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A Review: A Look At Formaldehyde

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Summary

Formaldehyde (FA) - also known as methyl aldehyde - is the smallest member of saturated aldehydes used in various fields, especially in agriculture, medicine, cosmetics, and cleaning and construction chemicals. It is used in the pharmaceutical and medical industries as a protective and sterilizing agent, most commonly for cadaver fixation. Despite its wide range of benefits and use, Formaldehyde's harmful effect on human health can't be ignored. This article delves into the properties of FA, areas of usage, harmful effects on human health and protective measures.

Key words: Formaldehyde, cadaver fixation, human health,

Özet

Formaldehit (FA), tarım, tıp, kozmetik, temizlik, yapı kimyasalları başta olmak üzere pek çok alanda kullanılan, doymuş aldehitler sınıfının en küçük üyesidir ve metil aldehit olarak da bilinmektedir. Formaldehit koruyucu ve sterilize edici bir madde olarak ilaç sanayide, tıbbi laboratuvarlarda yaygın bir şekilde ise kadavra tahnitninde kullanılmaktadır. Formaldehit tıpta hayatı kolaylaştıran pek çok alanda kullanılmasına karşın insan sağlığına zararları göz ardı edilemez. Bu yüzden çalışmamızda FA'nın özellikleri, kullanım alanları, insan sağlığına zararlı etkileri ve koruyucu önlemleriden bahsedilmiştir.

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Anahtar kelimeler: Formaldehit, Kadavra Tahniti, İnsan Sağlığı.

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Introduction

Pure formaldehyde (FA), is soluble in water, colourless, pungent and a toxic chemical. Due to the fact that FA is very reactive, it can become gaseous in any environment [1,2]. Therefore, the human body is exposed to FA mainly through the respiratory tract and to a lesser degree by digestion and through skin absorption. FA in the body is transported through the vessels and converted into formic acid in the liver or erythrocytes. As it cannot be stored, it is expelled through urine, faeces, and exhalation [1,3].

FA, which causes high irritation to mucous membranes 1, non-enzymatically binds to proteins, nucleic acids, and unsaturated fatty acids with a great affinity and causing denaturation. This results in cytotoxicity, causing inflammatory, necrotic and allergenic reactions, and a mutagenic effect.

Animal studies indicate that FA can cause irreversible damage to the nasal epithelium of some rats, even development of neoplasia[4].

The mutagenic and carcinogenic properties of FA are shown in studies where DNA synthesis and repair is inhibited at high doses of FA exposure [5,6]. It is emphasized in a study by Teng et al. in 2001 that very low concentrations of FA has caused oxidative damage in isolated rat hepatocytes 7. Güleç and colleagues also reported a decrease in SOD and CAT enzyme activities in liver tissues in rats exposed to FA [8].

Formaldehyde Usage In Medicine and Daily Life

It is classified as Group 2A in terms of carcinogenicity by the International Agency for Research on Cancer (IARC) [9,10] indicating its highly carcinogenic nature. However, FA is widely used in our daily lives and working areas. In daily life; FA can be found on toothpaste, cleaning materials, aseptic solutions, disinfectants, gasoline, natural gas, fuel-oil, exhaust fumes of diesel vehicles, cosmetic products, and paper products [11-14].

FA is widely used in the industrial field, it can be part of paint, plastic, construction material, furniture, carpet, rubber, stationery materials, building insulation materials, laminate parquet, wall coverings and textile industry [9,11-14].

It is known that cigarette smoke contains formaldehyde (FA is taken an average of 0.38 mg of per box) [15,16], and passive smokers may be exposed to FA through the respiratory tract [17]. Exposure to FA is mostly observed in health and industrial workers [18].

FA has very common usage in medicine as well, as a preservative liquid and sterilizing agent in medical laboratories. FA, being a powerful disinfectant, is effective against bacteria, fungi, and viruses[1,19,20].

Besides, FA is used in anatomy laboratories for cadaveric embalming; in histology and pathology laboratories for tissue fixation; in dentistry; in haemodialysis solutions; in sterilization processes; in chronic cystitis treatment; and in some medicines as a preservative substance 10,11. It is also used as an aseptic in the operating room, intensive care, and surgical services.

The Effects FA On Organisms

Toxic Effects

The harmful effects of exposure to FA can be observed throughout the body. While the most affected system is the respiratory, the most affected organ is the eye. Even at very low concentrations (0,24 ppm), symptoms such as eye pain, foggy-misty vision, redness, liquid discharge, stinging, and even long term exposure may result in chronic conjunctivitis [11,21,22]. Findings such as burning sensation in the nose and throat, wheezing, coughing can be counted among the adverse effects on the respiratory system in short-term exposures to FA (0.5 ppm) [11,23]. Further FA exposure can lead to life-threatening clinical conditions such as dyspnoea, pneumonia, inflammation, and pulmonary oedema [20,24].

Formalin solutions (more than 2%) in contact with the skin may cause itching, rash, allergic contact dermatitis [25,26].

Oral exposure of FA may also cause gastrointestinal irritation and gastritis. FA is used to increase the shelf life in many packaged products, making it possible for FA to be taken orally. The conversion of formaldehyde to formic acid is a rather rapid process, and therefore makes a serious local corrosive effect on the upper GIS. At the end of this process, perforation, ulceration, abdominal pain, nausea, diarrhoea, necrosis and bleeding can occur. Subsequently, it can result in circulatory disturbance, haematuria, metabolic acidosis, anuria, kidney damage and sudden death [27,28].

The effects on the nervous system are so important that it cannot be ignored. While a headache, dizziness, weakness, irritability, malaise, sleep disturbance, and loss of appetite occur during short-term effects of FA; epilepsy, emotional disorders, and memory impairment can be seen after long-term exposures. The abundance of neurological symptoms in short-term and long-term exposures in individuals working in environments with FA, supports the idea that FA causes neurotoxicity [29,30]. Furthermore, studies have shown that FA decreases brain cell volume, number, and inhibits cell growth [31-32]. FA is also reported to cause mental instability, mood alterations, and deterioration in learning skills. In a study conducted on rats, motor activity deceleration was detected due to a reduction of the hypothalamic level of dopamine and serotonin [3,33].

Several experimental investigations have revealed that FA induces oxidative degeneration in various tissues [34,35]. In 2002, a study on a testicular tissue showed that FA administration by respiratory tract reduced copper and zinc levels of an antioxidant enzyme called superoxide dismutase (SOD) [34]. It is suggested that oxidative damage to the testicles has occurred due to the fall in copper and zinc levels, and this oxidative damage may also cause spermatozoal abnormalities. It is also known that FA causes infertility [11,36]. People with asthma, which is a serious public health problem that is estimated to affect about 300 million people worldwide, are especially vulnerable against FA. It is proven asthmatic people who are exposed to FA suffer from respiratory problems more often. The prevalence of asthma and chronic bronchitis in children at home with FA levels of 70-140 µg/m3 is significantly higher, highlighting the relationship between FA exposure and asthma. In studies conducted, FA exposure is proven to be one of the causes of occupational asthma.

Unfortunately nearly all houses are contaminated with FA, as traces of it exists on numerous items used in daily life (such as; cigarette smoke, catalytic and kerosene lighters, adhesives, flooring, cabinets, wall coverings, furniture, room sprayers, fabric weaves, carpets, wallpapers, various liquids used in cleaning, floor polishes etc.).

In addition, experts emphasize that the newer the contaminated product, the greater the chance of spread of formaldehyde into air. Despite the proven variety of negative health effects; its economic and practical advantage is the reason for its frequent usage.

Conclusion

It is known that FA is used in many places all over the world and is a prominent threat to human health. However, these disadvantages do not decrease the rate of use because it is a cheap disinfectant and an effective fixing solution. In this context, protective measures are at the forefront in decrease its adverse health effects. The concentration of FA in solution, while still being sufficient for tissue detection, should not exceed 10%. Areas where FA exposure takes place should be designed in such way that the FA vapour is evacuated immediately. This can be achieved by having the necessary and sufficient ventilation systems and properly sealing any solution containing or material that came in contact with FA.

The laboratory personnel with upper and lower respiratory tract diseases and chronic conjunctivitis should avoid all exposure to FA. The contact period with formaldehyde should be reduced by providing rotations between laboratory personnel. In addition, the protective effects of melatonin, vitamin E and omega-3 against the harmful effects of FA should not be ignored.

As a result, all studies suggest that the formaldehyde in an environment of workers should be reduced to a minimum level and not exceed the permissible limit of 0.3 ppm. Lastly transport of FA should be provided in sealed containers with the appropriate air conditioning.

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