Embalming Chemicals

Embalming chemicals are a variety of preservatives, sanitizing and disinfectant agents and additives used in modern embalming to temporarily prevent decomposition and restore a natural appearance for viewing a body after death. A mixture of these chemicals is known as **embalming fluid** and is used to preserve deceased individuals, sometimes only until the funeral, other times indefinitely.

Typically embalming fluid contains a mixture of formaldehyde, methanol, ethanol and other solvents. The formaldehyde content generally ranges from 5 to 29 percent and the ethanol content may range from 9 to 56 percent.

How They Work

Simply explained, embalming fluid acts to *fix* (denature) cellular proteins, which means that they cannot act as a nutrient source for bacteria and it also kills the bacteria themselves. Formaldehyde fixes tissue or cells by irreversibly connecting a primary amine group in protein with nearby nitrogen in protein or DNA through a $-CH_2-$ linkage called a Schiff base. The end result also creates the simulation, via color changes, of the appearance of blood flowing under the skin.

Modern embalming is not done with a single fixative. Rather various different chemicals are used to create a mixture called an arterial solution which is generated specifically for the needs of each case. For example a body needing to be repatriated overseas needs a higher index (percentage of diluted preservative chemical) than one simply for viewing (known in the United States and Canada as a funeral visitation) at a funeral home before cremation.

Process

Embalming fluid is injected into the arteries of the deceased during embalming. Many other bodily fluids may be drained or aspirated and replaced with the fluid as well. The process of embalming is designed to slow or stop decomposition of the body.

Chemicals and Additives

It is important to distinguish between an arterial chemical (or fluid), which is generally taken to be the product in its original composition, and an arterial solution, which is a diluted mixture of chemicals and made to order for each body. Non-preservative chemicals in an arterial solution are generally called "accessory chemicals" or co/pre-injectants, depending on their time of utilization.

Potential ingredients in an arterial solution include:

- Preservative (Arterial) Chemical. These are commonly a percentage (normally 18%-35%) based mixture of formaldehyde, glutaraldehyde or in some cases phenol which are then diluted to gain the final index of the arterial solution. Methanol is used to hold the formaldehyde in solution. Formalin refers specifically to 37% aqueous formaldehyde and is not commonly used in funeral embalming but rather in the preservation of anatomical specimens.

- Water Conditioner. These are designed to balance the "hardness" of water (the presence of other trace chemicals that changes the water's pH or neutrality) and to help reduce the deceased's acidity, a by-product of decomposition, as formaldehyde works best in an alkaline environment. Additionally, water conditioners may be used to help "inactivate" chemotherapy drugs and antibiotics which may bind to and render ineffectual the preservative chemical.

- Cell Conditioner. These chemicals act to prepare cells for absorption of arterial fluid and help break up clots in the bloodstream.
- Dyes. Active dyes are use to restore someone's natural coloration and counterstain against conditions such as jaundice as well as to indicate distribution of arterial fluid. Inactive dyes are used by the manufacturer of the arterial fluid to give a pleasant color to the fluid in the bottle, but does nothing for the appearance of the embalmed body.
- Humectants. These are added to dehydrated and emaciated bodies to help restore tissue to a more natural and hydrated appearance.
- Anti-Edemic Chemicals. The opposite of humectants these are designed to draw excessive fluid (edema) from a body.
- Additional Disinfectants. For certain cases, such as tissue gas, specialist chemicals normally used topically such as Dis-Spray are added to an arterial solution.
- Water. Most arterial solutions are a mix of some of the preceding chemicals with tepid water. Cases done without the addition of water are referred to specifically as

"waterless". Waterless embalming is very effective but not economically viable for everyday cases

- Cavity Fluid. This is a generally a very high index formaldehyde or glutaraldehyde solution injected undiluted directly via the trocar incision into the body cavities to treat the viscera. In cases of tissue gas phenol based products are often used instead.
- Prior to the advent of the modern range of embalming chemicals a variety of alternative additives have been used by embalmers, including Epsom salts for endemic cases and milk in cases of jaundice, but these are of limited effectiveness.
- A famous arsenical embalming compound in the late 19th century was Professor Pludeman's Eternal Egyptian Embalming Elixir. It was also recommended as a tonic and nostrum, reported to cure a litany of afflictions. Professor Pludeman claimed to consume a tablespoon daily, until he died of heavy metal poisoning.
- Embalming chemicals are generally produced by specialist manufacturers, two of the oldest and biggest being the Dodge and Champion Companies but there are many smaller and regional producers such as Lears, Genelyn, Frigid to name but a few among hundreds. Additionally many funeral homes generate their own fluids.
- Following the EU Biocides Legislation it is possible that formaldehyde may be banned in Europe in September 2006. IARC Classes Formaldehyde as a Class 1 Carcinogen. There are alternatives to formaldehyde and phenol-based fluids, but these are technically not preservatives but rather sanitizing agents and are not widely accepted. As of the end of September it is now illegal to sell or use phenol in embalming. Formaldehyde although now illegal to sell within Europe due to non compliance with EU law will continue exploiting a loophole in the law till 2008.

Formaldehyde

The chemical compound **formaldehyde** (also known as **methanol**) is a gas with a pungent smell. It is the simplest aldehyde. Its chemical formula is H_2CO. Formaldehyde was first synthesized by the Russian chemist Aleksandr Butlerov in 1859 but was conclusively identified by August Wilhelm von Hofmann in 1868.

Formaldehyde readily results from the incomplete combustion of carbon-containing materials. It may be found in the smoke from forest fires, in automobile exhaust, and in tobacco smoke. In the atmosphere, formaldehyde is produced by the action of sunlight and oxygen on atmospheric methane and other hydrocarbons. Small amounts of formaldehyde are produced as a metabolic byproduct in most organisms, including humans.

Properties

Although formaldehyde is a gas at room temperature, it is readily soluble in water. It is most commonly sold as a 37% aqueous solution with trade names such as **formalin** or **formol**. In water, formaldehyde converts to the hydrate $CH_2(OH)_2$. Thus formalin contains very little H_2CO. These solutions usually contain a few percent methanol to limit the extent of polymerization.

Formaldehyde exhibits most of the chemical properties of the aldehydes, except that it is more reactive. Formaldehyde is a good electrophile. It can participate in electrophilic aromatic substitution reactions with aromatic compounds and can undergo electrophilic addition reactions with alkenes. In the presence of basic catalysts, formaldehyde undergoes a Cannizaro reaction to produce formic acid and methanol.

Formaldehyde reversibly polymerizes to produce its cyclic trimer, 1,3,5-trioxane or the linear polymer polyoxymethylene. Because of the formation of these derivatives, formaldehyde gas deviates strongly from the ideal gas law, especially at high pressure or low temperature.

Formaldehyde is readily oxidized by atmospheric oxygen to form formic acid. Formaldehyde solutions should be protected from air.

Production

Industrially, formaldehyde is produced by the catalytic oxidation of methanol. The most commonly used catalysts are silver metal or a mixture of an iron oxide with molybdenum and vanadium. In the more commonly used iron oxide system (Formox process), methanol and oxygen react at 250°C to produce formaldehyde according to the chemical equation:

$$\mathbf{2\ CH_3OH + O_2 \rightarrow 2\ H_2CO + 2\ H_2O}$$

The silver-based catalyst is usually operated at a higher temperature, about 650 °C. On it, two chemical reactions simultaneously produce formaldehyde: the one shown above, and the dehydrogenation reaction:

$$\mathbf{CH_3OH \rightarrow H_2CO + H_2}$$

Further oxidation of the formaldehyde product during its production usually gives formic acid which is found in formaldehyde solution, found in ppm values.

On a smaller scale, formalin can be produced using a whole range of other methods including conversion from ethanol instead of the normally-fed methanol feedstock. Such methods are of less commercial importance.

Biology

An aqueous solution of formaldehyde can be used as a disinfectant as it kills most bacteria. It is also used as a preservative in vaccinations. In medicine, formaldehyde solutions are applied topically to dry the skin, such as in the treatment of warts.

Formaldehyde mixed with 30-35% of water is called FORMALIN which is used to store biological specimens in laboratories. Formaldehyde preserves or fixes tissue or cells by irreversibly cross-linking primary amine groups in proteins with other nearby nitrogen atoms in protein or DNA through a -CH2- linkage.

Formaldehyde based solutions are used in embalming to disinfect and temporarily preserve human remains pending final disposition. It is the ability of formaldehyde to fix the tissue that produces the tell-tale firmness of flesh in an embalmed body. While other, heavier aldehydes also produce a similar firming action, none approaches the completeness of formaldehyde.

Formaldehyde is also used as a detergent in RNA gel electrophoresis, preventing RNA from forming secondary structures.

Industry

Most formaldehyde is used in the production of polymers and other chemicals. When combined with phenol, urea, or melamine, formaldehyde produces a hard thermoset resin. These resins are commonly used in permanent adhesives, such as those used in plywood or carpeting. It is used as the wet-strength resin added to sanitary paper products such as (listed in increasing concentrations injected into the paper machine headstock chest) facial tissue, table napkins, and roll towels. They are also foamed to make insulation, or cast into molded products. Production of formaldehyde resins accounts for more than half of formaldehyde consumption.

Formaldehyde is still used in low concentrations for process C-41 (color negative film) stabilizer in the final wash step, as well as in the process E-6 pre-bleach step, to obviate the need for it in the final wash.

Formaldehyde is also used to make numerous other chemicals, used in personal care products such as toothpaste. Many of these are polyfunctional alcohols such as pentaerythritol, which is used to make paints and explosives. Other formaldehyde derivatives include methylene diphenyl diisocyanate, an important component in polyurethane paints and foams, and hexamine, which is used in phenol-formaldehyde resins and to make the explosive RDX.

Formaldehyde, along with 18 M (concentrated) sulfuric acid (the entire solution often called the Marquis reagent) is used as an MDMA "testing kit" by such groups as Dancesafe as well as MDMA consumers. The solution alone cannot verify the presence of MDMA, but reacts with many other chemicals that the ecstasy tablet itself may be cut with. The reaction itself produces colors which correlate with such chemicals.

Health Effects

In high amounts formaldehyde is toxic. Because formaldehyde resins are used in many construction materials, including plywood and spray-on insulating foams, and because these resins slowly give off formaldehyde over time, formaldehyde is one of the more common indoor air pollutants. At concentrations above 0.1 ppm in air, formaldehyde can irritate the eyes and mucous membranes, resulting in watery eyes. If inhaled, formaldehyde at this concentration may cause headaches, a burning sensation in the throat, and difficulty breathing, as well as triggering or aggravating asthma symptoms. The United States Environmental Protection Agency USEPA allows no more than 0.016 ppm formaldehyde in the air in new buildings constructed for that agency.

Large formaldehyde exposures, for example from drinking formaldehyde solutions, are potentially deadly. Formaldehyde is converted to formic acid in the body, leading to a rise in blood acidity (acidosis), rapid, shallow breathing, blurred vision or complete blindness, hypothermia, and, in the most severe cases, coma or death. People who have ingested formaldehyde require immediate medical attention.

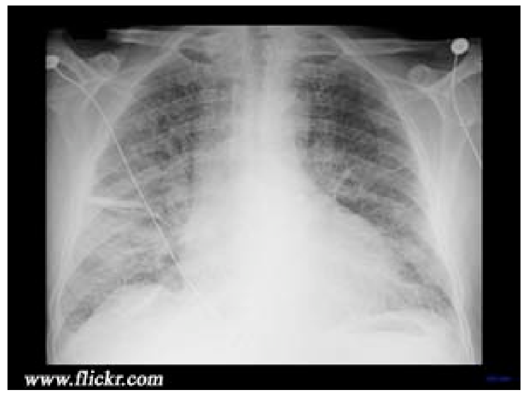
In the body, formaldehyde can cause proteins to irreversibly bind to DNA. Laboratory animals exposed to large doses of inhaled formaldehyde over their lifetimes have developed more cancers of the nose and throat than are usual, as have workers in particle-board sawmills. However, some studies suggest that smaller concentrations of formaldehyde like those encountered in most buildings have no carcinogenic effects. Formaldehyde is classified as a probable human carcinogen by the U.S. Environmental Protection Agency, and as having sufficient evidence that formaldehyde causes nasopharyngeal cancer in humans by the International Agency for Research on Cancer.

Formaldehyde can cause allergies, and is part of the standard patch test series. People with formaldehyde allergy are advised to avoid formaldehyde-releasing chemicals as well (e.g. Quaternium-15, imidazolidinyl urea, and diazolidinyl urea).

Occupational Health and Safety

Formaldehyde is mainly produced by the oxidation of methanol, itself obtained from natural gas. It is primarily used to produce glues used in the manufacture of particleboard, veneers, wood furniture and other wood products. Formaldehyde is also used in the manufacture of various plastics, some fertilizers, resins used in foundry sand moulds, and some paints and varnishes. The textile industry uses these resins as finishers to make fabrics crease-resistant. The substance is also used in the synthesis of other chemical products and for its bactericidal properties in many formulations of disinfectant products, cosmetics, embalming fluids and solutions for preserving biological tissues.

Occupational exposure to formaldehyde by inhalation is mainly from three types of sources: thermal or chemical decomposition of formaldehyde-based resins, formaldehyde emission from aqueous solutions (for example, embalming fluids), or the production of formaldehyde resulting from the combustion of a variety of organic compounds (for example, exhaust gases). In the workplace, exposure to formaldehyde occurs in various ways. In its gaseous form, it is absorbed by the respiratory tract; in aqueous solution, it is absorbed through skin contact. The health effects associated with exposure to this substance vary with the exposure route and the concentration or dose absorbed.



In extreme situations such as accidents, formaldehyde may be present at high concentrations in the air, representing a considerable immediate danger. Concentrations equal to or greater than 20 ppm can cause serious pulmonary oedema and eventually death. In the case of direct skin contact, formaldehyde may produce skin lesions such as irritation, irritant contact dermatitis and allergic contact dermatitis. The symptoms are itching, tingling and redness. Skin sensitization is likely to appear after contact with aqueous solutions of formaldehyde at concentrations equal to or greater than 2%, or even solids or resins containing free formaldehyde. When someone is sensitized, skin allergy (erythema) symptoms may occur at every contact with solutions of increasingly lower concentration (starting at 0.5% formaldehyde).

These effects are easily avoidable by protecting exposed skin for example, by wearing gloves. Following exposure to contaminated air, the first effect is irritation of the mucous membranes of the eye and upper respiratory tract (nose and throat). The related symptoms are tingling, redness or burns to the nose and throat, nasal discharge and watery eyes. These symptoms are generally negligible to slight for formaldehyde concentrations below 1 ppm. They can become bothersome and even intolerable at higher concentrations mainly when they exceed 2 to 3 ppm. In rare cases, formaldehyde causes sensitizing or allergic type changes in lung function.

These are manifested by a decrease in lung capacity and by asthma attacks likely to recur at decreasing concentrations. These effects were observed with asthmatic and non-asthmatic subjects exposed to more than 2 ppm.(2) Nevertheless, there is no consensus in scientific literature that asthmatics have a more severe reaction to formaldehyde exposure than non-asthmatics. The allergenic effect of formaldehyde can be worsened by the presence of particles or dust (for example, wood dust), that trigger bronchial reactions even at concentrations below 2 ppm.

Getting Back to Basics

The ability to analyze the predisposing conditions surrounding the death is one of the most critical aspects of the embalming process. This includes: How these conditions influence the outcome of the embalming process, what would be the potential dangers associated with the death to the embalmer and the anatomical changes and/or the environment. To find answers to these and other questions that impact how the body is embalmed requires a certain amount of analytical skill. The professional licensed embalmer's analytical skills must be cultivated once the initial required education has been completed. This is enhanced during a well-supervised internship under the careful eye of a qualified preceptor or mentor. The embalmer must develop a well-cultivated ability to think through the basics that will preserve the true art and science of embalming. To forget these basic facts is to destroy the foundation of the funeralization process.

The embalming process begins with complete controlled disinfection of the body from the time of removal to the final dressing or disposal of the body, even if direct disposal is requested. A safe working environment must be maintained. It is important to have a family member identify the body of the deceased especially if direct cremation is the choice of final disposition. Sanitation procedures must be followed not only for the family, but for those who are responsible for the care and treatment of the body.

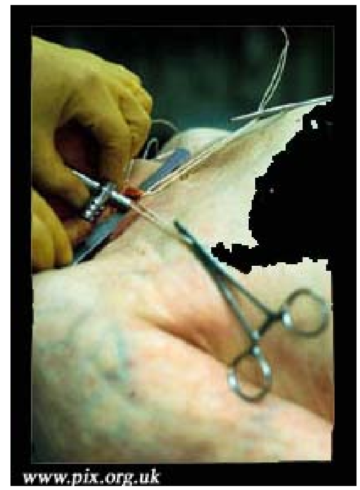
In some instances, the art of embalming has become the major concern with the advent of centralized preparation facilities with high volume preparation. This focus on the art results in some situations where the visual aspects of the treatment meet the psychological needs of the bereaved, but the biological needs are not fully met. Preservation is as vital, if not more so, than the art of embalming. Without adequate preservation, the body becomes a medium for the growth of pathogenic microbes that continue to mutate and become opportunistic in character. If bodies are not saturated with quality germicidal arterial fluids, we have not truly achieved depth preservation and areas that could support microbial growth could be present. It is the body tissue mass as well as the enzymes that must be inactivated. It is the operator's option as to method of embalming, what anatomical point of injection to use and how to control the drainage that will result in sufficient chemical saturation.

As an example, let's say the cervical injection is our primary point of choice. An incision is made approximately one inch in length between the sternal and clavicular attachment of the sternocleidomastoid muscle. This only means the surface incision is small. Internally, the blunt dissected may be as much as three inches allowing the operator ample space to dissect the vessels. Once the vessels are exposed we can insert a drain tube of ample size to fill the lumen of the internal jugular vein and a short arterial tube superiorly and inferiorly in the right common carotid artery. The superior arterial tube would be inserted so as not to enter the right internal carotid bypassing the external carotid or in the external carotid bypassing the internal carotid artery.

The arterial tube is placed inferiorly just above the bifurcation of the right common carotid and right subclavian. In most cases, the embalmer will be able to control the distribution of the arterial injection throughout the body.

The only concern as to length of the arterial tubes used would be not knowing their position. Entry into the internal carotid artery would bypass the external carotid artery, which would prevent fluid from going into the face. Inferiorly, too long of an arterial tube could pass the right subclavian and enter directly into the brachiocephalic artery preventing distribution into the right arm.

At this point, one must determine what type and strength of arterial fluid is to be used. The common practice is to fill the embalming machine tank, add one bottle of fluid and inject. Some operators will analyze each individual body and approach the arterial injection on an individual basis. Others fill the tank prior to seeing the body and inject every body the same.



Due to the circumstances associated with the death, some operators choose to use a preinjection chemical or a very weak dilution to prepare the vascular system for final injection. After the primary injection the following concentrations are increased as to the needs of the process. Dehydration may be due in part to the cause of death, the arterial chemical strength or environment in which the body is retained. Internal control may be the method of choice to restore naturalness to the tissue, body and features. As important as the arterial injection is the method of controlled drainage for depth preservation. We have two choices: continuous free flow or restricted.

Continuous injection and drainage have always been considered the least effective and least scientifically correct method of embalming. Yet it still is the most popular method currently used today. On the other hand, it might be the most dangerous to the operator and environment.

Continuous injection and drainage allow the arterial fluid to follow the course of least resistance. We get surface preservation that serves the art purpose (creates a memory picture). We do have another consideration, knowing the sewage system is well saturated with high levels of toxic preservative chemicals that are not absorbed into the body tissues.

Alternate injection and drainage has been considered to be as scientifically correct a method of embalming because it allows the arterial chemical to overcome the internal resistance. This provides the opportunity for the arterial chemical to saturate the body tissue for depth preservation. Retention of the active preservative chemicals in the body tissue is the objective of the embalming process, not the external environment. Once the arterial injection is complete, aspiration should be considered. The question is how soon after the embalming do we aspirate the contents of the hollow organs? Two schools of thought exist. The first is immediately after injection. The other is to wait until the arterial chemical has had some time to interact with the visceral organs. This creates the necessary rigidity to allow the trocar to penetrate and drain the contents of the hollow organs.

The point of entry of the trocar should be of major concern to prevent cross-contamination of the visceral organs. A method for consideration would be an entry point at the level of the diaphragm. Using the diaphragm as a natural barrier, insert the trocar superior into the thoracic cavity and aspirate the contents. Completely remove the trocar, clean/sanitize and reinsert inferiorly and aspirate the abdominal and pelvic cavities. Follow the same procedure for injecting cavity chemical. Following the aforementioned procedure of aspiration, respirate the body prior to shipping and/or dressing the body. All orifices should be cleaned and packed.