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Eric J. Esswein & Mark F. Boeniger

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Effect of an Ozone-Generating Air-Purifying Device on Reducing Concentrations of Formaldehyde in Air

Eric J. Esswein[A,C] and Mark F. Boeniger[B]

[A]Department of Family & Preventive Medicine, Rocky Mountain Center for Occupational & Environmental Health, Building 512, The University of Utah School of Medicine, Salt Lake City, Utah 84112; [B]National Institute for Occupational Safety and Health, Industry Wide Studies Branch, Robt. A. Taft Laboratory, 4676 Columbia Parkway, MS R-14, Cincinnati, Ohio 45226; [C]Current Address: National Institute for Occupational Safety and Health, Hazard Evaluation and Technical Assistance Branch, Robt. A. Taft Laboratory, 4676 Columbia Parkway, MS R-11, Cincinnati, Ohio 45226

Formaldehyde, an air contaminant found in many indoor air investigations, poses distinct occupational exposure hazards in certain job categories (e.g., mortuary science) but is also of concern when found or suspected in office buildings and homes. A variety of air-purifying devices (APDs) are currently available or marketed for application to reduce or remove concentrations of a variety of indoor air pollutants through the use of ozone as a chemical oxidant. An investigation was conducted to determine if concentrations of formaldehyde similar to those found in industrial hygiene evaluations of funeral homes could be reduced with the use of an ozone-generating APD. An ozone-generating APD was placed in an exposure chamber and formaldehyde-containing embalming solution was allowed to evaporate naturally, creating peak and mean chamber concentrations of 2.5 and 1.3 ppm, respectively. Three 90-minute evaluations were conducted to establish a change in concentration for formaldehyde generated in the chamber. To ensure air mixing, a fan on the APD was allowed to run but the ozone-generating electrostatic plates were removed. After baseline concentration curves for formaldehyde were determined, the electrostatic plates were installed in the APD and the reproducibility of static concentrations of approximately 0.5 ppm ozone was evaluated. In a third evaluation, ozone was introduced into the chamber when formaldehyde was present at peak concentrations of 2.5 ppm. Continuous-reading instruments were used to sample for formaldehyde and ozone. Active sampling methods were also used to sample simultaneously for formaldehyde and a possible reactant product, formic acid. Triplicate measurements were made in each of three evaluations: formaldehyde alone, ozone alone, and formaldehyde and ozone combined. Concentrations of formaldehyde were virtually identical with and without 0.5 ppm ozone. No reduction in formaldehyde concentration was found during a 90-minute evaluation using ozone at this concentration with peak and average concentrations of approximately 2.5 and 1.3 ppm formaldehyde, respectively. The results of this investigation suggest that the use of ozone is ineffective in reducing concentrations of formaldehyde. Because ozone has demonstrated health hazards, and is a regulated air contaminant in both the occupational and ambient environment, the use of ozone as an air purification agent in indoor air does not seem warranted. **Esswein, E.J.; Boeniger, M.F.: Effect of an Ozone-Generating Air-Purifying Device on Reducing Concentrations of Formaldehyde in Air. Appl. Occup. Environ. Hyg. 9(2): 139–146; 1994.**

Introduction

Air-purifying devices (APDs) are available to the public and marketed for use in the United States to reduce or remove chemical and particulate contaminants, odors, or other substances believed to be harmful or offensive to occupants of indoor spaces. APDs employ a variety of methods including filtration, sedimentation, electrostatic precipitation, and chemical oxidation to achieve their stated purpose of purifying the air. Some models even advertise a capability of reducing concentrations of radon in air. Little evidence on actual performance of most APDs is available. With the exception of high-efficiency particulate air (HEPA) filter systems, most performance reports on air purifying devices come from anecdotal evidence. A need exists for systematic studies objectively describing the performance of APDs.

Because the costs associated with ventilation system design, installation, and maintenance are often prohibitive for small businesses, an increasing number of portable air purification devices have been developed and are marketed for use. One type of APD currently sold for use in the mortuary science field is the negative ion/ozone generator

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which produces negative ions and a variable quantity of ozone to electrostatically and chemically interact with indoor air contaminants, specifically formaldehyde in this case. The rationale for this type of APD in the mortuary field is to remove formaldehyde in the gaseous state through organic chemical oxidation using ozone. A balanced chemical equation for this reaction is:

$$HCHO + O_3 \longrightarrow HCOOH + O_2$$

where formaldehyde and ozone react on a one-to-one basis yielding formic acid and oxygen. The gas-phase kinetics of the oxygen-containing organics such as formaldehyde and acetylaldehyde have been studied.[1] The formaldehyde–ozone reaction proceeds very slowly, having a rate constant of $<2.1 \times 10^{-24}$ cm³ molecule^{-1} sec^{-1} at room temperature (298 K).

An equation describing this reaction is given by:

$$\tau O_3 = (k\,[O_3])^{-1}$$

where τO_3 is the approximate life time (≈68% removal) of the reacting organic (measured in seconds), k is the rate constant for the reaction of the organic with ozone, and $[O_3]$ is the concentration of ozone. As an example, for reactions involving molecules with rate constants of 1.0×10^{-21} and ozone in concentration of 40 ppb (1×10^{12} molecules cm^{-3}), a period of 30 years would be necessary for the reaction to proceed to 68 percent completion.

Negative ion generation, an electrostatic means of air cleansing used in some APDs, may serve as a secondary means of air purification through sedimentation of contaminants adsorbed onto charged particles. The efficacy of negative ion generators, however, remains contentious.[2]

In mortuaries, it has been shown that concentrations of formaldehyde (H_2CO) are generated during embalming procedures which attain or exceed the permissible exposure limit (PEL) of 0.75 ppm established by the Occupational Safety and Health Administration (OSHA).[3–7] Funeral homes are often older buildings with adjoining rooms which comprise the interior spaces. The embalming room, however, unlikely to be seen by the general public, is often located in the basement of the building where a capable local ventilation system is frequently lacking. The potential for formaldehyde exposure is high in this trade and the health status of morticians is often suspect. A study of six funeral homes with modern, well-equipped embalming facilities in the Detroit area revealed 50 percent to be inadequate in some aspect of ventilation system capability.[8]

The tissue-hardening and preservative properties of formaldehyde were discovered in 1893.[9] It is the coagulation of proteins that makes formaldehyde useful as an embalming agent but also toxic to living tissue. Formaldehyde-containing embalming chemicals pose an exposure hazard to morticians when ventilation is lacking or insufficient during work practices. The effects of inhalation exposure to formaldehyde are well documented in the literature and include chronic bronchitis, dyspnea, nasal, eye, and skin irritation.[7,10–12] Formaldehyde is a known animal carcinogen and is considered a potential human carcinogen by the National Institute for Occupational Safety and Health (NIOSH), The American Conference of Governmental Industrial Hygienists (ACGIH), and OSHA.[13]

The purpose of this investigation was to determine if an ozone-generating APD could reduce concentrations of formaldehyde similar to those found in industrial hygiene evaluations of funeral homes.[4,5,14,15] The study was designed to simulate average formaldehyde concentrations in the real-work environment on a small, controlled scale. The findings were reviewed with consideration of the known toxicity of ozone.

Methods and Materials

To determine if concentrations of formaldehyde could be reduced by using an ozone-generating APD, a test atmosphere of formaldehyde-containing embalming solution was first created and the stability and reproducibility of the test atmosphere were determined. To determine efficacy, measurements of formaldehyde concentration were first made in the absence and then in the presence of a fixed concentration of ozone produced by the APD. Direct-reading instruments and active sampling methods were used to sample for formaldehyde, ozone, and a possible reactant product, formic acid.

An ozone-generating APD (Alpine Air Products™, Minneapolis, Minnesota) was selected for the investigation because it is solicited for use in mortuary operations to reduce or eliminate concentrations of formaldehyde through ozonation. The Model C150 operates on standard household alternating current. The device generates ozone by electrically charging a pair of ceramic and metal mesh plates which are located within the machine. A 75 ft³/min free air delivery fan is used to move air through the unit and distribute the ozonized air.

An exposure chamber constructed of corrugated cardboard with dimensions $99 \times 68.6 \times 76$ cm (volume = 0.52 m³) was placed in a standard laboratory hood. An opening of 20×20 cm was cut in the side of the box, covered with clear plastic, and sealed with tape. The opening served as a window to inspect the APD to ensure that it was functioning and to ensure consistent placement of the air sampling equipment. The chamber was initially monitored with an Interscan™ Model 4160 Formaldehyde Analyzer (Interscan Corporation, Chatsworth, California) to ensure that formaldehyde gas was not initially present in the chamber as an artifact from off-gassing of any sort. The range of the 4160 was 0 to 20 ppm with a minimum detectability of 1 percent of full scale or 0.2 ppm. The instrument uses a small air pump to draw an air stream past an electrochemical sensor where formaldehyde gas molecules move through a diffusion media and are adsorbed onto an electrocatalytic sensing medium which generates an electric current proportional to the gas concentration. Before sampling began, the Interscan analyzer was allowed to equilibrate in ambient air for 5 minutes. The sampling inlet of the Model 4160 was connected with a ⅜-inch o.d. Teflon® sampling tube which allowed sampling from the inside of the exposure chamber through a ⅜-inch hole in the wall of the chamber.

To generate an experimental concentration of formaldehyde using a common embalming solution, Champion HAR™ (Champion Products, Springfield, Ohio) was used to wet a lab tissue which was draped over a clean 250 mL laboratory beaker and placed in the chamber. The embalming solution was added drop by drop onto the lab tissue using a 10 mL pipette. To assure consistency during the course of the investigation, the locations of the APD and the beaker were marked on the floor of the chamber. Through experimentation, 11 drops of embalming solution were found to create peak concentrations of formaldehyde in the range of 2.5 to 2.6 ppm. According to the material safety data sheet, the solution is 35 percent formaldehyde (w/w). An analysis of this product was conducted by gas chromatograph-mass spectrometer detection (GC-MSD) in the continuous scan mode from 20 to 400 atomic mass units.

Average chamber concentrations of formaldehyde during the 90-minute evaluation were approximately 1.3 ppm. Peak and average concentrations of 2.5 ppm and 1.3 ppm, respectively, were desired as experimental test levels as these levels are consistent with values found in the literature and believed likely to occur in mortuary operations.[4] Throughout the evaluation, one of the end-flaps on the exposure chamber was allowed a 3 cm opening. Opening or closing flaps on the exposure chamber allowed variable amounts of room air to enter and mix in the chamber. During initial evaluations to determine if it was possible to create stable baseline concentrations of formaldehyde, an opening of 3 cm was found to allow initial concentrations of formaldehyde to peak and stabilize at approximately 2.5 ppm. This opening also allowed for an average concentration of 1.3 ppm formaldehyde to be resident in the chamber during the evaluation. The APD was inside the exposure chamber during the entire investigation. When ozone was not wanted during the initial baseline generation of formaldehyde concentrations, the electrostatic plates were removed from the machine, but the fan was allowed to run to ensure air mixing inside the chamber. Excellent air mixing was confirmed initially with the use of smoke tubes.

The initial portion of experiments performed in the evaluation involved three 90-minute trials, conducted to establish baseline concentration curves of the change in concentration of formaldehyde in the absence of ozone. Sampling was performed at 21°C. Ninety minutes was chosen as the duration of the evaluation period because it approximated the longest duration of time necessary for professional embalmers to complete an embalming.[12] Dynamic monitoring of the formaldehyde concentration was conducted using the Interscan Model 4160 analyzer. Signal output from the 4160 was continuously recorded using a Rustrak Ranger® datalogger (Gulton, East Greenwich, Rhode Island).

The second portion of the experiment established and verified that the APD was capable of ozone generation. The electrostatic plates were installed in the APD and a Mast Development Company Model 727-3 Ozone Monitor (Mast Development, Reno, Nevada) was used to monitor real-time ozone concentrations generated using the APD. The Model 727-3 is a direct-reading, active sampling UV absorption ozone photometer. A 35.5-cm cell is used to photometrically analyze an air sample which is drawn into the photometer by a diaphragm type pump. The monitor digitally displays concentrations in the range 0.00 to 9.99 ppm. Signal output in volts was sent via wire connected to terminals on the rear of the instrument to a Rustrak Ranger continuous datalogging device.

The sampling connection on the Mast 727-3 was made using ¼-inch o.d. Teflon tubing which was inserted into the exposure chamber through a ¼-inch hole in the chamber wall. To ensure proper functioning, the analyzer was allowed a warm-up period of approximately 30 minutes before monitoring began. It was not possible to obtain an ozone calibration gas for the Mast 727-3. However, the machine was recently purchased and factory calibration data using a primary standard were available. Dräger® colorimetric tubes were also used during an initial trial generation of ozone, and a confirmation of 0.7 ppm readout was consistent with a length of stain on the tube indicating 0.7 ppm of ozone.

The APD is advertised as capable of adjustable ozone generation. Ozone output is controlled with mechanical adjustment of a rheostat on the machine. However, no value or amount of ozone output is listed on the face of the adjustment knob. To obtain a moderate output, and because maximum and minimum concentrations of ozone were assumed at either end of the adjustment range, the adjustment knob was turned to approximately 45 percent of the range. This represented approximately an "eleven o-clock" position. A baseline concentration in the range 0.45 to 0.60 ppm ozone was initially established at this position of adjustment. This second experiment was conducted, with the APD adjusted as described, and three 90-minute runs were recorded using the Mast 727-3 ozone monitor to determine the generation reproducibility and stability of ozone.

In the third and final portion of the experiment, it was desired to determine if approximately 0.5 ppm ozone would have an effect on accelerating the disappearance of a 2.5 ppm peak and 1.3 ppm average concentration of formaldehyde. Consistent with the prior test methods used for the independent generations of formaldehyde and ozone, three evaluations of formaldehyde combined with ozone were then conducted. During these evaluations formaldehyde was generated in the exact method used for the baseline evaluations and the electrostatic plates were left installed in the APD. The ozone output adjustment was at the same eleven o'clock position as previously described. The Interscan Model 4160 and the Mast Model 727-3 were used to continuously sample for formaldehyde and ozone, respectively. Output from the Interscan and Mast units was stored in a Rustrak Ranger continuous datalogger.

To verify the average formaldehyde concentration in the

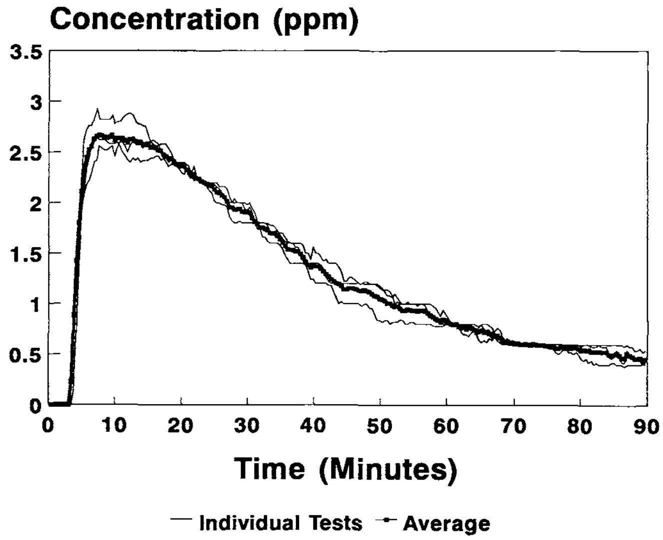

FIGURE 1. Change in concentration of formaldehyde without ozone.

chamber, pairs of Ace Glass Company Model 9110 Midget Gas Bubblers (coarse frit) and Gillian low-flow (Model LFS 113D C) battery-operated personal sampling pumps were located outside the chamber and were used to simultaneously collect air samples. Formaldehyde was collected in 20 mL of 1 percent sodium bisulfite solution.

NIOSH Method 3500 (visible absorbtion spectrometry) was the method of analysis used by the laboratory for formaldehyde determination. Sampling pumps were calibrated using a primary standard (bubble burette) to a flow rate of 0.3 L/min. Teflon tubing connected the bubblers on the sampling side of the train. Bubbler solution was quantitatively transferred to Nalgene® low density polyethylene bottles, refrigerated, and shipped to the laboratory for standard chromotropic analysis. One media blank was prepared during each triplicate run of the evaluation.

Prior evaluations established individual baselines for formaldehyde and ozone in the chamber. During this final portion of the investigation three sampling periods of 90 minutes each were performed involving the combination of formaldehyde and ozone. During each of these sampling periods, two samples for formic acid were collected using ORBO® 53 silica gel tubes. If formaldehyde were to react with ozone, formic acid is the likely product of the reactants. Formic acid is reported to be formed by the reaction of the formaldehyde free hydroxyl group with the ozone molecule.[16] Detecting formic acid could substantiate an oxidation of formaldehyde with the ozone generated by the APD. The ORBO tubes were inserted through the wall of the exposure chamber at mid-height distance and battery-powered Gillian low-flow pumps calibrated to a flow rate of 0.2 4 min were used to collect the sample.

Tygon® tubing connected the ORBO tubes to the Gillian personal sampling pumps. One media blank was treated in the same manner as the sample tube except for exposure in the chamber.

TABLE I. Average Concentrations of Formaldehyde (in ppm) Generated Using Embalming Solution During Baseline Evaluations

Evaluation Number	Mean Concentration
1	1.23
2	1.32
3	1.36
Mean	1.30
SD*	0.06

CV among evaluations = 5.1 percent.
*Standard deviation among evaluations.

Results

The change in concentration of formaldehyde without ozone over a 90-minute time period is shown in Figure 1. Three experimental runs are indicated by the thin lines. The mean is shown by the bold line. The initial concentration peaked at approximately 2.6 ppm and the final concentration was 0.5 ppm. Table I illustrates average formaldehyde concentrations sampled by the Interscan 4160 during each experimental run. The cumulative average was 1.3 ppm. The coefficient of variation (CV) during the sampling was 5.1 percent between each run.

Figure 2 illustrates the dynamic concentration of ozone sampled by the Mast 727-3 during each of the runs of baseline ozone generation using the APD. Table II shows the mean concentration of ozone during each run and the CV among evaluations. The mean of the three trials was 0.46 ppm and the CV was 8.35 percent. Concentrations of ozone varied more during the initial 20 minutes of the sampling period and appeared to rise somewhat after 30 minutes, continuing a slight rise to 90 minutes. Overall, the mean concentration of the three trials was relatively stable during the 90-minute course of the evaluation.

Table III shows the active and dynamic sampling results used to confirm the presence of formaldehyde during the

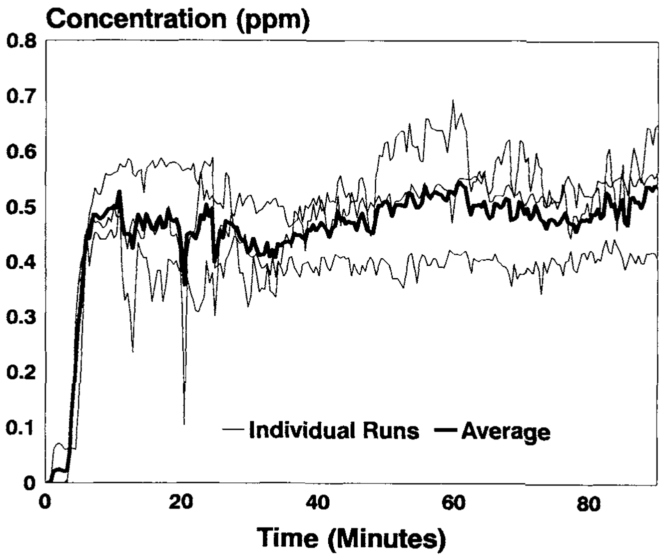

FIGURE 2. Ozone concentration during each test run.

TABLE II. Average Concentrations (in ppm) of Ozone Generated Using the APD During Baseline Evaluations

Evaluation Number	Mean Concentration
1	0.41
2	0.48
3	0.47
Mean	0.46
SD*	0.04

CV among evaluations = 8.4 percent.
*Standard deviation among evaluations.

final experimental run using ozone and formaldehyde. The results from the bisulfite bubbler active sampling method in Table III indicate that formaldehyde was present at a concentration at least as high as that measured by the Interscan Model 4160 formaldehyde analyzer, indicating that the direct-reading analyzer was not being biased by the possible presence of positive interferences that might be in the embalming solution. The bisulfite bubbler method is highly specific to formaldehyde but may have produced slightly higher results than the Interscan 4160 because the impinger method is unrestrained in its collection of all species of formaldehyde-containing compounds, whereas detection by the instrument is by diffusion of the species through a membrane to the electrocatalytic sensor. Monomeric formaldehyde is expected to have a higher diffusion rate across a membrane than the oligomers and other possible species of formaldehyde.

Three experimental trials were conducted to determine if concentrations of formaldehyde generated using embalming solution were reduced by the introduction of ozone. The result of this investigation indicates that concentrations of formaldehyde are virtually identical after a 90-minute trial in the absence of ozone and in the presence of 0.5 ppm ozone (1.30 ppm versus 1.32 ppm, respectively). Table IV shows mean formaldehyde concentrations in the presence and absence of approximately 0.5 ppm ozone. Figure 3 graphically illustrates concentrations of formaldehyde and ozone monitored during the final sampling period. Figure 4 shows the change in formaldehyde concentration with and without ozone over the 90-minute period. The inset in Figure 4 shows the same data, using a logarithmic ordinate and a linear abscissa, indicating the change in formaldehyde occurred as a decreasing exponential, or a first-order rate of change.

Linear regression analysis of the log transformed data shown as an insert in Figure 4 was performed. Due to a small amount of deviation of the data around the regression line and the resulting tight confidence intervals, a statistically significant difference in the slope of each line was detected. However, the difference was attributed to a smaller decline in formaldehyde concentration *with* ozone than that observed without ozone. Since no logical reason could be attributed to this finding, it was concluded that the outcome represents analytical imprecision and/or deviations in the performance of the chamber. From a more practical perspective, the final mean formaldehyde concentrations at the termination of each of the 90-minute trial runs (both with and without ozone) were identical, implying no difference in formaldehyde concentrations with 0.5 ppm ozone or a lack thereof.

Formic acid was only detected in one of six ORBO tube samples at a concentration of 0.17 ppm. The analytical limit of detection for formic acid was reported at 4 μg per sample, which is equivalent to a minimum detectable concentration of 0.11 ppm based on an average sample volume of 19.1 L.

A GC-MSD total ion chromatogram for the HAR embalming solution is shown as Figure 5 with the identified peaks labeled. The primary compounds found in this solution were formaldehyde and possibly its associated oligomers, methanol, ethanol, ethyl acetate, and possible glycol compounds.

Discussion

In this investigation, the presence of ozone did not reduce formaldehyde concentrations in air at the concentration evaluated and under the conditions of the designed experiment. An attempt was made to simulate a real embalming situation by: 1) using embalming fluid; 2) using evaporation as the means of airborne generation; 3) provid-

TABLE III. Results of Impinger Sampling and Dynamic Sampling (Interscan 4160) for Formaldehyde Using Embalming Solution During the Final Evaluation with 0.5 ppm Ozone*

Impinger Sample No.	Air Volume	Impinger Concentration	Average Concentration	Interscan 4160	Average Difference
1a	26.6	1.59			
1b	26.5	1.59	1.59	1.33	0.26
2a	25.5	1.92			
2b	25.5	1.76	1.84	1.35	0.46
3a	26.5	1.66			
3b	26.1	1.56	1.61	1.26	0.35
Mean			1.68	1.32	0.36
SD			0.14[A]	0.05[B]	0.12

*All concentrations of formaldehyde are reported in parts per million over a 90-minute sampling period.
[A]CV among impinger sampling = 8.2 percent.
[B]CV among Interscan 4160 = 3.6 percent.

TABLE IV. Average Concentrations of Formaldehyde (in ppm) With and Without 0.5 ppm Ozone During 90-Minute Experiments

Evaluation Number	Concentration Without Ozone	Concentration With 0.5 ppm Ozone	Mean Difference*
1	1.23	1.33	+0.10
2	1.32	1.35	+0.03
3	1.36	1.26	−0.10
Mean	1.30	1.32	+0.03

*Compared to "without ozone" experiments.

ing a moderate amount of dilution ventilation and mixing; and 4) using exposure conditions consistent with those reported in the literature for embalming procedures. However, it is possible that there are other unrecognized variables in an embalming room that could also influence the disappearance of formaldehyde which were not taken into account in the present experiment.

A real-world evaluation in an embalming room was not undertaken because of the expected large variability in airborne formaldehyde concentrations that would require extensive sampling to first generate a reference concentration in which to compare the effectiveness of ozone generation. Also of concern would be the potential for the unpleasant effects of ozone exposure upon the embalmers and investigators during the investigative process.

The results of this investigation show that the use of ozone in the quantity evaluated failed to bring about a reduction in formaldehyde concentration. A likely reactant product, formic acid, was also not present to any significant degree. One reason for this may be the presence of formaldehyde polymers and oligomers that evolve upon the reaction of formaldehyde with air, and methanol.(17) Methanol is present as a preservative in embalming products at a concentration of approximately 7 percent w/w. The GC-MSD

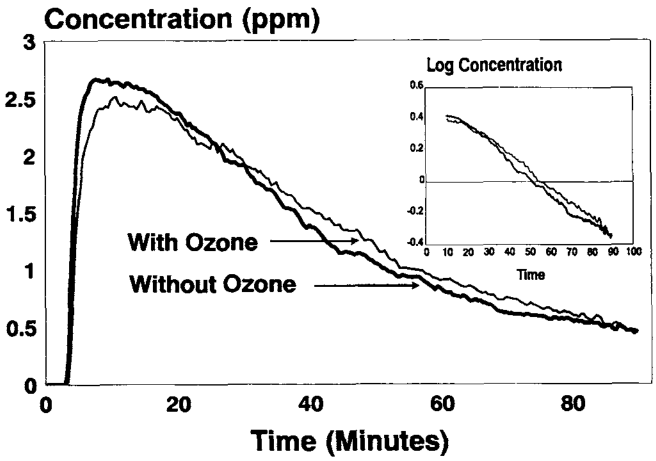

FIGURE 4. Comparison of change in concentration of formaldehyde with and without ozone.

total ion chromatogram shown as Figure 5 identifies other possible forms of formaldehyde in solution, in addition to monomeric formaldehyde. The peak eluting at approximately 3.5 minutes is believed to represent oligomers of formaldehyde. Methanol is seen with the formaldehyde and water peak. Formaldehyde polymers and oligomers are reportedly joined through oxygen atoms rather than by C-C linkages.(16) The formation of formaldehyde oligomers upon reaction with methanol has been well established in the literature.(15,18) The polymers and oligomers may not be reacting with ozone because the free hydroxyl group is bound by the reacting polymer, and as a consequence of this, formic acid is not produced, or produced in only insignificant quantities. Another possible reason suggested by the rate constant for the formaldehyde–ozone reaction is that the 90-minute time interval was insufficient for the reaction to proceed at the part per million concentration of reactants.

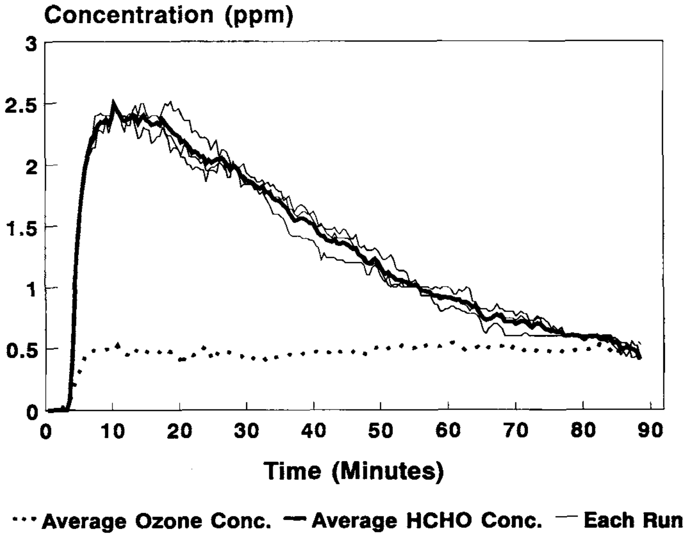

FIGURE 3. Change in concentration of formaldehyde in presence of constant concentration of ozone.

If ozone were used as an air purification agent using the method described in this article, one would hope it would be present in quantities less than 0.5 ppm since the PEL for ozone is 0.1 ppm. Presumably, at lower ozone concentrations, the likelihood of the formaldehyde–ozone reaction would diminish even further. In this evaluation, formaldehyde was initially present in peak concentrations in excess of the short-term exposure limit, at 3.3 times the PEL, and ozone was consistently present at 5 times the PEL.

Of critical importance to this discussion is the sensibility and utility of ozone as an air purification agent. Generation of ozone as a primary method of air purification is a serious issue because ozone is a regulated substance in both the occupational and ambient environment. The fact that the odor threshold for ozone is the same as the PEL, and that ozone can produce olfactory fatigue, makes it an especially insidious air contaminant. If ozone were used as an air purification agent in the same space being occupied by people, a high level of concern would be reasonable due to the health effects that are attendant with ozone exposure.

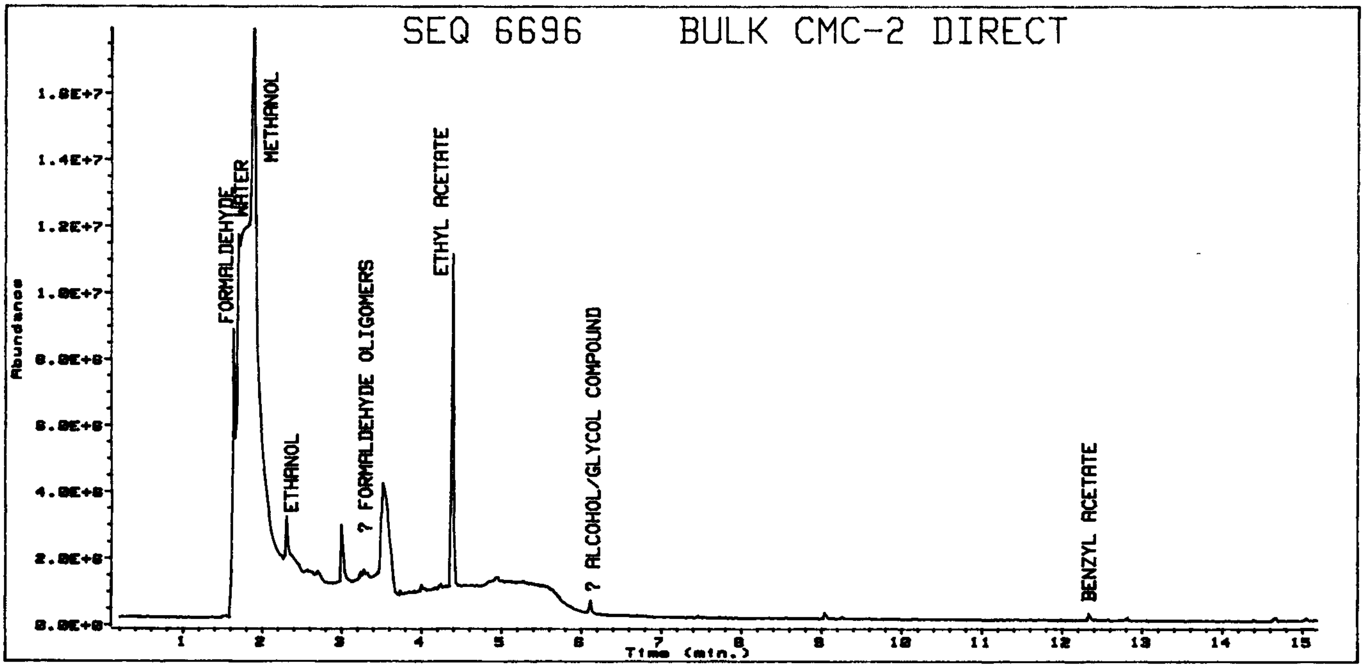

FIGURE 5. GC-MSD total ion chromatograph of embalming solution.

Historically, the proposed use of ozone as an air disinfectant can be found dating back to Victorian times.[19] Currently however, there is a tremendous amount of information available which conclusively addresses the respiratory toxicity of the chemical.[20-23] In fact, ozone has been called the most extensively studied chemical with respect to airway responsiveness.[24] Airway inflammation, a decrease in forced expiratory volume at 1 second (FEV_1) and damage to the ciliated cells are all noted as pulmonary responses to ozone exposure.[25]

Last, from a product safety perspective, adequate warnings are necessary with products which have the potential to create potentially toxic environments. Considerations of using an APD to reduce or eliminate air contaminants, whether chemical or biological, via introduction of a second contaminant like ozone, with the possible chemical interaction and evolution of a third contaminant, suggests the potential for creation of a toxic troika. If an employer used an ozone-generating APD in industry, the employer would need to comply with occupational safety and health regulations and limit employee exposure to ozone.

Conclusions

Ozone was not found to have any effect on reducing concentrations of formaldehyde in this investigation. In replicate 90-minute evaluations using static concentrations of 0.5 ppm ozone produced using an ozone-generating APD, no change was found in average concentrations of approximately 1.3 ppm formaldehyde with or without the use of ozone. Ozone is a widely studied toxic substance with demonstrated adverse health effects. It is a regulated air contaminant in both the occupational workplace and in the ambient environment. Based on the results of this experiment, ozone does not appear to be efficacious at reducing concentrations of formaldehyde in air. Considering the toxic nature of the substance, the use of ozone to improve the quality of indoor air does not appear to be warranted.

Disclaimer

Mention of company or product names does not constitute endorsement by the National Institute for Occupational Safety and Health.

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