



Hydrogen Peroxide

Toxicological Overview

Key Points

Kinetics and metabolism

- Hydrogen peroxide may only cause toxicity at the site of contact but not systemic toxicity
- Hydrogen peroxide generates hydroxyl radicals that induce lipid peroxidation within exposed cells which can lead to DNA damage and cell death

Health effects of acute exposure

- The main toxic effect of exposure to hydrogen peroxide is irritation at the site of contact
- Acute inhalation of hydrogen peroxide causes irritation to the nose, throat and respiratory tract. In very severe cases bronchitis or pulmonary oedema may occur, which can potentially be fatal
- Ingestion of hydrogen peroxide results in gastrointestinal irritation, abdominal pain, foaming at the mouth, vomiting and haematemesis, gastric distension, gas embolism, fever, lethargy unconsciousness and in severe cases, can result in death
- Dermal exposure to dilute solutions may cause whitening of the skin, whilst more concentrated solutions can cause severe irritation and corrosion, severe burns, blisters, ulcers and permanent scarring
- Ocular exposure to hydrogen peroxide may cause corrosion, corneal burns, lacrimation, photophobia and permanent injury including blindness

Health effects of chronic exposure

- Chronic exposure to hydrogen peroxide is likely to cause similar adverse health effects to those seen following acute exposure, as it does not give rise to systemic toxicity
- Hydrogen peroxide is not considered to be a carcinogen

Toxicological Overview

Summary of Health Effects

Hydrogen peroxide may cause toxicity from all routes of exposure. Exposure to large quantities of hydrogen peroxide is most likely to occur in an occupational setting, due to its use at high concentrations (typically above 35%) in many industrial applications.

The main toxic effect resulting from exposure to hydrogen peroxide is irritation at the site of contact.

Inhalation of hydrogen peroxide causes irritation to the nose, throat and respiratory tract. In very severe cases bronchitis or pulmonary oedema may occur, which can potentially be fatal.

Ingestion of hydrogen peroxide results in gastrointestinal irritation, abdominal pain, foaming at the mouth, vomiting and haematemesis, gastric distension, gas embolism, fever, lethargy unconsciousness and in severe cases, can result in death

Dermal exposure to dilute solutions of hydrogen peroxide can cause whitening or bleaching of the skin. Solutions of 35% hydrogen peroxide cause mild irritation and concentrations above 50% cause severe irritation and corrosion, severe burns, blisters, ulcers and permanent scarring. Ocular exposure to hydrogen peroxide solutions of greater than 35% are expected to cause corrosion, corneal burns, lacrimation, photophobia and permanent injury including blindness.

Chronic exposure to hydrogen peroxide is likely to cause similar adverse health effects to those seen following acute exposure, as it does not give rise to systemic toxicity.

There is no evidence to suggest that hydrogen peroxide causes reproductive or developmental toxicity in humans.

The International Agency for Research on Cancer (IARC) has noted that there is inadequate evidence in humans for the carcinogenicity of hydrogen peroxide. The overall conclusion of IARC was that hydrogen peroxide is not classifiable as to its carcinogenicity to humans (group 3). Hydrogen peroxide has some mutagenic potential in *in vitro* systems, but it is not possible to conclude whether it has mutagenic potential *in vivo*.

Kinetics and Metabolism

Few data are available regarding the kinetics of hydrogen peroxide.

Absorbed hydrogen peroxide is very rapidly broken down by enzymes, including glutathione peroxidase or catalase in tissue and hence does not give rise to systemic toxicity [1, 2]. Formation of hydroxyl radicals in cells of tissues of first contact may induce lipid peroxidation, DNA damage and cell death [1].

Sources and Route of Human Exposure

Hydrogen peroxide may cause toxicity from all routes of exposure.

Exposure to large quantities of hydrogen peroxide is most likely to occur in an occupational setting, due to its use at high concentrations (typically above 35%) in many industrial applications [3]. In occupations where hydrogen peroxide is used, personal protective equipment is recommended [4].

The general public may be exposed to small amounts due to its use at low concentration (approximately 3-6%) in many domestic products such as chlorine-free bleach and in peroxide-based hair dyes. Small amounts are also formed in the body as a by-product of normal enzymatic processes [5].

Health Effects of Acute / Single Exposure

Human Data

General toxicity

The main toxic effect resulting from exposure to hydrogen peroxide is irritation at the site of contact [3].

Inhalation

Hydrogen peroxide does not readily form a vapour at room temperature. However, if heated or misted, acute inhalation of hydrogen peroxide will cause irritation to the nose, throat and respiratory tract. Dyspnoea and cough have also been reported [6]. In very severe cases bronchitis or pulmonary oedema may occur, which can potentially be fatal [3]. In human volunteers exposed to an aerosol of hydrogen peroxide for 4 hours, the threshold for respiratory tract irritation was 10 mg m^{-3} [3].

Ingestion

Acute ingestion of hydrogen peroxide results in gastrointestinal irritation, and possible gas embolism. Concentrations greater than 30 – 40 % cause severe irritation, with signs and symptoms including abdominal pain, foaming at the mouth, vomiting and haematemesis, and gastric distension. Fever, lethargy, shock, unconsciousness and respiratory arrest may also occur. Concentrated solutions may cause gas embolism, and in severe cases, death may occur within minutes of ingestion [3, 6]. However, most cases of acute ingestion of hydrogen peroxide result only in mild adverse effects [6].

Dermal / ocular exposure

Dermal exposure to dilute solutions of hydrogen peroxide cause whitening or bleaching of the skin due to microembolism caused by oxygen bubbles in the capillaries [1, 3]. Dermal contact with solutions of 35 % hydrogen peroxide cause mild skin irritation. Solutions of 50 % hydrogen peroxide and above cause severe irritation and corrosion, severe burns, blisters, ulcers and permanent scarring [3, 6].

Ocular exposure to hydrogen peroxide solutions of greater than 35 % are expected to cause corrosion, corneal burns, lacrimation, photophobia, conjunctivitis and permanent injury including blindness [3].

Animal and In-Vitro Data

Inhalation

No data on acute toxicity in animals following acute inhalation were available.

Ingestion

No data on acute toxicity in animals following acute ingestion were available.

Dermal / ocular exposure

No data on acute toxicity in animals following acute dermal or ocular were available.

Health Effects of Chronic / Repeated Exposure

Human Data

General toxicity

As hydrogen peroxide does not cause systemic toxicity, any adverse health effects observed following a chronic or repeated exposure would be expected to be similar to those observed following an acute exposure.

Inhalation

A case study in which seven workers occupationally exposed to 12 – 41 mg m⁻³ hydrogen peroxide aerosols for one year reported eye and throat irritation and a gradual bleaching of their hair [3].

Ingestion

No data on chronic toxicity in humans following chronic ingestion were available. Ingestion is not a typical route of exposure to hydrogen peroxide [3].

Genotoxicity

No data was available regarding the genotoxicity or mutagenicity of hydrogen peroxide in humans [1, 3].

Carcinogenicity

IARC noted that there was inadequate evidence in humans for the carcinogenicity of hydrogen peroxide and concluded that, overall, it is not classifiable as to its carcinogenicity to humans (group 3) [1].

Reproductive and developmental toxicity

No data were located regarding the reproductive or developmental toxicity of hydrogen peroxide in humans [3].

Animal and In-Vitro Data

Inhalation

No data on chronic toxicity in animals following chronic inhalation were available.

Ingestion

Long-term oral administration of 0.1 - 0.15% hydrogen peroxide to mice gave rise to an inflammatory response in the gastro-duodenal tissue [3].

Genotoxicity

Hydrogen peroxide has been shown to cause DNA damage in bacteria and in cultured mammalian cells. Hydrogen peroxide was also positive for mutation in *Salmonella typhimurium* and *Escherichia coli* in the absence of metabolic activation. There is also evidence that it can cause mutations in Chinese hamster V79 cells and mouse lymphoma L5178Y cells at the *hprt* locus. Chromosomal aberrations and sister chromatid exchanges were induced in human and other mammalian cells *in vitro*. These positive results are believed to be due to generation of reactive oxygen species that would be rapidly detoxified *in vivo*. There was no evidence of chromosomal aberrations in the bone marrow cells of rats exposed to hydrogen peroxide *in vivo* [1].

Hydrogen peroxide has the potential for mutagenicity in *in vitro* systems, however, it is not possible to conclude that hydrogen peroxide is mutagenic *in vivo* [3].

Carcinogenicity

IARC have concluded that there was limited evidence in experimental animals for the carcinogenicity of hydrogen peroxide. This is based on an oral study in mice in which adenomas and carcinomas of the duodenum were observed. Other studies were considered inadequate for evaluation. Overall, it is not classifiable as to its carcinogenicity to humans (group 3) [1].

Reproductive and developmental toxicity

Only limited data are available on the reproductive and developmental toxicity of hydrogen peroxide from which it is not possible to draw any conclusions [3].

References

1. International Agency for the Research on Cancer (IARC), *Hydrogen Peroxide. Vol 71*, in *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans*. 1999, IARC: Lyon.
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3. Canadian Centre for Occupational Health and Safety (CCOHS), *Cheminfo: Hydrogen Peroxide solutions 35% and greater. Record number 198*. 1998.
4. International Programme on Chemical Safety (IPCS), *Hydrogen Peroxide (>60% solution in water). International Chemical Safety Card: 0164*. 2000, WHO: Geneva.
5. Canadian Centre for Occupational Health and Safety (CCOHS), *Cheminfo: Hydrogen Peroxide solutions of less than 8%. Record number 77*. 1998.
6. International Programme on Chemical Safety (IPCS), *Hydrogen Peroxide. Poisons Information Monograph. PIM 946*. 1998, WHO: Geneva.

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