Kerosene

Toxicological overview

Key Points

Kinetics and metabolism

- As kerosene is a mixture of chemicals, there is no definitive ADME (absorption, distribution, metabolism and excretion) data
- Limited data from metabolism studies suggest that kerosene is removed from circulation by the liver and lungs

Health effects of acute exposure

- The major route of exposure is by inhalation of liquid (aspiration)
- Kerosene vapours may be mildly irritating to the respiratory system and spray applications of kerosene may provoke signs of pulmonary irritation such as coughing and dyspnoea
- Acute dermal exposure may result in local irritation, but it is not considered to be a skin sensitiser
- Acute exposure to kerosene may result in CNS effects including irritability, restlessness, ataxia, drowsiness, convulsions, coma and death

Health effects of chronic exposure

- The most common health effect associated with chronic kerosene exposure is dermatitis, usually associated with inappropriate use of personal protective equipment
- Chronic exposure may also cause non-specific CNS effects such as nervousness, loss of appetite and nausea
- Kerosene does not have a measurable effect on human reproduction or development
- IARC concluded that there was inadequate evidence to classify kerosene as a human carcinogen

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Toxicological Overview

Kerosene is a liquid mixture of hydrocarbons (chain length C9 – 16) produced by the distillation of crude oil. The preferred Chemical Abstracts spelling is “kerosine”. The (UK) technical term for kerosene is “C2 Fuel Oil” (Annex I), as it is derived from the “kerosene” fraction of distilled crude oil. Older, flue-less appliances use “paraffin” (C1) fuel.

The general composition of C2 fuel oil is given at Annex II: For the purpose of this document, kerosene will be used as a synonym for C2 domestic fuel oil. It is important to note that kerosene is not a synonym for “jet fuels” (which are a distinct class of petroleum distillate product containing a range of chemical additives).

Summary of Health Effects

The principal adverse effect arising from ingestion of kerosene is chemical pneumonitis secondary to aspiration of vomitus.

Ingestion of kerosene or acute exposure to vapour may lead to general signs of intoxication such as mild CNS symptoms (dizziness, headache, nausea) and vomiting.

Skin exposure to kerosene may result in dermatitis through the extraction of endogenous skin lipids.

Whilst kerosene is not considered a direct-acting dermal carcinogen, chronic skin exposure may result in tumourigenesis.

Kinetics and metabolism

As kerosene is a mixture of chemicals, there is no definitive ADME (absorption, distribution, metabolism and excretion) data.

Two studies have indicated poor oral availability in the baboon and dog [1, 2].

Individual components of kerosene are known to undergo dermal absorption [3-6] and kerosene vapour is absorbed following pulmonary exposure [7]. The extent of dermal and pulmonary absorption is dose and time-dependent [8].

A limited number of (primate) metabolism studies suggest that kerosene is efficiently removed from the circulation by the liver and lungs [9].

There is currently no information on the elimination kinetics of kerosene.

Sources and route of human exposure

The main route of exposure to kerosene causing toxicity is via inhalation during ingestion (aspiration). Acute, oral exposures may occur from accidental or intentional ingestion. Inhalation or dermal absorption of kerosene may occur through occupational exposures (petrochemical and aviation sectors), from the use of commercially-available products such as paints and insecticides, via accidental release (e.g. road traffic incidents) or through substance abuse. Contaminated water may represent a substantial aspiration risk during whole body immersion (e.g. swimming or near-drowning).

Health Effects of Acute / Single Exposure

Human Data

General toxicity

The acute health risks involved in handling and using kerosene are minimal, provided that the product(s) are used in accordance with current safety practices [10]. The main hazard associated with kerosene is chemical pneumonitis, resulting from aspiration of vomitus following ingestion [11] or inhalation of kerosene liquid or contaminated water. A rare complication of kerosene intoxication may be cardiac arrhythmia and ventricular fibrillation, attributed to increased myocardial sensitivity to endogenous catecholamines [8].

Inhalation

Whilst kerosene vapours may be mildly irritating to the respiratory system [8], exposure is not likely to be fatal [7] as the low volatility of kerosene [12] limits air concentrations to below 100 mg m^{-3} [13], which is the approximate NOAEL (no observable adverse effect level) in several animal species [7]. However, exposure within a confined space at elevated temperature may induce narcotic effects such as narcolepsy, cataplexy and confusion [8, 14] and there is one report of a fatal (vapour) exposure in a child [15].

Spray applications may result in exposure to high concentrations of kerosene aerosol [16] which may provoke signs of pulmonary irritation such as coughing and dyspnoea [14], in addition to mild CNS depression.

Inhalation of water contaminated with kerosene may occur when swimming or as a result of near-drowning incidents and has been associated with “exogenous lipoid pneumonia” [17].

Aspiration of kerosene-contaminated vomitus is a secondary source of pulmonary exposure that may lead to chemical (lipoidal) pneumonitis [18], a delayed onset and potentially fatal lung disorder characterised by cyanosis, dyspnoea and chest x-ray opacities [19].

Ingestion

Signs of oral kerosene poisoning include diarrhoea, nausea and vomiting. Approximately 30 – 50% of children presenting with suspected kerosene ingestion are asymptomatic [7].

Children have survived ingestion of up to 1.7 g kg^{-1} and recorded instances of fatal poisoning have been associated with doses ranging from ~ 2 to 17 g kg^{-1} [7, 20, 21]. However, death following oral exposure is normally associated with aspiration of vomit rather than systemic toxicity *per se;* vomiting occurs in approximately one third to one half of patients [22].

Dermal / ocular exposure

Kerosene is a mild, transient ocular irritant that may produce conjunctivitis, hyperaemia and lacrimation [3, 14].

Acute dermal exposure may result in local irritation (erythema, pruritis) but is not considered to be a skin sensitiser [3]. A small proportion of individuals (<5%) may exhibit hyper-sensitivity to kerosene and skin contact may result in "burn-like" injuries [23-25]: histological analysis of full-blown pustular eruptions have shown inter- and intra-cellular oedema with intra-epidermal vesicles [25, 26]. It is conceivable that hypersensitivity may be the result of concurrent dermatitis resulting in "excited skin syndrome" ("angry back syndrome") [27].

Neurotoxicity

Acute exposure to kerosene in humans has been associated with a variety of CNS effects, including irritability, restlessness, ataxia, drowsiness, convulsions, coma and death [13]; these are generally considered to be secondary effects resulting from hypoxia [28]. Lethargy and "other CNS complications" were reported in ~ 5% of volunteers ingesting 10 – 30 ml of kerosene [13].

Delayed effects following an acute exposure

There is limited evidence to suggest that long-term pulmonary residual effects may occur following chemical pneumonitis [18, 22]. These effects are considered minor and are of unknown clinical relevance [12].

Animal and In-Vitro Data

General toxicity

The oral toxicity (LD_{50}) of kerosene in a variety of laboratory animals is of the order 20 – 30 g kg^{-1} [7, 29]. Intra-tracheal dosing of kerosene liquid (which models the aspiration of vomit in humans) results in a substantial (10- to 150-fold) increase in toxicity and is consistent with known human health effects. However, studies with monkeys (unspecified strain) and guinea pigs have indicated that lung pathology may occur following oral or parenteral exposure to kerosene, although this effect is not reproducible in all species [7, 29]. It has not been possible to determine a LCt_{50} for kerosene vapour due to its relatively low volatility: An 8 hour exposure to saturated (deodorised) kerosene vapour in dogs, cats or rats did not result in mortality [30].

Delayed effects following an acute exposure

The available literature pertaining to the long-term effects of kerosene following acute exposure is mainly concerned with jet fuels [13, 31] and thus its relevance is uncertain due to the presence of chemical additives. In general, single (acute) oral, dermal and ocular exposures do not result in persistent effects.

Health Effects of Chronic / Repeated Exposure

Human Data

General toxicity

The most common health effect associated with chronic / repeated kerosene exposure is dermatitis [31] which may be associated with insufficient or inappropriate use of personal protective equipment (PPE) in occupational environments. Lung effects (such as dyspnoea) have been reported, but tend to be associated with "high level" exposures [31]. It is conceivable that similar lung and skin effects may be observed in some individuals following a single, acute exposure.

Inhalation

There are currently no unequivocal studies to relate chronic or repeated kerosene exposures to long-term pulmonary dysfunction (other than that putatively associated with aspiration of contaminated water or vomit). There is limited evidence to suggest that chronic exposure may be associated with a tightness of chest and breathing difficulties, although a review of the duration and extent of exposure in such studies was not reported [31].

Ingestion

Chronic, oral exposure to kerosene is unlikely to arise under normal circumstances and there is currently no human data on the chronic effects of kerosene ingestion.

Dermal / ocular exposure

Chronic skin exposure to kerosene is known to cause dermatitis: Table 1 summarises the result of a dermatological study of ball-bearing workers (n=79) exposed on a daily basis to kerosene.

Table 1: Summary of lesion severity (as a function of overt skin pathology), expressed as a percentage of a total factory population [25, 32].

Lesion Severity	Corresponding Sign	% Presenting
Absent	Asymptomatic	16
Low	Erythema	65
Moderate	Eczematous lesions	15
Severe	Defatting dermatitis	4

Neurotoxicity

Long-term exposures to "low" concentrations of kerosene have been reported to produce non-specific CNS effects such as nervousness, loss of appetite and nausea that are not related to hypoxia [13].

Genotoxicity

An increase in cytogenetic changes (chromosomal aberrations in peripheral lymphocytes and bone-marrow micronuclei) has been reported in a limited study of workers exposed to a mixture of kerosene, bunker fuels, white spirit and xylene [33]. However, the mixed exposure precludes any specific conclusions and the results do not correlate with the effects of kerosene-only exposure in animals or *in vitro* mutagenicity tests.

Carcinogenicity

An excess of lung cancer was seen in a large cohort of Japanese workers exposed to kerosene, diesel oil, crude petroleum and mineral oil [29]. In another Japanese study, an excess of stomach cancer was observed amongst workers possibly exposed to kerosene, machine oil or grease [29]. Three case-control studies found an association between lung cancer and the use of kerosene stoves for cooking amongst women in Hong Kong; however, no distinction was made between exposure to kerosene *per se* and exposure to its combustion products [29]. Given that such studies could not attribute the effects to a particular chemical, the IARC evaluated mid-distillate fuel oils as being “not classifiable as to their carcinogenicity to humans (Group 3)” [29]: there is “inadequate evidence” to classify kerosene as a human carcinogen and “limited evidence” for the carcinogenicity of kerosene to experimental animals.

Reproductive and developmental toxicity

Current evidence indicates that kerosene does not have a measurable effect on human reproduction or development [3]. This is in accordance with animal studies.

Animal and In-Vitro Data

General toxicity

In general, animal data is in accordance with the known human effects of kerosene.

Inhalation

Pulmonary pathology (inflammatory cell infiltrates and morphological changes to tracheal epithelia) and cardiovascular changes (resembling atherosclerosis) have been observed in guinea pigs following exposure to high concentrations (up to 34 g m^{-3}) of kerosene aerosol for 15 minutes per day over a three week period [34-36]. Continuous (3 month) exposure of rats and mice to up to 1 g m^{-3} aviation fuel (JP-8) vapour resulted in male rat-specific pathology (nephropathy) that was not thought to be of relevance to humans [37].

Ingestion

No studies on the chronic effects of oral exposure to kerosene were identified. In a study with JP-8 jet fuel, male rat-specific effects (α-2-microglobulin nephropathy) were noted following three month oral gavage (up to 3 g kg^{-1}) [38]. Interestingly, there were also effects that were not species-specific, including perianal dermatitis and gastritis. However, it should be noted

that JP-8 contains a variety of chemical moieties in addition to those associated with kerosene.

Dermal / ocular exposure

Dermatitis was observed in mice topically exposed to kerosene (applied in muslin cloth) for 15 to 60 minutes each day for one week which resolved within three weeks [39]. Pathological changes (hyperplasia and visual scores of irritation) were also observed in mice exposed twice a week for two weeks to deodorised kerosene, but the lesion severity did not correlate with tumour-promoting activity when compared against four other petroleum products [40]. When applied three times a week for up to six weeks, repeated cycles of necrosis and regeneration were observed that were deemed sufficient to represent an epigenetic mechanism for tumourigenesis.

Genotoxicity

Negative results were obtained when kerosene was investigated for its ability to induce gene mutation using Salmonella typhimurium TA98 or TA100, with and without an exogenous metabolic activation system [29].

Negative results were also obtained in a mammalian cell assay, using the mouse lymphoma L5178Y $TK^{+/-}$ cells (also in the presence or absence of metabolic activation) [29].

There is one report of an *in vivo* assay investigating the ability of kerosene to induce chromosomal aberrations in the bone marrow of rats using the intra-peritoneal route of administration (single dose or daily for five days). No aberrations were observed [29].

Together, these data imply that kerosene does not have any significant mutagenic activity.

Carcinogenicity

There is limited evidence from skin-painting studies that kerosene can induce skin tumours in mice and the IARC concluded that there was limited evidence in animals for the carcinogenicity of straight-run kerosene and fuel oil [29].

It is recognised that kerosene does not have any significant mutagenic potential and that the tumorigenic activity of middle distillate fuels (including kerosene) is likely a result of a non-genotoxic processes resulting from chronic irritation [8, 14, 29, 31, 41, 42].

Reproductive and developmental toxicity

Deodorised kerosene was assessed using OECD (Organisation for Economic Cooperation and Development) Guideline 421 for reprotoxic or developmental effects in rats [43]. The evaluation involved dermal exposure to up to 494 mg kg^{-1} day^{-1} for up to 8 weeks. No pathological effects were observed on reproductive organs and no excessive anomalies were found in the first generation of pups. The authors concluded that the NOAEL for deodorised kerosene was 494 mg kg^{-1} day^{-1}. Kerosene (unspecified grade) was also investigated in a developmental toxicity study in rats using inhalation exposure of up to 315 ppm (2.55 g m^{-3}): no teratogenic effects were noted [44].

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Annex I: Classification of Fuel Oils.

Classification of various grades of fuel oil according to crude distillate fraction ("crude fraction") and application. Source: Annex A to BS 2869:1998 [45].

Category	Crude Fraction	Primary Application
A1	Middle distillate	Automotive diesel fuel.
A2		Agricultural engine fuel.
C1	Paraffin	Flue-less heating appliances.
C2	Kerosene	Vaporising or atomising domestic heating appliances.
D	Middle distillate	Atomising burners for domestic, commercial or industrial applications.
E - H	Residual distillate	Atomising burners for boilers or certain industrial engines which may require pre-treatment or additives.

Conversion factor 1ppm = 6.99 mg m^{-3}; 1 mg m^{-3} = 0.143 ppm.

Annex II: Composition of C2 Fuel Oil (Example).

Summary of the main constituents of kerosene (C2 Fuel Oil), expressed as average percentage weight per volume (% w/v). Note that the actual composition will differ according to batch and geographical source. Adapted from Potter and Simmons [46] and IARC Monograph 45 [29].

Class	Example Compound(s)	Average Concentration (%)
n-Alkanes	*n*-heptane	80
	n-octane	
	n-nonane	
	n-decane	
	n-undecane	
	n-dodecane	
	n-tridecane	
	n-tetradecane	
	n-pentadecane	
	n-hexadecane	
	n-heptadecane	
	n-octadecane	
	n-nonadecane	
	n-eicosane	
	n-heneicosane	
Branched alkanes	Isodecane	
	Isoundecane	
	Isododecane	
	Isotridecane	
	Isotetradecane	
Alkyl-monoaromatics	1,2,3,4-tetramethylbenzene	13
Di-aromatics	Fluorene	7
Mono-aromatics	Indene	
	Tetralin	
	1-methyltetralin	
	2-methyltetralin	
Naphthalenes	Napthalene	
	1-methylnaphthalene	
	2-methylnaphthalene	
	1,4-dimethylnaphthalene	
Polynuclear aromatics	Acenaphthene	
	Acenaphthylene	
	Anthracene	
	Phenanthrene	
	2-methylanthracene	
	9,10-dimethlanthracene	
	Fluoranthene	
	Pyrene	
	2,3-benzofluorene	
	Benzo(α)fluorene	
	7,12-dimethylbenz(α)anthracene	

This document will be reviewed not later than 3 years or sooner if substantive evidence becomes available.