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CHLOROFORM IN EMBALMING: A MODERN ABSURDITY

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ABSTRACT: Chloroform is still formulated into some old style embalming fluids and still used by some embalmers. The exposure dangers, environmental considerations and disposal hazards of chloroform is enormous. A history of chloroform and it's properties is systematically discussed. The health dangers and disposal problems are delineated. The marginal value of use in embalming fluid is explained. The specifics of chloroform exposure and the problems with disposal in the embalming room are covered. A summary and recommendations for elimination of chloroform in embalming fluid and embalming usage is discussed.

INTRODUCTION. Believe it or not, chloroform is still formulated into some old-fashioned and antiquated embalming fluid formulas. Some embalming chemical manufacturers currently make and sell embalming chemicals that contain chloroform as a designated hazardous ingredient. The use of chloroform is a leftover from the early days of embalming fluid manufacture when the use of this chlorinated solvent seemed prudent and the health dangers were not recognized. Today, there is no reason for chloroform to be in embalming fluid and the exposure and health hazards are significant and the environmental impact from use and disposal of chloroform is enormous. Chloroform is an additional carcinogenic chemical that is decidedly difficult to use and dispose of in the embalming room, with little or no practical value to justify its presence, let alone use by embalmers.

What is chloroform? Where did it come from? Why was it ever in embalming chemicals in the first place? What are the dangers to embalmers of its use? What are the hazards of use and disposal in embalming rooms and what's the solution to these problems? Let us begin with a discussion of the history and physical properties of this deadly chlorinated solvent.

HISTORY AND PHYSICAL PROPERTIES: Chloroform, a typical example of a trihalomethane, has become known as a relatively dangerous and potentially lethal solvent of industry. It was used with abandon in the past for a myriad of solvent type duties and as a chemical precursor for numerous chemicals. It is now treated with much more respect and care and its uses are severely limited compared to just a few decades ago.

Chloroform is a clear, colorless or water-white liquid with a sweet, burning, ethereal odor. It is essentially non-flammable, one of its only redeeming qualities from a safety point of view. It is slightly soluble in water, miscible in water might be a better characterization with less than 1 mg/ml solubility values. It sinks in water and can separate out under certain circumstances. It has a bad tendency to significantly dissolve and attack plastics, rubbers, latex, and coatings with deleterious effects. It has a vapor pressure at room temperature of 159mmHg, which makes chloroform a very volatile chemical. The vapor density is quite high at 4.12 compared to ambient air and chloroform sinks rapidly in the atmosphere which does allow it to be somewhat controlled by exhaust systems when it is evolved.

Chloroform reacts violently with strong bases and other oxidizers, sometimes explosively, with several byproducts of reaction. The chief uses of chloroform in industry is as a solvent and a precursor for manufacture of refrigerant chemicals, such as HCFC-22 and others. Other chemicals produced are diisocyanates and related chemical cousins. The other predominant use is as a solvent for pharmaceutical manufacture. A problem for manufacturers in the safety aspects of chloroform is the high odor threshold at anywhere from 85 ppm to 133-276 ppm, according to which source and scientific study you consult. At any rate, overexposure to chloroform invariably occurs before the odor is detected, a problematic situation for the chemical industry. The fatal oral dose is also quite low at 10ml or less, which is less than 1/3 ounce and the fatal inhalation dosage is not far behind. Needless to say, definitive safety measures need to be in place for safe manufacture and use in industry.

Another problem is that chloroform can evolve from other chlorination procedures in industry and cause an exposure problem. Chloroform can form from chlorination of swimming pools with chlorine chemicals and appear also in hot tubs, jacuzzis and even in municipal water treatment systems from various disinfection by chlorinated chemicals. Chloroform can even be detected from prolonged hot water showers in residences where chlorinated, treated municipal water is used as a source. A significant problem is the appearance of chloroform in the waste stream from paper pulp mills, with chloroform being an unwanted byproduct of bleaching of pulp and paper with chlorine. Chloroform discharge is also noted from sanitary service industry and sanitation chemical manufacture involving chlorine-based chemicals with the resulting environmental impact significant.

Chloroform, when released into the environment is mostly degraded by interaction with hydroxyl radicals (OH⁻) in the atmosphere, but is slowly degraded, if at all, when it seeps into groundwater. Its persistence and reactivity in soil is minimal and, consequently, it chiefly ends up in groundwater as a problem contaminant. The half-lives in air are surprisingly long at 3.2 months typically with total loss reaction occurring usually only after 5 months or more. The degradation products from atmospheric reaction are as or more dangerous

than chloroform. These include predominantly hydrogen chloride and phosgene, a highly reactive acid and a toxic gas, with both being contributors to pollution and unhealthy air.

Chloroform has been used for a laundry list of uses in the past. It has been used as a general purpose solvent for fats, oils and greases. It was in spot removers in earlier times. It has been used in fire extinguishers, along with carbon tetrachloride, chloroform's other deadly cousin. It saw use as an insecticide and pest fumigant and was used as an anesthetic gas in surgical operations. It was never effective as a useful disinfectant, as its spectrum of use was very limited and problematic. It has been banned by the FDA for all uses in food, drug and cosmetics.

The discovery of chloroform is generally credited to Liebig in 1831 and its appearance on the medical scene was the result of James Young Simpson's use of chloroform as an anesthetic gas for midwifery in Scotland in 1847. He had discovered that chloroform was more effective than ether, which was the current gas used for anesthesia. Chloroform became popular in anesthesia in 1857 after Queen Victoria used it for the childbirth of Prince Leopold. Chloroform "frolics" became popular in Victorian England as a result of its intoxicant properties and competed with ether inhalation parties as the preferred parlor game of the time (with the attendance of a royal physician considered *de rigeur*). These inhalation parties eventually subsided when it was discovered that chloroform and other intoxicant gases had serious exposure and health effects. The exposure problems and health dangers with chloroform are enormous and that is our next topic.

HEALTH EFFECTS AND EXPOSURE PROBLEMS: Chloroform is basically a human poison and the exposure hazards associated with its use are serious. Essentially, exposure typically occurs either by inhalation or ingestion, but skin absorption is also a definite exposure route. The vapors are irritating to the eyes and respiratory tract and a major effect of inhalation is CNS (central nervous system) depression. Cardiac arrhythmias can occur at high dosages with liver and kidney damage (typically manifested as hepatitis and jaundice) at varying lower doses. Inhalation effects also include GI (gastro-intestinal) effects, dizziness, nausea, headache, vomiting with resultant liver/kidney involvement.

Chloroform is on 10 Federal regulatory lists and is listed as a major toxicant and contributor to pollution. California Air Pollution Hot Spots lists chloroform as a hazard with a REL (reference exposure level) of 35mcg/m³, which is equal to roughly 7-8 ppb (parts per billion). Chloroform is embryotoxic and fetotoxic in numerous lab animals by both routes of exposure. It is teratogenic (birth defect causing) in animal studies with abortions and shortened term pregnancies with difficulties in rats and altered sperm production effects in mice.

Chloroform is classified as a carcinogen by about every agency there is. EPA lists it as 2B, IARC as 2B, NIOSH-X, NTP-R, ACGIH-A3, Federal Republic of Germany (MAK) as class 4 and the State of California as Ca (classified cancer causing). Animal studies have confirmed kidney and liver tumors by oral exposure and kidney tumors and necrosis by inhalation studies. It is implicated in colon, rectal and bladder cancers in various human epidemiological studies.

Skin absorption exposure results in redness, numbness, dry skin and eczema and skin defatting and necrosis with repeated exposures. A serious problem is that chloroform requires special chemically-resistant gloves (such as Viton and PVA), which are unsuitable for use in embalming rooms and other embalming chemicals. Consequently, there is no good way to protect from chloroform breakthrough and permeation in typical glove materials.

The limits for inhalation exposure are relatively low for such a volatile chemical. OSHA sets a ceiling of 50 ppm, while ACGIH establishes a more conservative 10 ppm for a TWA (8hr time weighted average) and NIOSH sets a 2 ppm limit with an unusual 2 hour time frame. The biggest problem is that the odor threshold is so extremely high compared to the maximum allowable exposure limits. Odor thresholds are reported as low as 85 ppm and as high as 133-276 ppm. This means that you are overexposed to chloroform at 4-10 times the allowable ACGIH limits (which are the most realistic) before you can even notice the chemical by smell.

Exposure of the general public to chloroform is by inhalation of polluted industrial air and off-gassing from manufacture, but most significantly by water supply contamination. Groundwater contamination by trihalomethanes, in general, is a serious environmental problem with expensive remediation necessary to restore water supplies to safe limits. Typical drinking water in the United States has trace or greater amounts of chloroform in it. The EPA limits for contamination are established at 100 mcg/L. Any amount above this contamination level must be remediated by filtration or other methods. The constant and persistent use of chlorine and chlorination products is the chief cause of this environmental pollution and contamination. Fortunately, chloroform does not significantly bio-accumulate in nature but can be found in stored fat deposits of humans with only slow dispersal. Chloroform is #11 on the list of hazards with the most environmental impact combined with human health hazards (The CERCLA Priority List of Hazardous Substances). Chloroform does not linger or accumulate in soil, however, accumulation and concentration in groundwater is significant with relatively long half-lives under varying conditions. A significant number of municipal water systems have chloroform and trihalomethanes contamination problems from polluted wells, aquifers and other surface water sources.

EMBALMING PROBLEMS: By now, it is obvious that the problems this chemical brings with it to the embalming room are overwhelming. Chloroform is a serious exposure to deal with in embalming fluid, not to mention the difficulties of storage, use and disposal. In addition to all the above, chloroform is another carcinogen in the embalming room, in addition to formaldehyde, wood dust compounds and TCE drywash/cleaning solvents. Why do we need another carcinogen in the embalming room?

The inhalation dangers are glaring: high volatility/vapor pressure with relatively low limits of safe exposure and odor threshold that is through the ceiling—allowing gross overexposure before detection. Skin absorption accidents are also a problem and an unsolvable problem with traditional nitrile or latex glove usage during embalming. Hopefully, you abandoned latex gloves long ago, if not do so, they are dangerous (due to allergenic potential) and useless against embalming chemicals. The breakthrough

times for latex is a pathetic 90 seconds or less for formaldehyde and not much better for other chemicals in embalming. It's a joke to be using latex during the embalming operation. Nitrile (the preferred embalming glove) is, however, not protective against chloroform and latex is useless. The only gloves suitable for chloroform use are terrible choices for water-based embalming scenarios and are not usable. Consequently, there is no glove that is practicable for embalming use and is effective against chloroform. Chloroform also aggressively attacks plastics, rubber goods and coatings on many of the items in a typical embalming room.

Chloroform, being a trihalomethane, is a major environmental impact chemical and groundwater contaminant. How will you use and dispose of chloroform in the embalming room? It ends up down the drain as a potential pollutant and you document your use and disposal of chloroform in your OSHA manuals and MSDS's. The potential liabilities should be readily obvious.

The value or necessity of chloroform in embalming fluids eludes me. It is just another old-fashioned alternative solvent that performs no better than any of the other solvent chemicals present in embalming fluids (actually, in a lot of ways it's inferior) and is a leftover from the old days when medicinal chemicals seemed the logical choice for embalming formulations. Disinfectant action or sanitation ability is very poor and not really of consequence in justifying its use. Modern lower exposure alcohols and their higher molecular weight cousins are much preferred solvents for modern aldehyde-based embalming use. The environmental impact of these alcohols is also minimized and the disposal problems during use are not a factor.

SOLUTIONS: Quite simply, eliminate it immediately. It's basically not necessary anyhow, so why bother? Who wants one more cancer-causing chemical in the embalming room? Not me! Check your MSDS's (Material Safety Data Sheets), you may be unpleasantly surprised to find chloroform contained in one or more of your embalming fluids. The Champion Company eliminated chloroform from formulation years ago, but other embalming fluid makers have not—Buyer Beware! Return any leftover chemical containing chloroform to the manufacturer and don't purchase anymore in the future. There will not be any noticeable impact on your embalming results—actually, you won't even notice the difference.

SUMMARY: Chloroform is a leftover from the early days of embalming and is essentially unnecessary in modern well-formulated embalming chemicals. It's a significant exposure and inhalation hazard, is a known carcinogen, and a skin absorption problem because embalming gloves are useless against penetration of chloroform. It's a disposal and use hazard and there is no way to not contaminate the waste stream coming from the funeral home. The liability of being a documented user and disposer is enormous and totally unnecessary. Stop using embalming chemicals with chloroform as a constituent, you'll never notice the difference anyway. Overall total reduction of exposure to chemicals is the goal that all embalmers should strive for. Chloroform is truly an absurdity in modern embalming — get it off the shelf and leave it in the history books where it belongs.

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