Public Health England

Protecting and improving the nation's health

Nitric acid

Toxicological Overview

Key Points

Kinetics and metabolism

- nitric acid is corrosive at the site of contact and does not elicit systemic toxicity
- on contact with body tissues, nitric acid is rapidly broken down into its constituent ions

Health effects of acute exposure

- nitric acid is irritating and corrosive to all tissues with which it comes into contact
- acute inhalation of nitric acid vapour can lead to symptoms such as ocular and nasal irritation, sore throat, cough, chest tightness, headache, ataxia and confusion
- in severe cases, pulmonary oedema may develop hours or days following exposure
- acute ingestion may cause burns to the oesophagus and stomach which can cause ulceration, haemorrhage and perforation. Abdominal pain, nausea, salivation, vomiting, diarrhoea and haematemesis may occur, and some cases may be fatal
- dermal exposure may result in deep burns, blisters and permanent scarring
- ocular exposure may cause corneal burns, lacrimation, photophobia and blindness

Health effects of chronic exposure

- chronic inhalation exposure to nitric acid can cause respiratory irritation, leading to bronchitis and airways hyper reactivity and erosion of dental enamel
- dermal exposure to low concentrations of nitric acid can result in dermatitis
- strong inorganic acid mists found in occupational settings, which may include (but not limited to) nitric acid, are carcinogenic to humans, causing cancer to the larynx and possibly lung

PHE publications gateway number: 2014790

Published: December 2017

Summary of Health Effects

Concentrated nitric acid is highly corrosive to all tissues with which it may come into contact and exposure can occur via all routes (ingestion, inhalation, dermal and ocular absorption [1-3].)

The toxicity of nitric acid is due to its effects at the point of contact; it readily dissociates into simple ions and therefore systemic effects are unlikely.

Inhalation exposure to nitric acid is a common occupational hazard as it readily forms a vapour at room temperature. Symptoms of an acute inhalation exposure to nitric acid include a burning sensation, dry nose and throat, cough, chest pain, shortness of breath, headache and difficulty breathing [3]. An acute exposure to a high dose of concentrated nitric acid can cause pulmonary oedema, which has a latency period between 3 and 30 hours and can potentially be fatal [1, 4].

Long term inhalation exposure to nitric acid can lead to chronic respiratory irritation such as bronchitis and may also lead to dental erosion as the nitric acid deposits on the teeth and erodes the outer coating of the enamel [1].

Inhalation of strong inorganic acid mists, which may include nitric acid, causes cancer of the larynx; the evidence suggests exposure may also associated with lung cancer in humans [5].

Ingestion of nitric acid can cause burns to the lips, tongue, mouth, throat and stomach. Other symptoms can include abdominal pain, nausea, vomiting and diarrhoea [1]. In severe cases, the ingestion of a high dose of nitric acid may be fatal [2, 4].

Dermal exposure to nitric acid can result in severe burns, blisters and permanent scarring depending upon the concentration of the acid and the duration of exposure. Ocular exposure can cause severe eye burns, pain and redness which may lead to permanent injury and possibly blindness [1].

Kinetics and Metabolism

Nitric acid is a contact irritant that causes adverse effects at the site of exposure. The corrosive effects of nitric acid are due to the low pH. Aqueous solutions and vapours of nitric acid readily dissociate into hydrogen and nitrate ions.

Following inhalation exposure nitric acid reacts immediately with respiratory mucous membranes and does not appear to be absorbed after oral exposure [6, 7]. Exposure to nitric acid does not give rise to systemic toxicity as it is broken down at the point of contact and therefore causes adverse effects only at the site of exposure [6].

Sources and Route of Human Exposure

The routes of exposure to nitric acid are by inhalation, ingestion, dermal or ocular exposure [3, 8].

Nitric acid has a range of widespread uses in industry, and rarely found in household products [2]. Exposure to nitric acid is therefore most likely to occur in an occupational setting. Examples of occupations where exposure may occur include metal cleaners and etcher, manufacturing of explosives and production of ammonium nitrate fertilizers. The most likely routes of occupational exposure are inhalation of nitric acid vapours and skin or eye contact of nitric acid solutions. The UK short term Workplace Exposure Limit for nitric acid is 1 ppm (2.6 mg/m^3) averaged over a 15 minute period [9, 10].

Low concentrations of nitric acid may be present in the atmosphere as it may be formed by the conversion of nitrogen dioxide, which is a common air pollutant released into the environment from many commercial and industrial processes [11].

Health Effects of Acute/Single Exposure

Human data

General toxicity

Nitric acid is irritating and corrosive to any tissue with which it may come into contact. The severity of its effects is dependent upon the concentration of nitric acid and the duration of exposure.

Inhalation

Nitric acid readily forms a vapour at room temperature and so poses a potential inhalation hazard [3]. Symptoms of inhalation exposure to nitric acid vapours and mists include irritation of the nose, with sore throat, cough, chest tightness, headache, coughing, shortness of breath, and dizziness [12]. Major mucosal irritation to the upper respiratory tract and lungs was recorded at concentrations around 12 ml/m^3 (33.7 mg/m^3) [2]. Dyspnoea and stridor can occur due to laryngeal oedema. After a severe inhalation exposure to nitric acid, pulmonary oedema may develop hours or even days after exposure, which may possibly be fatal, with increasing shortness of breath, wheeze, chest pain and cough [1, 2, 4, 12, 13]. Cases of human poisoning, including death, have been observed at inhalation of nitric acid concentrations of 20% and higher [13].

Ingestion

Ingestion of nitric acid can cause immediate burns to the lips, mouth and throat [2-4, 14]. If nitric acid is swallowed, it can cause burns to the mouth, oesophagus and stomach, which can result in antral ulceration, haemorrhage and perforation.[1, 2, 15]

Nitric acid ingestion can also cause retrosternal and abdominal pain, dysphagia, nausea, hypersalivation, vomiting, diarrhoea and haematemesis. Additionally, ingestion of nitric acid may result in metabolic acidosis, shock, collapse, hypotension, acute renal failure and disseminated intravascular coagulation (DIC). Airway obstruction from laryngeal and/or epiglottic oedema may occur in severe cases [15]

In some cases, ingestion of a strong solution of nitric acid can prove to be fatal. The reported lowest fatal oral exposure dose for humans is 430 mg/kg body weight [2].

Dermal/ocular exposure

Nitric acid causes superficial coagulation burns (which may be self-limiting) and destruction of the surface epithelium [16]. Other effects of dermal exposure to nitric acid may be blisters, ulcers and permanent scarring, dependent upon the concentration of the acid and the duration of exposure [3, 14, 16]. Concentrated solutions of nitric acid cause burns to the skin, whereas dilute solutions can cause discolouration, mild irritation and hyperkeratosis [2, 17].

Contact to the eye from nitric acid causes immediate opacification of the corneal and conjunctival epithelium, imparting a yellow colour when the acid is concentrated [17, 18]. Short-term exposure of nitric acid into the eye can cause corneal ulcers and necrosis with permanent impairment of vision down to blindness [1, 2].

Delayed effects following acute exposure

Pulmonary oedema may develop 24 to 72 hours after an inhalation exposure to nitric acid, which can potentially be life threatening, with increasing breathlessness, wheeze, chest pain, cough, hypoxia and cyanosis [2, 4, 6, 12, 13]. Following recovery, relapses may occur with death caused by bronchopneumonia or pulmonary fibrosis [19].

Health Effects of Chronic/Repeated Exposure

Human data

Long term exposure to nitric acid can cause skin and respiratory irritation which may develop into chronic bronchitis. Repeated exposure to vapours, mists or aerosols of nitric acid has been shown to cause dental erosion [2, 3].

Inhalation

Long term inhalation exposures to nitric acid can cause chronic respiratory irritation, which may result in chronic bronchitis and airways hyper-reactivity [1].

Repeated exposure to nitric acid vapours, mists or aerosols may cause dental erosion. As nitric acid is inhaled, it may be deposited on teeth and cause decalcification resulting in erosion of tooth enamel [2, 3].

Ingestion

There is little human data on the effects of chronic or repeated ingestion of nitric acid, as chronic exposure by ingestion is unlikely due to the adverse acute effects. Yellowing to teeth may occur [2].

Dermal/ocular exposure

Repeated dermal exposures to low concentrations of nitric acid in solution, vapour or mist can result in dermatitis, characterised by erythema, itching and a dry scaly appearance.

Genotoxicity

There are limited data available regarding the genotoxicity of nitric acid. In an in vitro bacterial system (Ames test) nitric acid gave negative results in the presence and absence of metabolic activation [4, 7] .

Carcinogenicity

In a 2012 evaluation IARC classified strong inorganic acid mists as carcinogenic to humans (group 1). It should be noted that this classification concerns mists of strong inorganic acids that may include nitric acid but are not limited to nitric acid. The evaluation states that strong inorganic acid mist exposure causes cancer of the larynx and that there are positive associations between exposure and lung cancer [5].

Reproductive and developmental toxicity

There are limited data available on the reproductive and developmental effects of exposure to nitric acid.

Exposure to nitric acid does not generally result in systemic toxicity; therefore it is unlikely to have an effect on the developing fetus. However, symptoms associated with maternal injury following exposure may have an indirect effect on the fetus [4, 6, 7, 20].

References

1. European Chemical Agency, Background document to RAC opinion on nitric acid, in CLH report, Committee for Risk Assessment RAC, Editor. 2013.
2. Federal Institute for Risk Assessment (BfR), Health risks of nitric acid-containing cleaning products, Bundesinstitut fur Risikobewertung (BfR), Editor. 2010.
3. National Institute for Occupational Safety and Health (NIOSH), Nitric Acid, in International Chemcial Safety Cards (ICSC) 2014.
4. OECD, SIDS Initial Assessment Profile, U. ICCA, Editor. 2008.
5. International Agency for Research on Cancer IARC, Mists from strong inorganic acids, A review of human carcinogens. Monographs, 2012(100F).
6. National Research Council (US), Acute Toxicity of Nitric Acid, in Assessment of Exposure-Response Functions for Rocket-emission Toxicants, National Academy of Sciences, Editor. 1998, NCBI. p. Appendix F.
7. National Service Center for Environmental Publications, Acute Exposure Guideline Levels (AEGLs) for Nitric Acid, ed. U. EPA. 2008.
8. International Programme on Chemical Safety (IPCS), Nitric acid. International Chemical Safety Card: 0183. 2015, WHO: Geneva.
9. Toxbase.org. Nitric Acid. 2014; Available from: https://www.toxbase.org/Poisons-Index-A-Z/N-Products/Nitric-Acid----------/.
10. Health and Safety Executive (HSE), EH40/2005 Workplace Exposure Limits. . 2011.
11. United States Environmental Protection Agency. What is Acid Rain? 2017; Available from: https://www.epa.gov/acidrain/what-acid-rain.
12. Toxbase.org. Corrosives- inhalation. 2017.
13. Federal Institute for Occupational Safety and Health, Nitric Acid, in CLH Report; Proposal for harmonised Classification and Labelling. 2017: Germany.
14. National Institute for Occupational Safety and Health (NIOSH), NIOSH Pocket Guide to Chemical Hazards. Nitric Acid Centers for Disease Control and Prevention (CDC), Editor. 2016.
15. Toxbase.org. Corrosives- ingestion. 2016; Available from: https://www.toxbase.org/Chemicals/Management-Pages/Corrosives---ingestion/.
16. Toxbase.org. Skin decontamination- corrosives. 2017.
17. Toxbase.org. Chemcial Splashed or Sprayed in the Eyes. 2017.
18. W. M. Grant, J.S.S., Toxicology of the eye. Vol. II. 1993, Springfield, Illinois: Charles C Thomas Publisher.
19. Committee on Acute Exposure Guideline Levels, Acute Exposure Guideline Levels for Selected Airborne Chemicals, Committee on Toxicology Board on Environmental Studies and Toxicology Division on Earth and Life Studies National Research Council, Editor. 2013, National Academies Press (US): Washington (DC).
20. UK Teratology Information Service. Corrosive agents exposure in pregnancy. UKTIS Monograph 2016 [15/05/2017]; Available from: https://www.toxbase.org/Poisons-Index-A-Z/C-Products/Corrosive-agents-exposure-in-pregnancy/.

This document from the PHE Centre for Radiation, Chemical and Environmental Hazards reflects understanding and evaluation of the current scientific evidence as presented and referenced here.

First published: January 2018

For queries relating to this document, please contact: chemcompendium@phe.gov.uk

For all other enquiries, please contact: phe.enquiries@phe.gov.uk