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HEXANE IN EMBALMING: A NEW AND UNNECESSARY EXPOSURE/DISPOSAL PROBLEM FOR EMBALMERS

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Abstract: Hexane is now available as a component of embalming drywash/cleaning solvents. Hexane represents an additional exposure and disposal hazard for embalmers to deal with. The value of hexane usage is minimal, at best, as a component solvent in drywash/cleaning solvent chemicals in embalming rooms. Hexane hazards and exposure problems are discussed. Attempts by other industries to eliminate hexane usage are reviewed. Environmental concerns and disposal difficulties are delineated. Recommendations for elimination of hexane use and implementation of alternative solvents are discussed and a summary follows.

COMPLACENCY IS THE DEATH KNELL OF AN INDUSTRY.

—JHB

INTRODUCTION: N-hexane is now being formulated into some brands of drywash/cleaning solvents that are available to the embalming industry. This is a very poor choice of a solvent type chemical for embalming usage. I fail to understand the logic of introducing another hazardous ingredient into the chemical mix of embalming, unless absolutely necessary and indispensable. Such is not the case with n-hexane. Hexane and other hydrocarbon style solvents are not far superior or exceptional in their solvent abilities compared to acetone/alcohol solvent mixtures that are now being used as alternatives

to the TCE/PERC (trichloroethylene/perchloroethylene) solvents that have massive exposure and disposal problems.

The focus for modern embalming chemical formulation should be elimination of hazardous ingredients, if possible, and reduction of overall total chemical exposure for the embalmer. There is already enough chemical exposure for embalmers — they do not need any additional exposures or other problems associated with new hazards.

What is n-hexane? What industries and for what purposes is hexane utilized as a solvent chemical? What are the health effects and exposure dangers associated with its use? What are the environmental problems that arise from usage and the impact of disposal? These and other questions are the focus of the following section.

PROPERTIES AND USE: Hexane is a clear, slightly oily liquid with a disagreeable pungent gasoline like odor. It is derived from crude oil/petroleum as an extract of gasoline derivative components mix. It is insoluble in water and lighter in weight, therefore it floats on top of water if spilled. It is highly flammable and highly volatile forming an explosive mixture if dispersed into air. The odor threshold is at least 65 ppm or much higher, which is problematic for sensory detection before overexposure. Hexane generally refers to n-hexane, the straight chain isomer of hexane. You will also find "commercial hexane" or "petroleum naptha or ether" and this refers to a complex mix of isomeric hexanes, heptanes, cyclohexane, methylcyclopentane, some smaller gasoline isomers and ketones. N-hexane usually account for 20-80% of these mixes. Gasoline itself contains typically 2-5% n-hexane.

Hexane reacts vigorously with oxidizers and strong bleaching agents such as sodium and calcium hypochlorites. It attacks and softens rubber, latex, plastics and coatings. The vapors are much heavier than air and sink rapidly (vapor density = 2.97 relative to air) and the vapor pressure is quite high at 150 mmHg, which results in the flammability problem with hexanes.

Hexane is a massive use chemical in the United States with several hundred million pounds used yearly. It is predominantly used as a cost-effective extraction solvent for vegetable oils from various soybeans, cottonseeds, flax, corn and peanuts. It is also found in large quantities as a solvent and component of special glues for the shoe industry, roofing materials, and leather joining uses. In addition, n-hexane is a cleaner/degreaser solvent in the printing industry, furniture finishing and shoemaking. It is also popular as a specialty solvent for automotive repair involving brake shoes and brake pads cleaning and degreasing. It is used as the liquid in low-temperature thermometers and is present as the solvent in hobby and rubber cements. It has been used in book binding operations and is used in glues to manufacture baseballs.

HEALTH EFFECTS: In the atmosphere, n-hexane will break down by mostly hydroxyl radical oxidation in a matter of a few days. Consequently, half-lives in the environment are thankfully short. Hexane floats on top of water and usually evaporates with out any serious pollution problems of surface water.

Such is not the case in underground waters, such as wells and aquifers, with hexane accumulating and lingering in these systems. There is no essential soil action or accumulation or bioaccumulation in animals, therefore the only serious problem is underground water supplies. The EPA has standardized a HA (Health Advisory Limit) of 4 ppm for water systems. Any water sources found above this level are advised to be remediated before human use. The major sources of pollution are leaking underground storage gasoline tanks, industrial spills and excessive releases by users.

The main sources of exposure for individuals are during use (from inhalation), splashing (skin contact) and spills (high level exposures). Everyone is exposed to some hexane in the air from diverse sources such as automobile exhaust in large cities, industrial emissions and filling up your gas tank on your car. Typically, in a large metropolitan city the ambient hexane is present at 2 ppb (2 parts per billion). Hexane is on 4 Federal Regulatory Lists and the TRI (Toxic Release Inventory). The main exposure problem areas for individual human exposures to hexane are refineries, shoe and leather factories, petrochemical lab technicians, typesetters and printers, tire and rubber workers and auto mechanics.

After inhalation, hexane appears rapidly in the blood stream and is broken down and eliminated in a few days. Hexane is excreted in urine, along with its metabolites, and also exhaled back out of the lungs. Hexane does not bioaccumulate in the body. One of the metabolites of hexane, 2,5-hexanedione, is more dangerous than hexane itself and is tracked in human urine as a bio-indicator of hexane exposure. 2,5-hexanedione is the probable cause of the serious nerve damage and paralysis that can occur with high exposures to hexane. 2,5-hexanedione will appear at 4-5 mg/L in urine of workers that have been exposed to 50 ppm hexane, which is over 5 times the amount found in the general population.

Early symptoms and effects of hexane inhalation or exposure include vertigo, giddiness, headache and sensory impairment. Long term or high dose exposures manifest several serious health effects that encompass paralysis, numbness of the feet, hands and lower legs and various paresthesias. The medical diagnosis for this syndrome of symptom manifestation is generalized peripheral neuropathy, wherein definite nerve damage has occurred and paralysis is the result, if not corrected. Fortunately, in exposed workers the numbness and paralysis is usually recoverable and reversible within 6 months to one year after elimination of exposures. The cases of serious hexane exposures have drastically declined over the years due to elimination of hexane in many industries, reduced use and improved worker protection. Shoe workers were the most affected in the past, with very high numbers of overexposures reported. Serious overexposure reports are thankfully now rare, even in this high use industry.

Cancer has never been found to manifest in animal or human studies and most agencies do not consider it classifiable as a carcinogen. Testicular damage has been noted in high-exposure rats and lung lesions in rabbits and mice. N-hexane is currently under review by the EPA for carcinogenic potential. Teratogenic (birth-defect causing) effects have not been consistently found and n-hexane is not classed as a teratogen, but as a chemical of interest in causation. A prenatal solvent exposure study found a correlation between n-hexane and other organic solvents to color vision defects in newborns to mothers that were exposed.

Skin exposure is a rare route of exposure, as workers are almost always protected adequately by impervious gloves. Skin exposures will manifest as skin redness, dermatitis, eczema and eczema-like reactions and localized pain. Acceptable gloves used in industry include nitrile, Viton and PVA (polyvinyl alcohol). Latex gloves are totally useless and are actually softened and dissolved by hexane and related hydrocarbons. Limits of exposure are 50 ppm by both NIOSH and ACGIH and 500 ppm by OSHA. The IDHL (immediately dangerous to health and life) limit is set at 1100 ppm. A major problem with hexane is that the odor threshold is not even approached before the limits of exposure are exceeded. The odor threshold is typically reported by humans at 130 ppm with as low as 65 ppm and as high as 248 ppm being also noted. In other words, a person is hopelessly overexposed before the chemical is detected by smell, a very bad situation.

Research has documented that enhanced effects of exposure are noted when hexanes are combined with ketone mixtures. The exact reasons for this are not known, perhaps due to lung absorption rates or volatilities, at any rates higher exposure potentials are reported for these mixtures. A persistent hexane exposure problem in the general population is the misuse of hexane-containing hobby and model cements and glues. Glue sniffing by teenagers is a not uncommon scenario with numerous reported instances of paralysis and neuropathies every year.

Industry is actively working toward reduction and elimination of hexane as a chemical of extraction and solvation, because of serious concerns about pollution and health effects from trace amounts of hexane residuals in products. Alternative solvents are being used experimentally and others are under investigation as a hexane replacement. Hexane residuals are present, but only in small amounts in cooking oils and vegetable oil products. This has been considered not a problem in the past due to the volatility and rapid evaporation of hexane at cooking and frying temperatures. More recent thinking is reevaluating this belief and the industry is looking for solutions to use altogether. Several major players in crop oils extraction have converted to cold-pressing and expresser technologies that eliminate hexane completely. Vegetable and other oils, thus produced, are contaminant-free and healthier as they are not hydrogenated and not subjected to hexane solvent and heating degradation. These newer style oils that are being produced have the characteristics and advantages of the traditional cold-pressed olive oils. Other problems with hexane in industry are air pollution (from off-gassing and evaporation) and chemical releases with resultant environmental impact. Hexane is on the Toxic Release Inventory and is not to be released into the environment by sewers, drains or other methods which could impact the water supply.

EMBALMING PROBLEMS: By now it should be obvious, that like most hazardous chemicals in the embalming room, hexane definitely has exposure, use and disposal problems. Is it worth it to have it in the complex of embalming chemicals that we already have? — I doubt it. It adds very little to the solvent characteristics of an acetone/multi-alcoholic solvent mix to justify it's addition. Perhaps it cuts some greases a little better than alternative solvents, but the improvement is minimal. It is, however, a big step up from the old style drywash/cleaning solvents that contained TCE and PERC (trichloroethylene and perchloroethylene) that had and still does have serious exposure hazards, use and storage

problems and is not capable of being used without environmental pollution in an embalming room scenario.

The inclusion of hexane into the solvent mix of these chemicals potentiates the exposure parameters by mixing in with various acetone/ketones and alcohols. The odor threshold problem is another aspect that should be taken into consideration. Why use non-essential hazardous chemicals in the embalming room that you cannot detect by smell unless you are already overexposed? This is an absurdity that defies all logic. In fact, because the gasoline-like smell of hexane is definitely disagreeable, a masking agent is included to override the hydrocarbon-like smell. Esters are the usual choice with isopropyl acetate or t-amyl acetate being typically used for their slightly fruity odors.

Laughably, in the embalming industry, these chemicals are listed as secret ingredients and not disclosed. They are, in fact, nothing more than perfuming agents to mask the disagreeable smell of the hexane. The whole concept of secret ingredients in the embalming industry is basically a joke any how, as essentially all manufacturers know or can easily find out what the "secret" ingredients are. Apparently, the purpose of stating "trade secret" ingredients is to baffle and mystify the industry and create a voodoo quality to the product. Unfortunately, this is a subterfuge and little more. The Champion Company has never been guilty of this practice and never will be.

If hexane or any other hazardous embalming chemical had an essential, unique and irreplaceable use in the embalming room, then it would have some justification for use. That is just not the case with n-hexane. Also, how do you use a drywash/cleaning solvent containing hexane without a significant amount ending up down the drain? It's virtually impossible. Hexane is insoluble in water, flammable and explosive and very volatile — it is, after all, a hydrocarbon gasoline derivative. I don't think it's a good idea to document your use and disposal of this type of chemical in embalming rooms.

Including hexane into the solvent mix of drywash/cleaning solvents adversely impacts the overall total exposure limits in a negative way. The drastically lower limits for n-hexane (50 ppm ACGIH) are at least 4 to 10 times lower than for an acetone/alcohol mix (500 ppm/200 ppm ACGIH) and the volatilities are all similar. This is pushing the exposure parameters in the wrong direction — toward increased exposures, not less.

SOLUTIONS AND SUMMARY: The solution with this situation is simple — you just don't have to use this chemical in the embalming room. There are alternative drywash/cleaning solvents that are acetone/alcohol based that perform adequately without the problems of hexane in the mix. If an embalmer feels that a hydrocarbon type solvent like this is absolutely necessary in certain situations, then have a small consumer use applicator bottle of spot remover for those infrequent situations. Use, exposure and disposal problems are drastically reduced or eliminated when using these small quantities of spot remover on a sporadic basis.

The only justifications for the introduction of new or additional hazardous chemicals into em-

balming rooms are: 1. The new chemical being introduced is so far superior to existing chemicals in typical use and embalming result that it's value overrides the additional exposure concerns that accompany the new chemical; 2. the new chemical, by being introduced and used as a replacement or supplement to existing chemicals, reduces the overall total exposure values of the embalming chemical mix, with a resultant lower overall exposure to the embalmer.

In my opinion, hexane in the mix of chemicals used as drywash/cleaning solvents in embalming rooms accomplishes neither of these goals, and its use is not necessary or justified.

BIBLIOGRAPHY: As you would expect, the literature on hexane and its cousins is voluminous. Following are selected references to guide you in the examination of this massive body of research.

Hamelin,G.,et.al., Comparison of unchanged n-hexane in alveolar air and 2,5-hexanedione in urine for the biological monitoring of n-hexane exposure in human volunteers. Int Arch Environ Health. 2004 May;77(4): 264-70.

Yu,IT., et.al., Occupational exposure to mixtures of organic solvents increases the risk of neurological symptoms among printing workers in Hong Kong. J Occup Environ Med. 2004 Apr;46(4): 323-30.

Prieto,MJ., et.al., Free and total 2,5-hexanedione in biological monitorings of workers exposed to n-hexane in the shoe industry. Toxicol Lett. 2003 Dec. 10; 145(3): 249-60.

Gobba.F., Cavalleri,A., Color vision impairment in workers exposed to neurotoxic chemicals. Neurotoxicology. 2003 Aug; 24(4-5): 693-702.

Baldasseroni,A., et.al., Occupational exposure to n-hexane in Italy - analysis of a registry of biological monitoring. Int Arch Occup Environ Health. 2003 May;76(4): 260-6.

Hernandez-Viadel,M., et.al., Chronic exposure to 2,5-hexanedione impairs the glutamate-nitric oxide cyclic GMP pathway in cerebellar neurons in culture and in rat brain in vivo. Neurchem Int. 2003 Jun;42(7): 525-33.

Yost,MG., et.al., An evaluation of Fourier transform infrared (FTIR) spectroscopy for detecting organic solvents in expired breath. Appl Occup Environ Hyg. 2003 Mar; 18(3): 160-9.

Mateus,ML., et.al., Evidence of zinc protection against 2,5-hexanedione neurotixicity: correlation of neurobehavioral testing with biomarkers of excretion. Neurotoxicology 2002 Dec; 23(6): 747-54.

Iregren,A., et.al., Color vision and occupational chemical exposures: I. an overview of cause and effect. Neurotoxicology. 2002 Dec; 23(6): 719-33.

Georgieva, T., et.al., Possibilities to control the health risk of petrochemical workers. Int Arch Occup Environ Health. 2002 Oct; 75 Suppl:S21-6.

dos Santos,DR, et.al., Evaluation of 2,5-hexanedione in urine of workers exposed to n-hexane in Brazilian shoe factories. J Chromatogr B Analyt Technol Biomed Life Sci. 2002 Oct 5;778(1-2)

Mayan,O., et.al., Urinary 2,5-hexanedione as a biomarker of n-hexane exposure. Biomarkers. 2002 Jul-Aug;7(4): 299-305.

Pastore, C., et.al., Partial conduction blocks in n-hexane neuropathy. Muscle Nerve 2002 Jul;26(1): 132-5.

Burgaz,S., et.al., Cytogenetic analysis of buccal cells from shoe-workers and pathology/anatomy laboratory workers exposed to n-hexane, toluene, methylethyl ketone and formaldehyde. Biomarkers 2002 Mar-Apr; 7(2):151-61.

Issever,R, et.al., Impairment of colour vision in patients with n-hexane exposure dependent toxic polyneuropathy. Occup Med(Lond). 2002 Jun; 52(4): 183-6.

Shibata,E., et.al., Changes in n-hexane toxicokinetics in short-term single exposure due to exposure to methylethyl ketone in volunteers. Int Arch Occup Environ Health. 2002 Aug; 75(6): 399-405.

Spencer,PS., et.al., Aromatic as well as aliphatic hydrocarbon solvent axonopathy. Int J Hyg Environ Health. 2002 Mar; 205(1-2): 131-6.

Yu,RC., et.al., Toxicokinetic interaction of 2,5-hexanedione and methyl ethyl ketone. Arch Toxicol. 2002 Jan; 75(11-12): 643-52.

Carney,R, et.al., Early spatial memory deficit induced by 2,5-hexanedione in the rat. Toxicol Lett. 2002 Mar 10;128(1-3): 107-15.

Kuang,S., et.al., A clinical analysis of 102 cases of chronic n-hexane intoxication. Zhonghua Nei Ke Za Zhi. 2001 May; 40(5): 329-31(Chinese trans-abstract only),

Beall,C., Case-control study of intracranial tumors among employees at a petrochemical research facility. J Occup Environ Med. 2001 Dec; 43(12): 1103-13.

Pandit,GG., et.al., Monitoring of indoor volatile organic compounds and polycyclic aromatic hydrocarbons arising from kerosene cooking fuel. Sci Total Environ. 2001 Nov 12;279(1-3): 159-65.

Nijem,K., et.al., Solvent exposures at shoe factories and workshops in Hebron city, West Bank. Int J Occup Environ Health. 2001 Jul-Sep; 7(3): 182-8.

Ritchie,GD., et.al., A review of the neurotoxicity risk of selected hydrocarbon fuels. J Toxicol Environ Health B Crit Rev. 2001 Jul-Sep;4(3): 223-312.

Nijem,K., et.al., Prevalence of neuropsychiatric and mucous membrane irritation complaints among Palestinian shoe factory workers exposed to organic solvents and plastic compounds. Am J Ind Med. 2001 Aug; 40(2): 192-8.

Mayan,O., et.al., Biological monitoring of n-hexane exposure in Portuguese shoe manufacturing workers. Appl Occup Environ Hyg. 2001 Jul;16(7): 736-41.

Palermo-Neto,J., et.al., Glue solvent inhalation impairs host resistance to Mycobacterium bovis-induced infection in hamsters. Vet Hum Toxicol. 2001 Feb;43(1): 1-5.

N-Hexane: Medical Guidelines. Hazard Evaluation System and Information. State of California. Dept. of Health Services, Dept. of Industrial Relations. Revised July 2000.

US Environmental Protection Agency., Integrated risk information system and chemical profiles. n-Hexane., Natl. Ctr. for Environmental Assessment. Office of Research and Development. Washington, D.C. 1999(revised).

OSHA Registry of Toxic Effects of Chemical Substances. On-Line Ed., n-hexane and related isomers. National Institute for Occupational Safety and Health. Cincinnati, OR, 1999(revised).

New Jersey Hazardous Substance Fact Sheet - Hexane., State of New Jersey., Dept. of Health and Senior Services., 1999(revised).

Agency for Toxic Substances and Disease Registry (ATSDR)., 1999(revised). Toxicological profile for hexane. Atlanta, Ga., US Dept. of Health and Human Services, Public Health Service Publication.

N-Hexane: International Chemical Safety Card., NIOSH division, Center for Disease Control., Washington, D.C. office., 2003.