

Bio-medical waste



Toxics Link
Factsheet
Number 27 / Dec 2005

Formaldehyde: A deadly disinfectant

Healthcare workers use formaldehyde regularly as a disinfectant and tissue fixative. This factsheet is an attempt to unveil formaldehyde – its uses, threats and measures to minimise its harmful effects.

Formaldehyde (FAH) is a colourless, flammable gas with a strong pungent odour. It is highly soluble in water and up to 55 per cent soluble in ether, acetone, benzene and alcohol. Being highly reactive, it combines readily with many substances and polymerises. It reacts violently with perchloric acid, aniline, performic acid, nitromethane, magnesium carbonate and hydrogen peroxide.

FAH is used in the liquid form as a water and methanol solution called formalin. This derivative of FAH is a mixture of 37-40 per cent formaldehyde, water and usually 10 per cent methanol. It has a clear to milky appearance and is also available as a white powder called para-formaldehyde.

Sources and uses

FAH is both directly emitted into the atmosphere and also formed in the atmosphere as a result of photochemical oxidation of reactive organic gases in polluted atmospheres containing ozone and nitrogen oxides. Vehicular exhaust and incomplete combustion are also prominent sources of formaldehyde. Catalytic cracking, coking operations and fuel combustion processes in refineries also produce FAH. Stone, clay and glass production processes that use fuel combustion sources such as boilers, furnaces and engines also generate formaldehyde. It is also a by-product of photochemical smog and smoke generated from incinerators and cigarettes. Unfortunately, it takes years to finally dissipate after being used in manufactured products.

FAH-based resins are used in pressed wood, cotton permanent press, grocery bags and waxed paper. It is also used in carpet



Formaldehyde is an effective disinfectant but can cause damage to those who come in contact with it.

AT A GLANCE

- ❖ Formaldehyde (FAH) is used as an anti-microbial bactericide and fungicide for maintenance of critical and semi-critical hospital equipment, floors, walls and other hospital areas.
- ❖ Chronic exposure to FAH is associated with respiratory symptoms and eye, nose and throat irritation.
- ❖ There is also evidence that women workers exposed to FAH experience menstrual disorders and pregnancy problems.
- ❖ Proper ventilation and protective clothing is key to reducing the risk of healthcare workers' exposure to FAH fumes.
- ❖ Switching to alternative disinfectants such as UV is the long-term solution to prevent exposure to this carcinogen.

Possible sources of formaldehyde at homes

The following is a list of household products that may contain FAH or FAH releasing agents:

- ◆ Adhesives, glues
- ◆ Air fresheners
- ◆ Cigarette smoke
- ◆ Cosmetics
- ◆ Dyes, paints
- ◆ Fibre board, particle board – furniture, fixtures, cabinets
- ◆ Floor polishes
- ◆ Fuel burning appliances – wood, kerosene
- ◆ Household liquid scouring cleaners
- ◆ Household rug and upholstery cleaners
- ◆ Markers
- ◆ Paper products
- ◆ Toilet bowl cleaners

The most probable route of human exposure to formaldehyde is inhalation. Inhaling it can cause symptoms ranging from mild irritation to severe difficulty in breathing

and furniture glues and can contaminate office air. Detergents, cosmetics and other domestic chemicals contain formaldehyde as an anti-microbial agent. FAH is also used in fumigants, soil disinfectants, embalming fluids and leather tanning. It is also used for disinfecting, cleaning and sterilising animal premises, such as chicken and poultry handling facilities.

Formaldehyde products have a variety of uses in hospitals:

- ◆ As tissue preservatives and in embalming fluids in autopsy rooms and pathology departments.
- ◆ In kidney dialysis units and central supply as a sterilising agent.
- ◆ In operating rooms as a disinfectant.

FAH is used as an anti-microbial bactericide and fungicide for the maintenance of critical and semi-critical hospital equipment, floors, walls and other hospital areas.

Pathologists use FAH as a tissue fixative. Physicians, nurses and dentists routinely use it in disinfection procedures. Technicians and cleaning personnel in healthcare facilities are also routinely exposed to FAH. Many detergents, disinfectants and cleaning agents used may also contain FAH.

Routes of exposure

There are four routes of exposure to a substance: ingestion, inhalation, skin absorption and eye contact. Since people may adapt to FAH, dependency upon the perception of formaldehyde by odour and eye irritation can lead to overexposure if the worker

is relying on these cues as a warning.

Ingestion: Eating or drinking is not considered a route to significant exposure to FAH. Nevertheless, cases have been reported of accidental FAH ingestion. Swallowing liquids containing 10 to 40 per cent FAH results in severe irritation of the mouth, throat and stomach. Severe stomach pains follow with possible loss of consciousness and death.

Inhalation: The most probable route of human exposure to FAH is inhalation. Inhaling FAH can cause symptoms ranging from mild irritation to severe difficulty in breathing. The effect depends on the concentration of FAH. A concentration of 100 ppm is dangerous to health and life.

Skin absorption: This is a major route of exposure. Skin contact with FAH can result in reactions ranging from mild irritation to severe allergic dermatitis. Concentrated solutions of FAH will cause the skin to discolour, crack, dry and scale. A number of factors affect skin absorption of FAH. Absorption is increased if there is an existing dermatitis or acne and if the skin is broken or irritated. High humidity and the area of the skin exposed will also affect the degree of absorption. Allergic contact dermatitis is commonly seen among medical personnel who use FAH.

Eye contact: Eye contact results from spills or splashes of FAH. Eye contact reactions range from mild irritation to permanent corneal cloudiness and, finally, loss of vision. The severity of injury is determined by the concentration of the solution and the duration of contact. Eye irritation is a common complaint of persons exposed to FAH vapour.

Legal exposure limits

As per the Occupational Safety and Health Administration (OSHA), the permissible exposure limit (PEL) for FAH is 0.75 part of FAH per million parts of air (0.75 ppm). The exposure may go up to these PEL limits at times but it is important to note that the average exposure for any eight-hour work shift should not be more than 0.75 ppm.

The short-term exposure limit (STEL) for FAH is 2.0 ppm. The average exposure during any 15-minute period must not exceed this limit.

Why is formaldehyde dangerous?

FAH can cause serious health problems, even in small amounts. In some cases, exposure to FAH can increase a person's sensitivity to other irritants or chemicals that were never a problem in the past, making them allergic to almost any chemical substance. For some people, exposure to FAH has permanently impaired their health and well being.



Fume hoods in pathology labs, such as the one above, protect workers from formaldehyde fumes.

Health effects

Vapours of FAH are highly irritating to the eye and the respiratory tract. Acute effects include nausea, headaches and difficulty in breathing. In addition, FAH can induce or exacerbate asthma. Chronic exposure is associated with respiratory symptoms and eye, nose and throat irritation. Repeated exposure of skin to liquid FAH causes irritation and allergic dermatitis.

Effects of short-term exposure

The following are the acute effects observed after short-term exposure to FAH:

- ◆ Low exposure levels (0.1-5 ppm): Burning, tearing of eyes and skin irritation.
- ◆ Moderate exposure levels (10-20 ppm): Burning of eyes, nose and trachea; severe coughing; severe difficulty in breathing and intense tearing of the eyes.
- ◆ High exposure levels (50-100 ppm): Tightening in the chest; irregular heartbeat; severe headache; pulmonary edoema (fluid in the lungs); inflammation of the lungs; possibly even death.

Chronic (long-term, delayed) effects

The following are the chronic effects observed after long-term exposure to FAH:

- ◆ **Sensitisation:** Some workers may be especially sensitive to FAH and may develop an allergic reaction at a very low-level of exposure. This is called 'sensitisation' and it can occur suddenly, even after an employee has worked with FAH for years with no reaction. Where ventilation is poor, exposure to FAH in offices can lead to

The International Agency for Research on Cancer (IARC), which is a part of the World Health Organization, has designated formaldehyde as a known cause of several types of throat and nasal cancer

'tight building syndrome' or 'indoor air pollution' where workers develop allergies and flu-like symptoms.

- ◆ **Eye damage:** The eyes, nose and throat are irritated by FAH vapours at levels as low as about 0.3 ppm. This exposure can cause red, teary, burning eyes, sneezing and coughing and sore throat. Some people are sensitive to FAH at low levels, while others are FAH-tolerant at levels as high as a few ppm with little or no reaction. Direct contact with the eye will cause severe burning and tearing. Liquid FAH solutions contacting the eyes can damage the cornea, possibly causing blindness.
- ◆ **Skin:** FAH solutions can destroy the skin's natural protective oils, causing dryness, flaking, cracking and dermatitis (skin rash). Dermatitis may range from simple reddening of the skin to severe cracking and blistering. Prolonged exposure may cause the fingernails to turn soft and brown. Workers exposed to FAH solutions or resins can develop eczema (flaking and itching skin), which may involve the eyelids, neck, hands, arms, armpits and scrotum. The condition may also be caused by contact with clothing contaminated with FAH. Skin contact can also cause an allergic reaction (redness, itching, hives and blisters). It has been observed that as many as one in 20 workers who are regularly exposed to FAH develop an allergic skin reaction.
- ◆ **Lungs:** High levels (5-30 ppm and higher) of FAH can severely irritate the lungs, causing chest pain and shortness of breath. Repeated exposure to FAH can cause allergic asthma. Symptoms of asthma include chest tightness, shortness of breath, wheezing and coughing. However, formaldehyde's long-term effects on the lungs are not fully understood.
- ◆ **Cancer:** The International Agency for Research on Cancer (IARC), which is a part of the World Health Organization, has designated FAH as a known cause of several types of throat and nasal cancer. The National Institute for Occupational Safety and Health (NIOSH) has recommended that FAH be treated as a potential human carcinogen. The American Conference of Governmental Industrial Hygienists (ACGIH) also calls FAH a suspected human carcinogen. According to the US Environmental Protection Agency (USEPA), limited human studies have reported an association between FAH exposure and lung and nasopharyngeal cancer.
- ◆ **Reproductive system:** There is also evidence that women workers exposed to FAH experience menstrual disorders and pregnancy problems. Other studies have found that FAH can damage the genetic make-up of certain cells, which means it may cause birth defects.

Formaldehyde usage and awareness in Delhi hospitals

Toxics Link surveyed formaldehyde usage in three hospitals of Delhi. The major applications of formaldehyde were found to be:

- ◆ As a tissue fixative.
- ◆ As a fumigation agent.
- ◆ For disinfections, especially in dialysis units.

In hospitals, FAH is used in the form of formalin (40 per cent concentration). These solutions are diluted according to usages. Hospitals also use FAH tablets for disinfecting certain instruments.

Healthcare workers are not very aware of its health hazards. Hence they hardly take any precaution to safeguard themselves against any possible occupational exposure.

Hospital 1

Usually formalin is used as a tissue fixative in the histology lab of the hospital. The solution is diluted to 10 per cent for use. The monthly consumption is around 5 litres diluted to 80 litres. The hospital has installed a fume hood to ensure that the workers are not exposed to FAH fumes. The workers do not take any special precaution but do use masks and gloves at all times. The remaining solution is thrown down the sink, which means that it contaminates the normal wastewater stream.

The hospital also uses FAH for fumigation. The monthly consumption of FAH for this purpose is

around 5-10 litres. For fumigation the microbiological section dilutes the solution. The workers are provided with an oxygen mask but they hardly use it and do get exposed to FAH fumes. Ammonia is used to neutralise formalin.

FAH is also used in dialysis units for disinfecting the tubes as well as the dialysis machine. The monthly consumption of formalin solution for this purpose is around 30-35 litres.

It has been observed that the workers in the hospital need specialised training and capacity building on the safe handling of the chemical.

Hospital 2

Formalin is used as a disinfectant even here but the stress is more on mechanical cleaning. The hospital is also shifting towards ultra-violet disinfection systems. The technology is expensive and demands conducive conditions. Hence, it is being implemented in a phased manner. The operation theatre (OT), labour rooms and nursery rooms have been installed with UV disinfection system. FAH is still used in other areas, and to disinfect patients with infectious diseases like measles.

Formalin is also used for tissue preservations and is present in some wards for biopsy sample collection. The solution used for fixation is the diluted version. The histology department prepares the solution and sends it to different wards and OTs. The remaining solution is then disposed off in the waste water drain.

The dialysis unit uses formalin to disinfect tubing but citric acid is used to disinfect dialysis machines. Apart from this, formalin solution is used in some OTs and wards for fumigation. FAH tablets are also being used in this hospital for disinfection of instruments that cannot be autoclaved.

Studies have found that formaldehyde can damage the genetic make-up of certain cells, which means it may cause birth defects



Formaldehyde is used as a steriliser in dialysis units as well as on patients' dialysis tubes.

Installing professionally designed ventilation systems and conducting regular maintenance on ventilation systems are effective measures of dealing with formaldehyde exposure

Training programmes include formaldehyde awareness. Workers are therefore aware of FAH hazards and take precautions while handling it. Also, the hospital is actively looking at other options and replacing FAH wherever possible.

Hospital 3

The third hospital has got primarily three utilities of FAH. It is used in the dialysis units. The level of FAH vapours is quite high in the dialysis wards, and the worker said that she is used to this high concentration of FAH. Diluted FAH is also used as a tissue fixative. The remaining solution is disposed off in the municipal waste disposal stream. FAH is also used for fumigation. Some of the specialised wards use UV disinfection. The monthly consumption of formalin is around 35-40 litres. FAH tablets are also used in small amounts for disinfecting instruments.

There is hardly any awareness among the healthcare workers about the hazards of FAH. No protective equipment is used to protect the workers.

Key observations

It has been observed in all the three hospitals that the awareness level of the healthcare workers on FAH safety and precaution is low. There is a need to adopt safe work procedures to protect healthcare workers from formaldehyde exposure.

The hospitals are aware of FAH hazards and are gradually working towards adopting suitable precautionary measures.

Fumigation, which is one of the major uses of formalin in all the hospitals, can be replaced by UV disinfection systems wherever possible, as was done by one of the hospitals. In places where it is not possible to have a UV disinfection system, care must be taken to prevent occupational exposure to formalin. One of the hospitals surveyed uses an ammonia solution to neutralise FAH vapours. Using protective gear during the process is also stressed upon.

For tissue fixation in histology labs, none of the hospitals were using alternatives. Since formalin

solution is cheaper, it is preferred over other options. But there are alternatives. One of the hospitals has installed fume hoods to prevent FAH vapour exposure. Another hospital has shifted its laboratory to a better-ventilated location. Care has been taken to prepare the FAH solution in a central location so that only a few workers deal with it.

A major use of FAH is in dialysis units. Formalin is still considered a good option for disinfecting dialysis tubes. One of the hospitals has, however, been using citric acid for this purpose.

Precautionary measures

The following methods should be adopted as precautions to prevent FAH hazards:

Training: All employees working with FAH or FAH-containing products should be provided specific information about the product and the hazards associated with it. They should be trained to use it safely, wear protective equipment and follow procedures in an emergency situation.

Material Safety Data Sheets (MSDSs): These sheets should be made available to each employee assigned to work with FAH. The MSDS should be provided to the employer by the manufacturer and should contain complete and detailed information on the chronic and acute health effects, fire and explosion hazards and safety precautions.

Substitution: One of the most effective methods of controlling exposure to FAH is to substitute it with a safer, less toxic material, wherever possible. Diluted bleach, for example, may be used to disinfect the exterior of dialysis units and is a safer alternative than cleaning agents containing FAH. Ethyl alcohol, polyethylene glycol or phenoxyethanol can be used as fixatives or preservatives as safer substitutes to FAH. Extreme care must be taken while selecting substitutes. It should be thoroughly evaluated for possible health effects prior to selection.

Ventilation: Local exhaust ventilation should be used to control workers' exposure to FAH. Laboratory work with formalin or specimens preserved in formalin should be done under a fume hood or in a biological safety cabinet. Alternatively, local ventilation with moveable ducting and adjustable air inlets may be used. However, these systems are often less effective because they are more easily tampered with.

All local exhaust ventilation systems should be checked regularly. Ventilation systems should also be changed whenever there is a change in process or operations. All ventilation systems provided to control contaminants should be exhausted separately from general room air to prevent exposure of other hospital workers. In a hospital, the use of floor fans and blowers in the ceiling are not enough to protect workers from exposure to FAH.

Ventilate the work area

- ◆ Install professionally designed ventilation systems to maintain FAH exposures below legal exposure limits.
- ◆ Conduct regular maintenance on ventilation systems and ensure that they are functioning properly.
- ◆ Do not allow ventilation systems to recirculate FAH vapours.

Precautions

- ◆ Use other sterilisation methods, such as autoclaving, whenever possible.
- ◆ Use non-FAH disinfectants. Diluted bleach solutions may be suitable.
- ◆ Use FAH-free fixatives for histopathological procedures, when possible.
- ◆ If FAH-based fixatives are necessary, use the least concentrated solution.
- ◆ Incorporate automatic dispensing systems to replace manual handling procedures, such as washing, disinfecting or dispensing.
- ◆ Conduct work with open containers with laboratory fume hoods or using other local exhaust ventilation systems.
- ◆ Ensure hemodialysis drain line connections are airtight to prevent FAH vapours from escaping into treatment rooms.
- ◆ Spend as little time as possible in areas where hemodialysers are reprocessed.

Special precautions

- ◆ FAH is flammable and explosive but only in higher concentrations. Explosive concentrations may build up in improperly ventilated storage rooms or fume hoods.
- ◆ FAH should never be stored near or used with hydrochloric acid because the two chemicals combine to form (bis) Chloromethyl Ether (BCME), a very powerful cancer-causing agent.

Respiratory protection: Respirators should be available for emergency use but they should not be used to protect workers from exposure to FAH on a day-to-day basis. In selecting the proper respirator, it is important to know all the hazards to which workers may be exposed.

Protective clothing: Employees working with liquid FAH should be provided with impervious clothing, heavy-duty waterproof gloves, face shields, chemical resistant aprons, boots and other protective clothing to prevent skin contact with FAH. Employees should wear chemical splash-proof safety goggles. Gloves made of nitrile, neoprene, butyl rubber or polyethylene laminate protect against incidental hand or skin contact with FAH. Gloves made

Formaldehyde should never be stored near, or used with, hydrochloric acid because the two chemicals combine to form (bis) Chloromethyl Ether (BCME), which is a powerful cancer-causing agent

of latex may not provide adequate protection and can cause allergic reactions.

Personal hygiene: Workers should thoroughly wash any areas that come in contact with FAH:

- ◆ After exposure and at the end of each workday.
- ◆ Before lunch breaks and rest periods.
- ◆ Before eating, or using toilet facilities.

Record keeping: Employers should establish and maintain accurate records of all monitoring of employees' exposure to FAH.

Medical surveillance

Since FAH is not retained in the body after the exposure, its levels cannot be detected through pathological tests of the blood or urine. However, physical symptoms such as respiratory irritation or dermatitis indicate overexposure to FAH.

A physician who knows the nature of a worker's exposure should perform the examination. Any other employees who may have been exposed to FAH should also be examined.

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*Compiled and written by Priti Mahesh
with inputs from the Toxics Free Health Care team*

For more information, please contact:

PRITI MAHESH
Srishti/Toxics Link

H2 Jungpura Extension

Ground Floor

New Delhi 110 014

Tel: +91-(0)11-24328006/0711

E-mail: priti@toxicslink.org