental method.

1.3.3 Interferences can be eliminated by altering chromatographic conditions in most cases.

1.3.4 The method allows simultaneous analysis of two or more analytes.

1.4 Disadvantages

1.4.1 The air volume sampled is limited by the capacity of the charcoal tubes. Exceeding the capacity of the charcoal tube results in loss of sample. The adsorptive capacity is decreased by high humidity.

1.4.2 The method is limited by the reproducibility of the pressure drop across the tubes. The pressure drop affects the flow rate causing the air volume to be imprecise.

1.4.3 The analyst must work with toxic solvents.

1.4.4 When many components are present, elimination of interferences becomes difficult.

:. Sampling Procedure

2.1 Apparatus

2.1.1 A calibrated personal sampling pump whose flow can be determined within ±5% at the recommended flow rate with the sampling device attached.

2.1.2 Charcoal tubes: Glass tubes with both ends flame sealed, 7 cm long with a 6-mm o.d. and 4-mm i.d., containing two sections of 20/40 mesh activated charcoal separated by a 2-mm portion of urethane foam. The activated charcoal is prepared from coconut shells and is fired at 600°C prior to packing. The adsorbing section contains 100 mg of charcoal, the backup section 50 mg. A3-mm portion of urethane foam is placed between the outlet end of the tube and the backup section. A plug of silylated glass wool is placed in front of the absorbing section. The pressure drop across the tube must be less than 1 in. of mercury at a flow rate of 1 L/min.

2.1.3 Certain analytes require petroleum base charcoal instead of coconut base charcoal. This requirement is specified in Section 4.

2.2 Reagents

None required in sampling procedure.

2.3 Technique

2.3.1 Immediately before sampling, break the ends of the tube to provide an opening at least

one-half the internal diameter of the tube (2 mm).

2.3.2 The smaller section of charcoal is used as a backup and should be positioned nearest the sampling pump.

2.3.3 The charcoal tube should be placed vertically during sampling to minimize channeling.

2.3.4 Air being sampled should not be passed through any hose or tubing before entering the charcoal tube.

2.3.5 Do not exceed the recommended air volume.

2.3.6 The charcoal tubes should be capped with the supplied plastic caps immediately after sampling. Under no circumstances should rubber caps be used.

2.3.7 One tube should be handled in the same manner as the sample tube (break, seal and transport) except that no air is sampled through this tube. This tube should be labeled as a blank.

2.3.8 Capped charcoal tubes should be wrapped end to end with official OSHA seals. They should be packed tightly and padded before they are shipped to minimize tube breakage during shipping.

2.3.9 For certain analytes where migration on the charcoal is a significant problem, it may be requested that two charcoal tubes be used in series in order that breakthrough may be distinguished from migration. These tubes must be separated and individually capped and sealed before shipping.

2.4 Breakthrough

Breakthrough data is presented on each analyte in its respective validated NIOSH method (Ref. 5.1).

2.5 Extraction efficiency

2.5.1 The back end of a charcoal tube is opened and the backup portion of activated charcoal is removed, leaving the front 100-mg portion of activated charcoal intact in the tube. The activated charcoal must be of the same lot as that in the tubes used to collect the samples. A known amount of analyte is injected directly into the activated charcoal with a microliter syringe and the tube is capped.

2.5.2 Six tubes at each of three concentration levels (0.5, 1, and 2 times the standard) are prepared by adding an amount of analyte equivalent to that present in a recommended air sample at the selected level. The tubes are allowed to stand at least overnight to assure complete adsorption of the analyte onto the charcoal. These tubes are referred to as the samples. A parallel blank tube should be treated in the same manner except that no analyte is added to it. The sample and blank tubes are extracted and analyzed in exactly the same manner as the sampling tube described in Section 3.

2.5.3 The extraction efficiency (E_E) equals the average weight in milligrams recovered from the tube divided by the weight in milligrams added to the tube, or

$$E_E = \frac{M_R}{M_S}$$

where: E_E is extraction efficiency

M_R is mass recovered

M_S is mass spiked

2.5.4 If there is a significant change in extraction efficiency over the range of loadings studied, a plotted curve of E_E versus mass recovered must be used to correct for adsorption losses.

2.5.5 If there is no significant change in E_E over the range studied, reconfirmations need only be carried out at one loading in the middle of the range.

2.6 Recommended air volume and sample rate

See Section 4. for recommended air volume and sampling rate.

2.7 Interferences

2.7.1 It is important to be aware of other components in the atmosphere which may interfere with the collection of the analyte.

2.7.2 High relative humidity may significantly affect the collection of some analytes.

2.8 Safety precautions

2.8.1 Care must be taken when opening the sealed ends of charcoal tubes to avoid cuts to the hands.

2.8.2 Safety glasses should be worn when opening the sealed ends of charcoal tubes to avoid injury to the eyes from glass splinters.

. Analytical procedure

3.1 Apparatus

3.1.1 Gas chromatograph equipped with flame ionization detector.

3.1.2 Columns. A variety of columns are suitable. Two good selections are a 60-m × 0.32 mm DB-1 capillary column with 1m df or a 60-m × 0.32 mm DB-Wax capillary column with 1 µm df. Similar columns from other manufactures are acceptable.

3.1.3 A suitable method of measuring peak areas, such as an electronic integrator or data system.

3.1.4 Two-milliliter vials with either screw-on or crimp-on caps which contain PTFE-lined septa.

3.1.5 Microliter syringes; one-microliter for GC injections and 10-µL for standard preparation, or other suitable sizes.

3.1.6 Pipets for dispensing extracting solvent (ES). A Glenco 1-mL reagent dispenser is adequate and convenient.

3.1.7 Volumetric Flasks. Five-milliliter and other convenient sizes.

3.1.8 Glass tubing cutter.

3.2 Reagents

3.2.1 Chromatographic quality extracting solvent (ES). Although carbon disulfide is commonly used as the ES, certain analytes can be more effectively extracted with the use of alternate solvents or solvent solutions. These alternate ESs are listed in Chemical Sampling Information located at http://www.osha.gov and are normally used when the single analyte is requested or when the requested analytes are known to be effectively extracted with that ES. When analysis for a number of analytes requiring different extracting solutions is requested, the preferred ES will usually be carbon disulfide.

3.2.2 Analyte standard, reagent grade.

3.2.3 Internal standard, (optional) reagent grade. *p*-Cymene and *n*-hexylbenzene are suitable internal standards for many solvents.

3.2.4 Chromatographic quality helium, nitrogen, hydrogen, and air.

3.3 Standard preparation

3.3.1 Prepare analyte standard at a concentration of 1 µL of analyte per milliliter of ES by adding 5 µL of analyte to a 5-mL volumetric flask partially filled with ES. Fill the volumetric flask to the mark and invert 3 or 4 times for proper mixing. Other size volumetric flasks may also be used to prepare the 1 µL/mL analyte standards. At least two standards at 1 µL/mL are prepared. Standards must be used the day they are prepared. In some cases, analyte standards in concentrations other than 1 µL/mL may be more suitable, especially with analytes that have extremely high or low OSHA standards.

3.3.2 Injection of standards is accomplished with a 1-µL or other suitable syringe. The syringe is rinsed thoroughly in carbon disulfide between standards. Injector septa should be checked for wear daily.

3.3.3 Injection sizes other than 1-µL and injection by means of a gas chromatograph autosampler are acceptable in most cases.

3.4 Preparation of samples

3.4.1 The status of the seals on each charcoal tube is noted and recorded as intact, broken, or none.

3.4.2 The field identification number, the laboratory identification number and signature of the industrial hygienist on each sample seal are checked with those on the sample identification sheets.

3.4.3 The seal is removed and the charcoal tube is opened with a glass tubing cutter at the end containing the larger portion of charcoal. The front and back sections of charcoal are transferred to separate 2-mL capped vials. The glass wool plug and the small wad of urethane foam separating the two sections of charcoal are discarded.

3.4.4 The charcoal lot number is noted in order that the proper extraction efficiency is used in later calculations.

3.4.5 Gas chromatography parameters are set as recommended in the instruments manual. Oven temperature and column are varied until an optimum chromatogram is produced by the analyte standard.

3.4.6 Once the internal standard has been verified as not interfering with other peaks in the chromatogram, the samples are extracted. One milliliter of ES is dispensed into each sample

vial. The vial is immediately sealed. Each vial is swirled periodically to increase the rate of extraction. Twenty to thirty minutes is typical for the extraction process.

3.5 Analysis

3.5.1 The data processor can be calibrated to provide results directly in units of mass. With a few of the analytes an additional similar correction may be necessary due to extraction efficiencies that change with concentration. The linear nature of the flame ionization detector allows the use of a point calibration, but the bracketing of samples with analytical standards is a good practice. The calculation of the equivalent air concentration for an analytical standard is detailed in Section 3.7.1.

3.5.2 Sample injection is accomplished with a 1-µL or other suitable syringe. The syringe is rinsed thoroughly in carbon disulfide between samples. Injector septa should be checked for wear periodically. Injection by means of a gas chromatograph autosampler is acceptable.

3.5.3 Bracket the samples with analytical standards if detected concentrations are above the PEL.

3.5.4 When the identity of a suspected analyte peak is in question, it should be confirmed by GC/MS, GC/IR, or by retention time on at least two GC columns containing different packing material. The identity of the analyte should be considered suspect when detected concentrations are above the PEL.

3.6 Interferences

Interferences to the analytical method will in most cases appear as poor resolution of the analyte peak from other components. This may be overcome by prudent selection of a more suitable chromatographic condition or column.

3.7 Calculations

3.7.1 An equivalent air concentration for analytical standards is used to calibrate the data processor such that analytical results are obtained directly in mass, mg.

$$W = V_S \times d$$

where: W is weight of analyte in µg
V_S is volume of analyte in µL
d is density of analyte in µg/µL

$$C_V = \frac{V_M W}{M_r V E_E}$$

where: C_V is air concentration reported to IH
V_M is molar volume at 25°C and 760 mmHg, 24.46 L/mol
W is weight of analyte
M_r is molecular weight of the analyte
V is air volume sampled
E_E is extraction efficiency

3.7.2 The following example is the calculation for toluene:

$$W = 867\ \mu g = 1\ \mu L \times 867\ \mu g/\mu L$$

$$C_V = 23.73\ ppm = \frac{(24.46\ L/mol)(867\ \mu g)}{(92.15\ g/mol)(10\ L)(0.97)}$$

The calculations should be considered an example only, and various parameters confirmed before used in actual analysis.

3.8 Safety precautions

3.8.1 Care must be taken when opening charcoal tubes to avoid cuts to the hands.

3.8.2 Safety glasses must be worn throughout the analytical procedure.

3.8.3 Work involving solvents open to the atmosphere must be performed in a hood.

3.9 Reporting results

3.9.1 When results uncorrected for air volume are greater than 10 ppm, three significant digits will be reported. For results below 10 ppm, the chemist will use his judgment, but in no cases report more than three significant digits.

3.9.2 The estimated detection limit based on the lowest mass per sample injected as a standard.

3.9.3 All concentration levels down to the detection limit are reported.

3.9.4 If the concentration of analyte found on the back section of the charcoal tube is equal to or greater than 25% of the concentration found on the front section, the charcoal tube is considered to be saturated and reported as such on the analyst worksheet.

3.9.5 The presence of significant peaks caused by unrequested components in the sample is noted on the analyst worksheet and they are identified and quantitated if possible.

3.9.6 All data processor print-outs and chart recorder chromatograms are filed in a central file according to laboratory sample identification number.

3.9.7 Analytical data and results are checked by a fellow chemist before the completed analyst worksheets are given to the team leader.

i. Analytes

'he following table contains those analytes which can be analyzed by this procedure. Standard size charcoal tubes :ontaining coconut base charcoal are used unless specified otherwise in the table. Listed PELs are 8-h time weighted iverages unless denoted as a ceiling concentration with a "(C)", before the PEL value. Before taking samples, the)SHA Chemical Sampling Information at http://www.osha.gov should be consulted for additional and more detailed nformation.

Table 4.
Recommended Sampli ng Parameters for Analytes Covered by This Procedure.

ANALYTE	PEL (ppm)	air vol (L)	max rate (L/min)	NIOSH Method
Allyl alcohol	2	10	0.2	1402
Allyl chloride	1	48	0.2	1000
n-Amyl acetate	100	10	0.2	1450
sec-Amyl acetate	125	10	0.2	1450
Benzyl chloride	1	10	0.2	1003
Bromoform	0.5	10	0.2	1003
Butyl acetate	150	10	0.2	1450
sec-Butyl acetate	200	10	0.2	1450
tert-Butyl acetate	200	10	0.2	1450
Butyl alcohol	100	10	0.2	1401
sec-Butyl alcohol	150	10	0.2	1401
tert-Butyl alcohol	100	10	0.2	1400
n-Butyl glycidyl ether (BGE)	50	10	0.2	1616
p-tert-Butyltoluene	10	24	0.2	1501
Camphor	2 mg/m^3	24	0.2	1301
Carbon tetrachloride	10	15	0.2	1003
Chlorobenzene (monochlorobenzene)	75	10	0.2	1003
Chlorobromomethane	200	5	0.2	1003
Cumene	50	10	0.2	1501
Cyclohexane	300	5	0.2	1500
Cyclohexanol	50	10	0.2	1402
Cyclohexene	300	5	0.2	1500
Diacetone alcohol (4-hydroxy-4-methyl-2-pentanone)	50	10	0.2	1402
o-Dichlorobenzene	(C)50	3	0.2	1003
p-Dichlorobenzene	75		0.05	1003
1,1-Dichloroethane	100	10	0.2	
1,2-Dichloroethylene	200	3	0.2	1003
Dichloroethyl ether	(C)15	15	1.0	1004
1,1-Dichloro-1-nitroethane**	(C)10	15	1.0	1601
Difluorodibromomethane(F-12-B2)*	100	10	0.2	1012
Diisobutyl ketone	50	10	0.2	1300
Dioxane (diethylene dioxide)	100	10	0.2	1602
Epichlorohydrin	5	20	0.2	1010
Ethyl acetate	400	6	0.2	1457

Ethyl sec-amyl ketone (5-methyl-3-heptanone)	25	25	0.2	1301
Ethyl bromide	200	4	0.2	1011
Ethyl butyl ketone (3-heptanone)	50	25	0.2	1301
Ethylene chlorohydrin**	5	35	0.2	2513
Ethyl ether	400	3	0.2	1610
Ethyl formate	100	10	0.2	1452
Glycidol (2,3-epoxy-1-propanol)	50	50	1.0	1608
n-Heptane	500	4	0.2	1500
Hexachloroethane	1	10	0.2	1003
n-Hexane	500	4	0.2	1500
2-Hexanone (MBK)	100	10	0.2	1300
sec-Hexyl acetate	50	10	0.2	1450
Isoamyl acetate	100	10	0.2	1450
Isoamyl alcohol	100	10	0.2	1402
Isobutyl acetate	150	10	0.2	1450
Isobutyl alcohol	100	10	0.2	1401
Isophorone**	25	12	0.2	2508
Isopropyl acetate	250	8	0.2	1454
Isopropyl ether	500	3	0.05	1618
Isopropyl glycidyl ether	50	10	0.2	1620
Mesityl oxide	25	25	0.2	1301
Methyl acetate	200	7	0.2	1458
Methylal (dimethoxymethane)	1000	2	0.2	1611
Methyl-(n-amyl)ketone	100	25	0.2	1301
Methylcyclohexane	500	4	0.2	1500
Methyl isobutyl carbinol	25	10	0.2	1402
α-Methyl styrene	(C)100	3	0.2	1501
Octane	500	4	0.1	1500
Pentane	1000	2	0.05	1500
2-Pentanone	200	10	0.05	1300
Phenyl glycidyl ether	10	50	0.1	1619
n-Propyl acetate	200	10	0.2	1450
Propyl alcohol	200	10	0.2	1401
Propylene dichloride	75	10	0.2	1013
n-Propyl nitrate**	25	70	0.1	S227
1,1,1,2-Tetrachloro-2, 2-difluoroethane	500	2	0.035	1016
1,1,2, 2-Tetrachloro-1, 2-difluoroethane	500	2	0.035	1016
1,1,2,2-Tetrachloroethane**	5	10	0.2	1019

Tetrahydrofuran	200	5	0.2	1609
Tetramethyl succinonitrile	0.5	48	0.2	S155
1,2,3-Trichloropropane	50	10	0.2	1003
Vinyl toluene	100	24	0.2	1501

*Use two charcoal tubes in series for sampling.
**Use petroleum base charcoal for sampling.

. References

5.1 "NIOSH Manual of Analytical Methods", ed. 4 Vol. 1-3 National Institute of Occupational Safety and Health, U.S. Government Printing Office, Washington, D.C. (1998)

)ccupational Safety & Health Administration
:00 Constitution Avenue, NW
Vashington, DC 20210

Desorption/QC Development Spreadsheet

Substance:	Methyl methacrylate	Analysis date:	3/15 - 16/02
IDC:	1774	Analyst:	ATN
CAS Number:	80-62-6	Instrument (F/R):	99F
IMIS:	1774	Desorption solvent:	Carbon disulfide
Study Type:	Desorption	Sequence/data files:	15mar02; 002 - 011
Prep date:	3/5/2002	Column:	SupelcoWax - 10
Prepared by:	DP	QC samples:	91073, -4
Notebook Reference:	Spiked neat		
Density:	936ug/ul		
Standard (mfg., lot):	Aldrich; Lot BI 05310 PU		
Date (received,opened):	5/18/2000		
Media:	SKC SCT lot 2000 in injection vials		

Standards

Amount (ug)	Area 1	Area 2	Mean	Rf. (ug/area)	% Difference injection	Standard prep reference
936	1949260		1949260	4.802E-04	100	GC standard log

Samples

Existing curve Y= 7.41263e-1 + 8.3221e-5 X - 6.93024e-9 X^2

Curve from this data curve Y= 7.9754e-1 + 1.08983e-4X - 2.12709e-8X^2

Sample Number	Amount Applied(ug)	Area 1	Amount Recovered	Percent Recovery	Old curve Corr rec	New curve Corr rec
35MM - 1	468	810002	388.949	83.109	107.572	99.328
35MM - 2	468	792084	380.345	81.270	105.284	97.223
35MM - 3	936	1751150	840.871	89.837	111.413	102.771
35MM - 4	936	1739260	835.162	89.227	110.712	102.122
35MM - 5	1872	3615540	1736.118	92.741	107.233	100.518
35MM - 6	1872	3574320	1716.325	91.684	106.155	99.446
35MM - 7	2808	5380680	2583.707	92.012	101.110	98.185
35MM - 8	2808	5426630	2605.771	92.798	101.857	99.023
35MM - 9	3744	7201210	3457.893	92.358	97.613	98.554
35MM - 10	3744	7237980	3475.549	92.830	98.047	99.057
			Mean=	89.787	104.700	99.623
			Sd=	4.212	4.874	1.723
			CV=	0.047	0.047	0.017

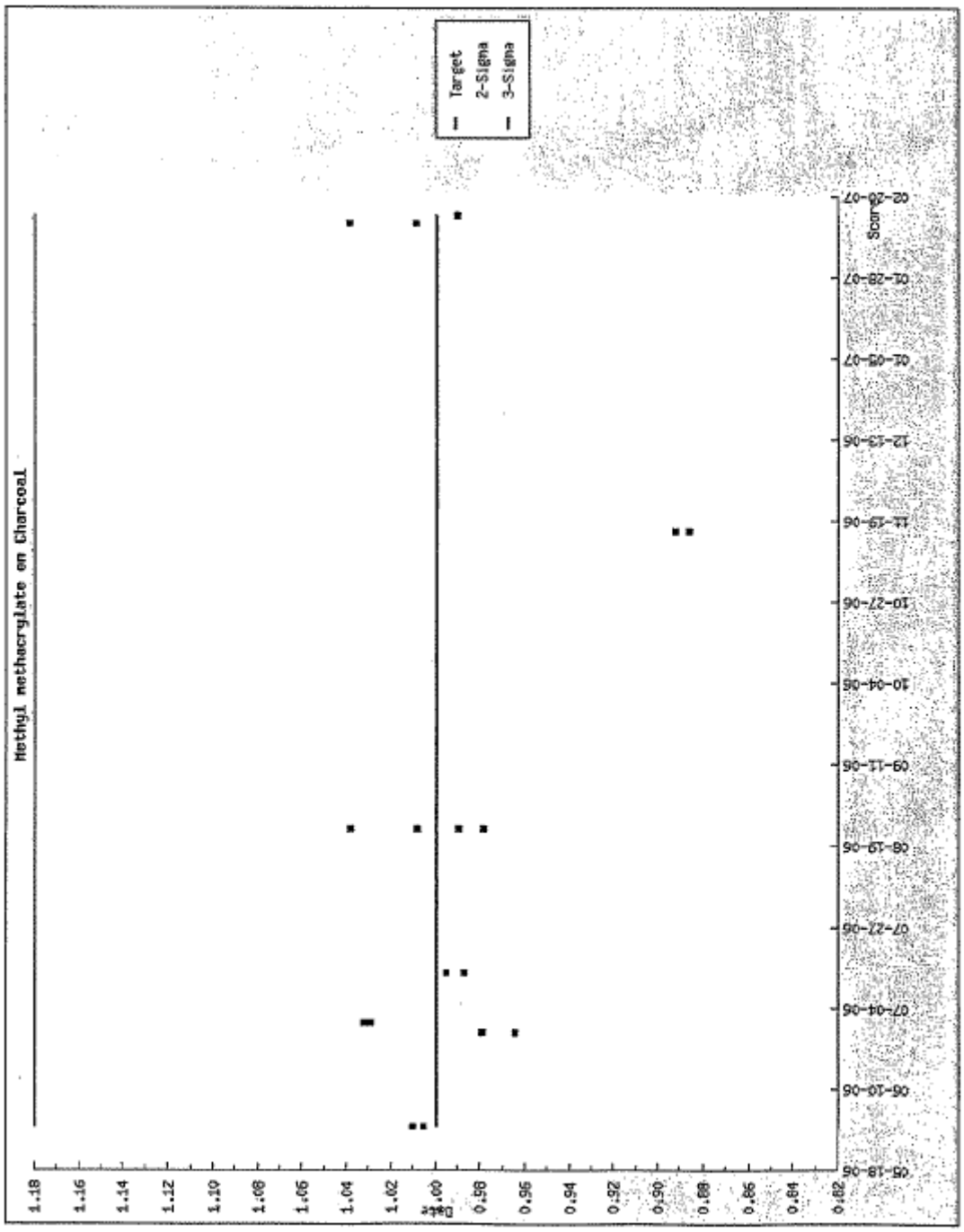
New curve uses 0.937 above 2560 ug found

Conclusions:

The notes on the old curve state that the curve was not the best fit at the low end, which is verified here. The new curve approximates this set of data better than the old curve.

Methyl methacrylate on Charcoal desorbed in CS2

QC Sample #	Comments	Substance	Spike Amount ug/sample	Result ug/sample	% Recovery	Analysis Date
120305	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	1872	1881	100.5%	5/31/2006
120306	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	2808	2836	101.0%	5/31/2006
120307	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	936	916	97.9%	6/27/2006
120308	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	3744	3610.7	96.4%	6/27/2006
120309	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	936	966	103.2%	6/30/2006
120310	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	2808	2890	102.9%	6/30/2006
120311	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	3744	3726	99.5%	7/14/2006
120312	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	1872	1847	98.7%	7/14/2006
120313	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	1872	1851	98.9%	8/24/2006
120314	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	2808	2745	97.8%	8/24/2006
120315	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	936	972	103.8%	8/24/2006
120316	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	1872	1887	100.8%	8/24/2006
120317	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	2808	2505	89.2%	11/17/2006
120318	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	3744	3318	88.6%	11/17/2006
120319	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	936	972.9	103.9%	2/13/2007
120320	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	3744	3776.4	100.9%	2/13/2007
120321	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	1872	1853.1	99.0%	2/15/2007
120322	Aldrich lot BI05310 PU 5/18/00	Methyl methacrylate on Charcoal	3744	3705.7	99.0%	2/15/2007


Methyl methacrylate on Charcoal
Target
2-Sigma
3-Sigma
Score
02-28-07
01-28-07
01-03-07
12-13-06
11-19-06
10-27-06
10-04-06
09-11-06
08-19-06
07-27-06
07-04-06
06-10-06
05-18-06
1.18
1.16
1.14
1.12
1.10
1.08
1.06
1.04
1.02
1.00
0.98
0.96
0.94
0.92
0.90
0.88
0.86
0.84
0.82

Desorption/QC Development Spreadsheet

Substance:	Ethyl methacrylate
IDC:	E115
CAS Number	97-63-2
IMIS	E115
Study Type:	Desorption
Prep date:	3/20/2003
Prepared by:	DP
Notebook Reference:	Book 2385 p. 69
Density:	917ug/ul
Standard (mfg., lot):	Aldrich; lot CI 06410 BU
Date (received,opened):	5/18/2000
Media:	SKC SCT lot 2000 in injection vials

Analysis date:	3/29 - 30/03
Analyst:	ATN
Instrument (F/R):	99F
Desorption solvent:	Carbon disulf
Sequence/data files:	28mar03; 04
Column:	Supelcowax
QC samples:	102025, -26

Standards

Amount (ug)	Area 1	Rf. (ug/area)	Standard prep reference
917	2749809	3.335E-04	d:\lab\org\gc\99\data\31mar03

Samples

Sample Number	Amount Applied(ug)	Area 1	Amount Recovered	Percent Recovery	Corrected Results
320E - 1	0.48	0	0.000	0.000	0.000
320E - 2	0.48	0	0.000	0.000	0.000
320E - 3	0.96	0	0.000	0.000	0.000
320E - 4	0.96	0	0.000	0.000	0.000
320E - 5	1.9	1282	0.428	22.501	35.700
320E - 6	1.9	1276	0.426	22.396	35.534
320E - 7	13.8	25673	8.561	62.039	94.901
320E - 8	13.8	25671	8.627	62.517	95.606
320E - 9	27.5	56686	18.904	68.740	100.868
320E - 10	27.5	56471	18.832	68.479	100.513
320E - 11	68.8	165496	55.189	80.217	99.278
320E - 12	68.8	166705	55.592	80.803	100.004
320E - 13	137.6	337774	112.640	81.861	101.313
320E - 14	137.6	334476	111.540	81.061	100.323
320E - 15	206.3	491973	164.062	79.526	98.423
320E - 16	206.3	494441	164.885	79.925	98.917
320E - 17	275.1	654208	218.164	79.303	98.148
320E - 18	275.1	658801	219.695	79.860	98.837
320E - 19	458.5	1058728	353.062	77.004	95.302
320E - 20	458.5	1083508	361.326	78.806	97.532
320E - 21	917	2252203	751.060	81.904	101.366
320E - 22	917	2282180	761.056	82.994	102.716
320E - 23	1834	4598701	1533.564	83.619	103.488
320E - 24	1834	4631060	1544.355	84.207	104.217
			Mean=	80.792	93.149
			Sd=	1.981	19.836
			CV=	0.025	0.213

Conclusions:

Data was used to set a desorption curve of
final result=recovered/(-0.0001077*recovered*recovered)+0.00298*recovered+0.6269)

Appendix C: Ventilation assessments for both nail salons

Table 9: Ventilation assessment for both nail salons*

Diffuser #	Nail Salon 1		Nail Salon 2	
	Door/Window	Door/Window	Door/Window	Door/Window
	Open (cfm)	Closed (cfm)	Open (cfm)	Closed (cfm)
0	118	120	184	177
1	140	137	197	200
2	135	137	168	164
3	176	178	197	199
4	94	92	178	167
5	NA	NA	175	171
6	NA	NA	182	181
7	NA	NA	197	200
8	NA	NA	187	180
9	NA	NA	160	150
Total Supply (cfm)	663	664	1825	1789
Return Volume (cfm)	735	713	1497	1480
ACH	5.9	6.0	12.0	11.8

* One door and one window

Appendix D: Pump calibration information

Location/Site	Nail salon 1					
Method	WOHL WG006		WOHL WG006		WOHL WG006	
Pump Info	AP Buck - A		AP Buck - B		AP Buck - C	
WOHL Lot #	2000		2000		2000	
Tube #	1676418010		1676418		1676418824	
Sample ID	A1		B1		C1	
Calibration Date 02/02/07	Pre-cal 1024	Post-Cal 1334	Pre-cal 1033	Post-Cal 1508	Pre-cal 1042	Post-Cal 1408
	0.0412	0.0403	0.0422	0.0415	0.0412	0.0433
	0.0410	0.0392	0.0419	0.0415	0.0413	0.0435
	0.0413	0.0392	0.0419	0.0414	0.0410	0.0437
Average L/min	0.0412	0.0396	0.0420	0.0415	0.0412	0.0435
Percent Difference	4.0		1.3		-5.5	
AVERAGE L/min	0.0404		0.0417		0.0423	
Total Sample Time (min)	190		275		206	
Total Air Volume (L)	7.670		11.477		8.721	

Location/Site	Nail Salon 1					
Method	WOHL WG006		WOHL WG006		WOHL WG006	
Pump Info	AP Buck - D		AP Buck - E		AP Buck - A	
WOHL Lot #	2000		2000		2000	
Tube #	1676418009		1676418013		1676418819	
Sample ID	D1		Area E1 (chem storage)		A2	
Calibration Date 02/02/07	Pre-cal 1155	Post-Cal 1704	Pre-cal 1213	Post-Cal 1938	Pre-cal 1435	Post-Cal 1753
	0.0425	0.0419	0.0399	0.0400	0.0391	0.0365
	0.0423	0.0411	0.0397	0.0403	0.0391	0.0366
	0.0425	0.0412	0.0396	0.0397	0.0389	0.0364
Average L/min	0.0424	0.0414	0.0397	0.0400	0.0390	0.0365
Percent Difference	2.5		-0.7		6.7	
AVERAGE L/min	0.0419		0.0399		0.0378	
Total Sample Time (min)	309		445		198	
Total Air Volume (L)	12.952		17.741		7.478	

Appendix D (Continued)

Location/Site	Nail salon 1			
Method	WOHL WG006		WOHL WG006	
Pump Info	AP Buck - B		AP Buck - D	
WOHL Lot #	2000		2000	
Tube #	1676418011		1676418826	
Sample ID	B2		D2	
Calibration Date 02/02/07	Pre-cal 1512	Post-Cal 1930	Pre-cal 1709	Post-Cal 1823
	0.0415	0.0425	0.0419	0.0431
	0.0415	0.0421	0.0414	0.0433
	0.0414	0.0417	0.0412	0.0434
Average L/min	0.0415	0.0421	0.0415	0.0433
Percent Difference	-1.5		-4.2	
AVERAGE L/min	0.0418		0.0424	
Total Sample Time (min)	258		74	
Total Air Volume (L)	10.780		3.136	

Location/Site	Nail Salon 2					
Method	WOHL WG006		WOHL WG006		WOHL WG006	
Pump Info	AP Buck - E		AP Buck - D		AP Buck - B	
WOHL Lot #	2000		2000		2000	
Tube #	1676418012		1676418016		1676418818	
Sample ID	TTP1 (area chem storage)		TTM1		TTN1 (attached to Light)	
Calibration Date 02/03/07	Pre-cal 1019	Post-Cal 1817	Pre-cal 1012	Post-Cal 1416	Pre-cal 0930	Post-Cal 1421
	0.0398	0.0390	0.0439	0.0440	0.0400	0.0405
	0.0401	0.0392	0.0437	0.0443	0.0396	0.0402
	0.0400	0.0390	0.0437	0.0436	0.0396	0.0407
Average L/min	0.0400	0.0391	0.0438	0.0440	0.0397	0.0405
Percent Difference	2.3		-0.5		-1.8	
AVERAGE L/min	0.0395		0.0439		0.0401	
Total Sample Time (min)	478		244		291	
Total Air Volume (L)	18.889		10.703		11.669	

Location/Site	Nail Salon 2			
Method	WOHL WG006		WOHL WG006	
Pump Info	AP Buck - D		AP Buck - B	
WOHL Lot #	2000		2000	
Tube #	1676418015		1676418823	
Sample ID	TTM2		TTN2 (attached to light)	
Calibration Date 02/03/07	Pre-cal 1421	Post-Cal 1758	Pre-cal 1430	Post-Cal 1808
	0.0440	0.0434	0.0398	0.0398
	0.0443	0.0437	0.0399	0.0395
	0.0436	0.0439	0.0398	0.0398
Average L/min	0.0440	0.0437	0.0398	0.0397
Percent Difference	0.7		0.3	
AVERAGE L/min	0.0438		0.0398	
Total Sample Time (min)	217		218	
Total Air Volume (L)	9.508		8.669	

WOHL Wisconsin Occupational Health Laboratory

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Wisconsin State Laboratory of Hygiene — University of Wisconsin

Analytical Laboratory Report

February 20, 2007

Report ID: 9056584

ADAM MARTY

Company Number: 30672

PROJ

Date Collected:	2/2/2007
Date Received:	2/6/2007
Date of Analysis:	2/13/2007
Date Reported:	2/20/2007

Analyst: _____

PATRICK RILEY, Chemist
rileypk@mail.slh.wisc.edu

Reviewer: _____

STEVE STREBEL, Organic Supervisor
ss@mail.slh.wisc.edu

WOHL uses only verified, secured electronic signatures on reports.
These signatures are as valid as original handwritten signatures.
If you have any questions regarding this report please feel free to contact the laboratory via email (as listed above) or via telephone at 800-446-0403

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Wisconsin State Laboratory of Hygiene

Analytical Results

University of Wisconsin

LAB NUMBER / FIELD NUMBER	DESCRIPTION			AIR VOLUME
1250485	SCT			7.670 liters
A1				
Ethyl Methacrylate		230 µg/sample	30 mg/m³	6.4 ppm
Methyl Methacrylate		3.9 µg/sample	0.51 mg/m³	0.13 ppm
COMMENTS: 580 ug, 75 mg/m3, and 32 ppm of Acetone and 190 ug, 6.1 mg/m3, and 2.5 ppm of Ethyl Alcohol present in sample #1250485.				
1250486	SCT			11.477 liters
B1				
Ethyl Methacrylate		460 µg/sample	40 mg/m³	8.6 ppm
Methyl Methacrylate		6.9 µg/sample	0.60 mg/m³	0.15 ppm
COMMENTS: 740 ug, 64 mg/m3, and 27 ppm of Acetone and 240 ug, 21 mg/m3, and 2.9 ppm of Ethyl Alcohol present in sample #1250486.				
1250487	SCT			8.721 liters
C1				
Ethyl Methacrylate		1300 µg/sample	140 mg/m³	31 ppm
Methyl Methacrylate		25 µg/sample	2.8 mg/m³	0.70 ppm
COMMENTS: 650 ug, 74 mg/m3, and 31 ppm of Acetone and 220 ug, 26 mg/m3, and 14 ppm of Ethyl Alcohol present in sample #1250487.				
1250488	SCT			10.780 liters
B2				
Ethyl Methacrylate		500 µg/sample	46 mg/m³	9.9 ppm
Methyl Methacrylate		6.7 µg/sample	0.62 mg/m³	0.15 ppm
COMMENTS: 700 ug, 65 mg/m3, and 27 ppm of Acetone and 210 ug, 19 mg/m3, and 10 ppm of Ethyl Alcohol present in sample #1250488.				
1250489	SCT			12.952 liters
D1				
Ethyl Methacrylate		760 µg/sample	59 mg/m³	13 ppm
Methyl Methacrylate		13 µg/sample	0.98 mg/m³	0.24 ppm
COMMENTS: 1000 ug, 78 mg/m3, and 33 ppm of Acetone and 250 ug, 19 mg/m3, and 10 ppm of Ethyl Alcohol present in sample #1250489.				
1250490	SCT			3.136 liters
D2				
Ethyl Methacrylate		150 µg/sample	49 mg/m³	11 ppm
Methyl Methacrylate		2.3 µg/sample	0.73 mg/m³	0.18 ppm
COMMENTS: 210 ug, 67 mg/m3, and 28 ppm of Acetone and 94 ug, 30 mg/m3, and 16 ppm of Ethyl Alcohol present in sample #1250490.				

Report ID: 9056584

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Wisconsin State Laboratory of Hygiene — University of Wisconsin

Analytical Results

LAB NUMBER / FIELD NUMBER	DESCRIPTION				AIR VOLUME
1250491	SCT				7.478 liters
A2					
	Ethyl Methacrylate	350 µg/sample	47 mg/m³	10.0 ppm	
	Methyl Methacrylate	5.2 µg/sample	0.70 mg/m³	0.17 ppm	
	COMMENTS: 630 ug, 85 mg/m3, and 36 ppm of Acetone and 140 ug, 18 mg/m3, and 10 ppm of Ethyl Alcohol present in sample #1250491.				
1250492	SCT				17.741 liters
E1					
	Ethyl Methacrylate	620 µg/sample	35 mg/m³	7.5 ppm	
	Methyl Methacrylate	10.0 µg/sample	0.56 mg/m³	0.14 ppm	
	COMMENTS: 770 ug, 43 mg/m3, and 18 ppm of Acetone and 230 ug, 13 mg/m3, and 6.7 ppm of Ethyl Alcohol present in sample #1250492.				
1250493	SCT				0.120 liters
F1					
	Ethyl Methacrylate	ND <0.80 µg/sample	ND <6.7 mg/m³	ND <1.4 ppm	
	Methyl Methacrylate	ND <2.0 µg/sample	ND <17 mg/m³	ND <4.1 ppm	
1250494	SCT				2.990 liters
G1					
	Ethyl Methacrylate	74000 µg/sample	25000 mg/m³	5300 ppm	
	Methyl Methacrylate	1300 µg/sample	430 mg/m³	100 ppm	
	COMMENTS: The Ethyl Methacrylate reported for sample #1250494 was greater than the upper calibration standard, therefore, these results should be considered to be approximate values. 36% and 33% of the Methyl Methacrylate and Ethyl Methacrylate, respectively, reported for sample #1250494 were detected on the back-up section of the tube.				

Displayed values on report have been rounded; however all calculations are performed using raw, unrounded intermediate results. Please contact the laboratory if you have any questions regarding our result calculation or rounding. All samples were received by the laboratory in acceptable condition unless otherwise noted.

ND = None Detected. Results are less than the method detection limit

Report ID: 9056584

WOHL Wisconsin Occupational Health Laboratory

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Wisconsin State Laboratory of Hygiene University of Wisconsin

Analytical Methodology

GENERAL SOLVENTS:

These samples are analyzed using WOHL method WG006, which is based on the method, OSHA 7.

The collection media is a SMALL (SCT) (SKC 226-01), LARGE (LCT) (SKC 226-09), JUMBO (JCT)(226-16) or JUMBO2 (226-16-02) Activated Charcoal tube.

Front and back sections of the tube are separately desorbed in 1 ml for SMALL tubes, 3 ml for LARGE tubes, 5 ml for JUMBO tubes, or 10 ml for JUMBO2 tubes of Carbon Disulfide for 30 minutes prior to analysis.

The samples are run on a Hewlett-Packard Gas Chromatograph equipped with an FID. The Primary and Confirming columns were chosen from the following:
Carbopack C /0.1% SP-1000
VoCol 105M Capillary
HP-5 Capillary
Supelcowax-10 Capillary
SPB-624 capillary

Samples may also have been confirmed on a Model 5972 Hewlett-Packard Gas Chromatograph Mass-Selective Detector containing a Nukol Capillary.

Reporting Limits are specific for each substance.

Results are not blank corrected unless noted in report.

REPORTING LIMITS:

This table contains the WOHL determined reporting limits for the compounds specified in this report. These numbers are based on the historical statistical data for a particular analyte or are based on WOHL determined values.

Analyte	Reporting Limit
Ethyl Methacrylate on SCT	1.8 µg/sample
Methyl Methacrylate on SCT	2 µg/sample

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Wisconsin State Laboratory of Hygiene

Analytical Quality Control

University of Wisconsin

Laboratory prepared quality control (QC) samples were analyzed along with the samples included in the analytical report. The analysis results for these QC samples are listed below.

Instrument Used for Analysis: Gas Chromatograph with FID

Laboratory Control Sample: 120319

QC Sample Media: SCT lot 2000 charcoal

Analyte	Target Value	Recovery (%)	Acceptable Recovery (%)	Pass/Fail
Methyl methacrylate on Charcoal	936 µg/sample	103.9	82 - 118	PASS

Laboratory Control Sample: 120320

QC Sample Media: SCT lot 2000 charcoal

Analyte	Target Value	Recovery (%)	Acceptable Recovery (%)	Pass/Fail
Methyl methacrylate on Charcoal	3744 µg/sample	100.9	82 - 118	PASS

The acceptable range for an analyte is based on the standard deviation of each analyte, which has been determined from statistical evaluation of the historical performance of the assay. The acceptable range includes up to 3 standard deviations, so a result within 3 standard deviations is considered to have passed the QC requirements. A result outside of the acceptable range is considered to have failed QC and may indicate the direction of possible bias for the samples included in the analytical report. The analytes used for QC determination will not always be the same analytes that appear in the samples for the report, however they are representative of the compounds found in the samples and indicative of overall assay performance.

End of Analytical Report

The results in this report apply only to the samples, specifically listed above, tested at the Wisconsin Occupational Health Laboratory. This report is not to be reproduced except in full.

WISCONSIN OCCUPATIONAL HEALTH LABORATORY (WOHL) SAMPLE SUBMISSION FORM

Bill To Adam Marty WOHL COMP# _____ Send Results To ATTN: Adam Marty

Phone # _____

FAX # _____

Email Address _____

Project _____ P.O. # _____

Date Sampled 02/02/07

Turnaround: ☐ RUSH (must be prearranged) ☐ PRIORITY ☒ NORMAL

SPECIAL INSTRUCTIONS
Please run OSHA PV2100 for Ethyl methacrylate & methyl methacrylate

See Steve Strebel for ?'s

◆ PLEASE GROUP SAMPLES BY MEDIA USED AND ANALYSIS REQUESTED. ◆

LAB USE ONLY	CUSTOMER FIELD #	SAMPLE MEDIA	WIPE SAMPLES	FOR AIR SAMPLES ONLY					ANALYSIS REQUEST
WOHL SAMPLE #			SIZE OF AREA WIPED EX: 2 IN x 2 IN	TIME ON	TIME OFF	TOTAL TIME (MINS)	FLOW RATE (L/MIN)	VOLUME (LITERS)	
1250485	A1	Charcoal Tubes	NA	1024	1634	190	.0404	7.670	OSHA PV2100
1250486	A2 B1			1033	1508	275	.0417	11.477	
1250487	B1 C1			1042	1403	204	.0423	8.721	
1250488	B2			1512	1930	258	.0418	10.780	
1250489	D1			1155	1704	309	.0419	12.952	
1250490	D2			1709	1823	74	.0424	3.138	
1250491	A2			1435	1753	198	.0378	7.478	
1250492	E1			1213	1938	445	.0399	17.741	

CHAIN OF CUSTODY: Relinquished _____ Date _____ Received _____ Date FEB - 6 2007

SAMPLE CONDITION
Adam OK
_____ NOT OK
See Sample Receipt Record

UPS, Fed-Ex & Other Shippers
Wisconsin Occupational Health Lab
2601 Agriculture Drive
Madison, WI 53718

US Postal Service
Wisconsin Occupational Health Lab
PO Box 7996
Madison, WI 53707-7996

Phone 608 224-6210
800 446-0403
FAX 608 224-6213

Sampling Questions
WOHLsampling@mail.slh.wisc.edu
Web Page/Order Media
http://www.slh.wisc.edu/wohl

SC I 2000 kr 2/6/07

WISCONSIN OCCUPATIONAL HEALTH LABORATORY (WOHL) SAMPLE SUBMISSION FORM

Bill To Adam Marty

WOHL COMP# _____

Send Results To ATTN: Adam Marty

Phone # _____

FAX # _____

Email Address _____

Project _____

P.O. # _____

Date Sampled 02/02/07

Turnaround: ☐ RUSH ☐ PRIORITY ☒ NORMAL
(must be prearranged)

SPECIAL INSTRUCTIONS
Please run OSHA PV2100 for ethyl methacrylate and methyl methacrylate

See Steve Strebel for ?'s

◆ PLEASE GROUP SAMPLES BY MEDIA USED AND ANALYSIS REQUESTED. ◆

LAB USE ONLY WOHL SAMPLE #	CUSTOMER FIELD #	SAMPLE MEDIA	WIPE SAMPLES SIZE OF AREA WIPED EX: 2 IN x 2 IN	FOR AIR SAMPLES ONLY TIME ON	TIME OFF	TOTAL TIME (MINS)	FLOW RATE (L/MIN)	VOLUME (LITERS)	ANALYSIS REQUEST
1250493	F1	charcoal tube	NA	1840	1844	4	.0301	0.120	OSHA PV2100
1250494	G1	↓		1846	1901	15	.1990	2.990	" " "

CHAIN OF CUSTODY: Relinquished _____ Date _____ Received _____ Date FEB - 6 2007

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800 446-0403
FAX 608 224-6213

Sampling Questions
WOHLsampling@mail.slh.wisc.edu
Web Page/Order Media
http://www.slh.wisc.edu/wohl

SAMPLE CONDITION
OK
_____ NOT OK
See Sample Receipt Record

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Wisconsin State Laboratory of Hygiene

University of Wisconsin

Analytical Laboratory Report

February 20, 2007

Report ID: 9056585

ADAM MARTY

Company Number: 30672

PROJ

Date Collected:	2/3/2007
Date Received:	2/6/2007
Date of Analysis:	2/13/2007
Date Reported:	2/20/2007

Analyst: _____

PATRICK RILEY, Chemist
rileypk@mail.slh.wisc.edu

Reviewer: _____

STEVE STREBEL, Organic Supervisor
ss@mail.slh.wisc.edu

WOHL uses only verified, secured electronic signatures on reports.
These signatures are as valid as original handwritten signatures.
If you have any questions regarding this report please feel free to contact the laboratory via email (as listed above) or via telephone at 800-446-0403

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Wisconsin State Laboratory of Hygiene

Analytical Results

University of Wisconsin

LAB NUMBER / FIELD NUMBER	DESCRIPTION			AIR VOLUME
1250478	SCT			18.889 liters
TTP1				
Ethyl Methacrylate		2.3 µg/sample	0.12 mg/m³	0.026 ppm
Methyl Methacrylate		88 µg/sample	4.7 mg/m³	1.1 ppm
COMMENTS: 180 ug, 9.4 mg/m3, and 3.9 ppm of Acetone present in sample #1250478. Traces of Ethyl Acetate, Methyl Ethyl Ketone (MEK), Isopropyl Alcohol, Toluene, Butyl Acetate (n-), Butyl Alcohol (n-), Limonene, Dichlorobenzene (p-), and Tetrahydrofuran present in all samples.				
1250479	SCT			10.703 liters
TTM1				
Ethyl Methacrylate		<=1.8 µg/sample	<=0.17 mg/m³	<=0.036 ppm
Methyl Methacrylate		130 µg/sample	12 mg/m³	2.9 ppm
COMMENTS: 120 ug, 11 mg/m3, and 4.6 ppm of Acetone present in sample #1250479.				
1250480	SCT			.084 liters
TTQ1				
Ethyl Methacrylate		ND <0.80 µg/sample	ND <9.5 mg/m³	ND <2.0 ppm
Methyl Methacrylate		ND <2.0 µg/sample	ND <24 mg/m³	ND <5.8 ppm
1250481	SCT			11.669 liters
TTN1				
Ethyl Methacrylate		<=1.8 µg/sample	<=0.15 mg/m³	<=0.033 ppm
Methyl Methacrylate		120 µg/sample	11 mg/m³	2.6 ppm
COMMENTS: 150 ug, 13 mg/m3, and 5.6 ppm of Acetone present in sample #1250481.				
1250482	SCT			9.508 liters
TTM2				
Ethyl Methacrylate		<=1.8 µg/sample	<=0.19 mg/m³	<=0.041 ppm
Methyl Methacrylate		300 µg/sample	32 mg/m³	7.7 ppm
COMMENTS: 130 ug, 14 mg/m3, and 5.8 ppm of Acetone present in sample #1250482.				
1250483	SCT			8.669 liters
TTN2				
Ethyl Methacrylate		<=1.8 µg/sample	<=0.21 mg/m³	<=0.044 ppm
Methyl Methacrylate		190 µg/sample	22 mg/m³	5.3 ppm
COMMENTS: 150 ug, 17 mg/m3, and 7.2 ppm of Acetone present in sample #1250483.				

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Wisconsin State Laboratory of Hygiene — **University of Wisconsin**

Analytical Results

LAB NUMBER / FIELD NUMBER	DESCRIPTION	AIR VOLUME
1250484	SCT	3.019 liters

TTR1

Ethyl Methacrylate	58 µg/sample	19 mg/m³	4.1 ppm
Methyl Methacrylate	66000 µg/sample	22000 mg/m³	5400 ppm

COMMENTS: The Methyl Methacrylate reported for sample #1250484 was greater than the upper calibration standard, therefore, these results should be considered to be approximate values. 35% of both Methyl Methacrylate and Ethyl Methacrylate reported for sample #1250484 were detected on the back-up section of the tube.

Displayed values on report have been rounded; however all calculations are performed using raw, unrounded intermediate results. Please contact the laboratory if you have any questions regarding our result calculation or rounding. All samples were received by the laboratory in acceptable condition unless otherwise noted.

ND = None Detected. Results are less than the method detection limit

<= Less Than or Equal To. The analyte was detected but at a level too low to be accurately quantitated. The actual amount is less than or equal to the reported value.

Analytical Methodology

GENERAL SOLVENTS:

These samples are analyzed using WOHL method WG006, which is based on the method, OSHA 7.

The collection media is a SMALL (SCT) (SKC 226-01), LARGE (LCT) (SKC 226-09), JUMBO (JCT)(226-16) or JUMBO2 (226-16-02) Activated Charcoal tube.

Front and back sections of the tube are separately desorbed in 1 ml for SMALL tubes, 3 ml for LARGE tubes, 5 ml for JUMBO tubes, or 10 ml for JUMBO2 tubes of Carbon Disulfide for 30 minutes prior to analysis.

The samples are run on a Hewlett-Packard Gas Chromatograph equipped with an FID. The Primary and Confirming columns were chosen from the following:
Carbopack C /0.1% SP-1000
VoCol 105M Capillary
HP-5 Capillary
Supelcowax-10 Capillary
SPB-624 capillary

Samples may also have been confirmed on a Model 5972 Hewlett-Packard Gas Chromatograph Mass-Selective Detector containing a Nukol Capillary.

Reporting Limits are specific for each substance.

Results are not blank corrected unless noted in report.

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REPORTING LIMITS

This table contains the WOHL determined reporting limits for the compounds specified in this report. These numbers are based on the historical statistical data for a particular analyte or are based on WOHL determined values.

Analyte	Reporting Limit
Ethyl Methacrylate on SCT	1.8 µg/sample
Methyl Methacrylate on SCT	2 µg/sample

Analytical Quality Control

Laboratory prepared quality control (QC) samples were analyzed along with the samples included in the analytical report. The analysis results for these QC samples are listed below.

Instrument Used for Analysis: Gas Chromatograph with FID

Laboratory Control Sample: 120319

QC Sample Media: SCT lot 2000 charcoal

Analyte	Target Value	Recovery (%)	Acceptable Recovery (%)	Pass/Fail
Methyl methacrylate on Charcoal	936 µg/sample	103.9	82 - 118	PASS

Laboratory Control Sample: 120320

QC Sample Media: SCT lot 2000 charcoal

Analyte	Target Value	Recovery (%)	Acceptable Recovery (%)	Pass/Fail
Methyl methacrylate on Charcoal	3744 µg/sample	100.9	82 - 118	PASS

The acceptable range for an analyte is based on the standard deviation of each analyte, which has been determined from statistical evaluation of the historical performance of the assay. The acceptable range includes up to 3 standard deviations, so a result within 3 standard deviations is considered to have passed the QC requirements. A result outside of the acceptable range is considered to have failed QC and may indicate the direction of possible bias for the samples included in the analytical report. The analytes used for QC determination will not always be the same analytes that appear in the samples for the report, however they are representative of the compounds found in the samples and indicative of overall assay performance.

End of Analytical Report

The results in this report apply only to the samples, specifically listed above, tested at the Wisconsin Occupational Health Laboratory. This report is not to be reproduced except in full.

WISCONSIN OCCUPATIONAL HEALTH LABORATORY (WOHL) SAMPLE SUBMISSION FORM

Bill To Adam Marty WOHL COMP# 30672 Send Results To ATTN: Adam Marty

Phone # _____

FAX # _____

Email Address _____

Project _____

P.O. # _____ Date Sampled 02/05/07

Turnaround: ☐ RUSH ☐ PRIORITY ☒ NORMAL
{ must be prearranged }

SPECIAL INSTRUCTIONS
Please run OSHA PV2100 for ethyl methacrylate & methyl methacrylate
*TTN1 has small hairline crack @ inlet see Steve Strebel for ?'s

♦ PLEASE GROUP SAMPLES BY MEDIA USED AND ANALYSIS REQUESTED. ♦

LAB USE ONLY WOHL SAMPLE #	CUSTOMER FIELD #	SAMPLE MEDIA	WIPE SAMPLES SIZE OF AREA WIPED EX: 2 IN x 2 IN	FOR AIR SAMPLES ONLY TIME ON	TIME OFF	TOTAL TIME (MINS)	FLOW RATE (L/MIN)	VOLUME (LITERS)	ANALYSIS REQUEST
1250478	TTP1	charcoal tube	NA	1019	1817	478	.0395	18.889	OSHA PV2100
1250479	TTM1			1012	1416	244	.0439	10.703	
1250480	TTQ1			1015	1020	5	.0169	.084	
1250481	TTN1			0930	1421	291	.0401	11.669	
1250482	TTM2			1421	1758	217	.0438	9.508	
1250483	TTN2			1430	1808	218	.0398	8.669	
1250484	TTR1			1708	1723	15	.201 .0200	3.019	

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Web Page/Order Media
http://www.slh.wisc.edu/wohl

SAMPLE CONDITION
dm OK
_____ NOT OK
See Sample Receipt Record

SEP 2000 Rev 2/6/07