CS INTERNATIONAL PROGRAMME ON CHEMICAL SAFETY

Health and Safety Guide No. 45

ACRYLAMIDE HEALTH AND SAFETY GUIDE

UNITED NATIONS
ENVIRONMENT PROGRAMME

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WORLD HEALTH ORGANIZATION, GENEVA 1991

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Health and Safety Guide No. 45

ACRYLAMIDE HEALTH AND SAFETY GUIDE

This is a companion volume to
Environmental Health Criteria 49: Acrylamide

Published by the World Health Organization for the International Programme on Chemical Safety
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WORLD HEALTH ORGANIZATION, GENEVA 1991

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INTRODUCTION

The Environmental Health Criteria (EHC) documents produced by the International Programme on Chemical Safety include an assessment of the effects on the environment and on human health of exposure to a chemical or combination of chemicals, or physical or biological agents. They also provide guidelines for setting exposure limits.

The purpose of a Health and Safety Guide is to facilitate the application of these guidelines in national chemical safety programmes. The first three sections of a Health and Safety Guide highlight the relevant technical information in the corresponding EHC. Section 4 includes advice on preventive and protective measures and emergency action; health workers should be thoroughly familiar with the medical information to ensure that they can act efficiently in an emergency. Within the Guide is a Summary of Chemical Safety Information which should be readily available, and should be clearly explained, to all who could come into contact with the chemical. The section on regulatory information has been extracted from the legal file of the International Register of Potentially Toxic Chemicals (IRPTC) and from other United Nations sources.

The target readership includes occupational health services, those in ministries, governmental agencies, industry, and trade unions who are involved in the safe use of chemicals and the avoidance of environmental health hazards, and those wanting more information on this topic. An attempt has been made to use only terms that will be familiar to the intended user. However, sections 1 and 2 inevitably contain some technical terms. A bibliography has been included for readers who require further background information.

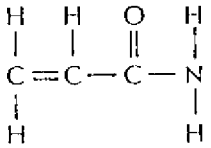
Revision of the information in this Guide will take place in due course, and the eventual aim is to use standardized terminology. Comments on any difficulties encountered in using the Guide would be very helpful and should be addressed to:

The Manager
International Programme on Chemical Safety
Division of Environmental Health
World Health Organization
1211 Geneva 27
Switzerland

THE INFORMATION IN THIS GUIDE SHOULD BE CONSIDERED AS A STARTING POINT TO A COMPREHENSIVE HEALTH AND SAFETY PROGRAMME

1. PRODUCT IDENTITY AND USES

1.1 Identity

Common name:	acrylamide
Chemical formula:	C_3H_5NO
Chemical structure:	
Relative molecular mass:	71.08
Common synonyms:	2-propenamide; acrylamide monomer; acrylic acid amide; acrylic amide; ethylene carboxamide; propenamide; propeneamide; propenoic acid amide
Abbreviations:	None
CAS registry number:	79-06-1
RTECS number:	AS3325000
United Nations number:	UN 2074; Class 6.1
Conversion factors:	1ppm = 2.91 mg/m^3 air, or 1mg/m^3 = 0.34 ppm at 25 °C and 101.4 kPa (760 mmHg)

1.2 Physical and Chemical Properties

Acrylamide is a colourless to white odourless solid that melts at 84–85 °C. On crystallization from benzene, leaf- or flake-like crystals are formed. Heating results in polymerization, which may be violent. Polymerization prevents the determination of a boiling point at ambient pressures but, at 3.34 kPa (25 mmHg), acrylamide boils at 125 °C. Polymerization also occurs with ultraviolet irradiation, and commercial solutions are stabilized with cuprous salts, *tert*-butylpyrocatechol, or other antioxidants. The solid is stable when stored in a cool, dry place.

Dehydration of acrylamide by phosphorus pentoxide (P_2O_5) produces acrylonitrile:

$$CH_2CHC(O)NH_2 - H_2O \rightarrow CH_2CHCN$$

The solubility (g/100 ml solvent at 30 °C) of acrylamide is as follows: water (215.5), methanol (155), ethanol (86.2), acetone (63.1), ethyl acetate (12.6). It is sparingly soluble in benzene (0.35) and heptane (0.0068).

Commercially, acrylamide is available as a crystalline solid or as a 50% or 30% solution in water. The solid is typically 98% pure, containing up to 0.8% water and 0.2% water-insoluble compounds. The nominal 50% solution contains 48–52% acrylamide and an inhibitor (e.g., 25 mg Cu^{++}/kg). Trace components in either will depend on the method of synthesis, and may include sulfates, acrylic acid, and 1–100 mg acrylonitrile/kg.

1.3 Analytical Methods

1.3.1 *Classical*

In the presence of sodium nitrite and acid (yielding nitrous acid *in situ*), acrylamide reacts to yield acrylic acid and nitrogen. This is the basis of a quantitative analytical method.

1.3.2 *Colorimetry*

Acrylamide reacts with diazomethane in methanol-ether solution to form a pyrazoline derivative that reacts with 4-dimethylcinnamaldehyde to form a bright purple Schiff base complex. However, this reaction is not specific for acrylamide, and there can be interference by many other organic compounds.

1.3.3 *Gas chromatography*

Acrylamide is brominated to form the 2,3-dibromopropionamide derivative, which is measured by gas chromatography using an electron capture detector (ECD). It can also be measured by a flame ionization detector (FID), but this is less sensitive.

1.3.4 *Ultraviolet detection*

Acrylamide and 2,3-dibromopropionamide are separated by means of high-pressure liquid chromatography (HPLC) and measured by UV detection. This is a rapid and sensitive method.

1.3.5 *High-pressure liquid chromatography (HPLC)*

Reverse phase HPLC can be used to determine the concentration of acrylamide or of 2,3-dibromopropionamide.

1.3.6 *Polarography*

Direct current and differential pulse polarography methods can be used to determine acrylamide levels in plastics, and in dust and airborne samples (collected in a water impinger). Differential pulse polarography is the more sensitive method.

1.4 Production and Uses

Acrylamide is produced commercially by the catalytic hydration of acrylonitrile. The most common catalysts are copper-based; other inorganic catalysts include manganese, rhodium, and cobalt compounds and, recently, biocatalytic systems have been used for large-scale production. Prior to 1970, sulfuric acid was used for the hydration, and

the acrylamide was separated by neutralization with ammonia. Other methods include the reaction of acryl chloride with ammonia in benzene, followed by filtration to remove ammonium chloride.

The principal use of acrylamide is in the production of high relative molecular mass polyacrylamides or copolymers, particularly with unsaturated quaternary ammonium compounds (cationic copolymers) or carboxylic or sulfonic acids (anionic copolymers). Polymers and copolymers are widely used: in effluent and sludge treatment as flocculants and coagulants, in crude oil recovery processes as viscosity modifiers, and in the paper industry as binders and for several other purposes. They are used as thickeners and binders in paints and coatings, in toiletries and cosmetics, as moisture-retaining additives in concrete, and as binding agents in foundry sand. They play various roles in textile processing and in the production of adhesives, tapes, and gels, including gels used for electrophoresis.

2. SUMMARY AND EVALUATION

2.1 Human Exposure to Acrylamide

Acrylamide is not known to occur naturally. When released into the air, acrylamide will be precipitated in solution, because of its high solubility, and will enter the surface water compartment. It is readily biodegraded in water. Persistence and accumulation of the monomer in the environment will not occur.

The general population may be exposed to small amounts of monomer acrylamide, derived from polymeric acrylamide used in water treatment and in the treatment of effluents, prior to their discharge to surface waters. Concentrations of acrylamide in tap-water and river water, in areas where acrylamide polymers were used for these purposes, were less than 5 μg/litre. Polyacrylamides containing small amounts of monomer are used in food preparation, the washing or peeling of fruit and vegetables, the printing of gelatin capsules for pharmaceutical use, and in food packaging. These uses result in negligible exposure of the general population.

Occupational exposure through inhalation is generally low. Acrylamide is readily absorbed through the skin and exposure by this route has probably accounted for the most severe cases of occupational poisoning.

2.2 Uptake, Metabolism, and Excretion

Acrylamide is readily absorbed by all routes, but toxicologically significant quantities are most likely to be absorbed unintentionally through the skin after splashing of the skin or clothing. Radiolabelled acrylamide, administered orally to rats at 10 mg/kg body weight, resulted in rapid uniform distribution of the radioactivity, which diminished biphasically with half-times of approximately 5 h and 8 days, respectively. Some 70% of the label was recovered in the urine, but none from the expired air. The amount of the label detected in the faeces (6%), was less than that in the biliary excretion, indicating some enterohepatic circulation. Acrylamide binds to haemoglobin and reacts with nucleophilic groups. It reacts with glutathione to form the *S*-β-propionamide glutathione conjugate, which is

then degraded by normal routes to give cysteine and *N*-acetylcysteine derivatives of this conjugate. The urine also contains metabolites that do not contain sulfur. Radiolabelled acrylamide administered to Porton Strain rats had a shorter elimination half-time of 1.9 h.

2.3 Effects on Organisms in the Environment

Acrylamide is biodegradeable. The biological oxygen demand (BOD) is 54–75% of the theoretical value based on conversion to nitrogen and ammonia.

LC_{50} values in fingerling rainbow trout (*Salmo gairdneri*) at 24, 48, 72, and 96 h were 300, 210, 170, and 162 mg acrylamide/litre, respectively. There were no clinical effects on swimming behaviour in goldfish (*Carassius auratus*) exposed to 50 mg acrylamide/litre for 30 days, but this concentration caused death in rainbow trout exposed for 15 days and there were other generalized toxic effects that impaired swimming behaviour. Though there were no behavioural effects at 25 mg/litre, enzyme studies revealed adverse hepatic effects in rainbow trout at this, and higher, concentrations. Metabolic studies indicated that acrylamide is rapidly absorbed and distributed within the bodies of trout, but that little biological concentration occurs (overall less than 1.65 on exposure to 0.71 mg/litre, although kidneys concentrated acrylamide four-fold). Excretion was biphasic and fairly rapid (half-time of the slow phase was 7.7 days, after a 72-h exposure to 0.71 mg/litre).

Some LC_{50} values in aquatic organisms were: (i) water flea (*Daphnia magna*) (48-h exposure) 160 mg/litre; (ii) rainbow trout (*Salmo gairdneri*) (96-h exposure) 110 mg/litre; (iii) fathead minnow (*Pimephales promelas*) (96-h exposure) 120 mg/litre; and (iv) bluegill (*Lepomis macrochinua*) (96-h exposure) 100 mg/litre.

2.4 Effects on Animals

Single doses of 100–200 mg acrylamide/kg body weight are lethal by most routes, in most species. A dermal LD_{50} in rats was 400 mg/kg body weight. Acute lethal doses in the monkey resulted in pathological changes in the lungs (congestion), liver (congestion, fatty degeneration, and necrosis), and kidneys (congestion and both glomerular and tubular degeneration).

SUMMARY AND EVALUATION

Acrylamide is neurotoxic in a number of animal species. Central nervous system effects predominate in acute poisoning, whereas peripheral neuropathy occurs with repeated exposures. Sensation is usually affected before motor function.

Repeated doses of 10–50 mg/kg body weight per day, by any route, in most experimental species, cause a neuropathy affecting principally the peripheral axons (both motor and sensory) and the visual system. In some cases, early effects may be reversible on cessation of dosing. In mice and rats, repeated doses cause testicular atrophy with degeneration of the germinal epithelium, but preservation of interstitial (Leydig) cells. In experimental animal studies, it has been reported that acrylamide crosses the placenta.

Negative findings have been reported in studies investigating the ability of acrylamide to produce gene mutations in bacteria (*Salmonella*) and in insects (*Drosophila*: sex-linked recessive lethal assay).

Acrylamide consistently produced chromosome damage in a range of cell types *in vitro*, and there was evidence of gene mutation in mammalian cells (mouse lymphoma cell assay). The ability of acrylamide to produce chromosomal damage was also shown in bone marrow cells *in vivo*: there were positive findings in metaphase analysis for chromosome damage and for the presence of micronuclei.

Evidence for *in vivo* effects on the chromosomes of male germ cells has also been obtained. There were positive results in cytogenetic studies on sperm cells and in dominant lethal assays. These effects appear to be heritable, since positive results were obtained in a heritable translocation assay, with effects (translocations) seen in the germ cells of offspring.

These data indicate that acrylamide is an *in vivo* mutagen, capable of producing heritable effects in germ cells.

In tests for potential as an initiator of carcinogenesis, acrylamide was administered orally three times a week, for two weeks, to mice in amounts equivalent to cumulative doses of 75, 150, and 300 mg/kg body weight. It was also given to other groups by intraperitoneal injection, or by painting of the dorsal skin. Following these treatments, animals were treated with thrice-weekly skin applications of the promoter 12-*o*-tetradecanoyl phorbol-13-acetate (1 μg in 0.2ml acetone), for 20 weeks. Treatment-

related increases in squamous-cell carcinomas were found with all routes of acrylamide administration, indicating that acrylamide is a potential initiator.

Thrice-weekly administration of acrylamide to mice at 6.25, 12.5, or 25 mg/kg body weight (orally) and 1, 3, 10, 30, or 60 mg/kg body weight (intraperitoneally), from the age of 8 weeks to 16 weeks, resulted in dose-dependent increases in the frequency of adenomas of the lung.

In a 2-year study in which acrylamide was administered in the drinking-water at 0, 0.01, 0.1, 0.5, or 2 mg/kg body weight per day, male rats developed adrenal phaeochromocytomas, mesotheliomas of the tunica of the testis, and follicular adenomas of the thyroid. Female rats had increased incidences of pituitary adenomas, thyroid follicular tumours, mammary tumours, oral papillomas, uterine adenocarcinomas, and clitoral gland tumours.

There is sufficient evidence to classify acrylamide as an animal carcinogen.

2.5 Effects on Human Beings

Acrylamide is moderately irritating on prolonged contact with the skin and is irritating to the eyes. An exfoliative, erythematous rash, particularly on the hands, can occur with long-term dermal exposure.

Polyneuropathy (characterized particularly by distal weakness and paraesthesia, ataxia, impaired fine movements and, later, reduced muscle power) is the best-recognized toxic effect. Repeated dermal exposure has been the usual route of absorption. Control of exposure in the early stages results in remission of symptoms; however, advanced symptoms may persist. Early signs of polyneuropathy may be erythema, sweating, and coldness and cyanosis of the hands and feet. Changes may occur in sensory nerve action potentials, vibration perception threshold, peripheral nerve conduction velocity, or in the electromyogram, before there are obvious symptomatic changes. Skin examinations and neurophysiological studies have been recommended for monitoring health effects. Neurotoxic effects may also follow ingestion. With toxic doses, these may include hallucinations and seizures and subsequent peripheral neuropathy. Ingestion can also result in gastrointestinal tract irritation and

haemorrhage, hepatotoxicity, respiratory distress, and hypotension. These effects may be delayed.

Acrylamide forms haemoglobin adducts and the determination of *S*-(2-carboxyethyl) cysteine in hydrolysed haemoglobin by gas chromatograph-mass spectrometry has been used, as a measurement of absorbed dose, in monitoring exposure.

No epidemiological data are available to evaluate the carcinogenicity of acrylamide for human beings. On the basis of experimental animal data, the International Agency for Research on Cancer (IARC) classifies acrylamide as "possibly carcinogenic to humans".

3. CONCLUSIONS

Exposure of the general population to acrylamide is limited by: (*a*) the low monomer levels permitted in polyacrylamides and acrylamide co-polymers used for purposes where there may be direct or indirect human contact, and (*b*) the low levels in drinking-water. Occupational exposure may occur in the manufacture and use of acrylamide and its polymers and repeated skin contact presents the greatest risk of poisoning. Proper working practices and hygiene measures, such as frequent laundering of work clothing and decontamination of surfaces with which body contact is possible, are important in preventing excessive exposure. Skin and eye irritation occur with acute exposures.

Neurotoxicity is well described. Presymptomatic changes may be detectable in the electromyelogram (EMG) and nerve conduction velocity. The earliest clinical signs are trophic changes in the skin. Early local symptoms appear distally and include impaired fine movements and ataxia and there may be generalized tiredness. Sensory and power loss occur later. Early changes reverse rapidly on cessation of exposure.

On the basis of experimental animal data, acrylamide is considered to be possibly carcinogenic for human beings.

4. HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

4.1 Main Human Health Hazards, Prevention and Protection, First Aid

Acrylamide vapour and solutions are irritating to the skin and eyes. Acrylamide is well absorbed through the skin, and can damage the liver and kidneys (see Summary of Chemical Safety Information, section 6).

While neurotoxic symptoms are unlikely after single exposures, previous exposures to clinically subtoxic doses could result in symptoms, apparently related to a single major exposure. The onset of symptoms may be significantly delayed following exposure.

4.2 Advice to Physicians

Thorough and vigorous washing of the skin with water will minimize systemic absorption following skin contamination. The absence of progressive changes in the electromyogram or the nerve conduction velocity signifies that neuropathy is unlikely.

Following ingestion, effects may be delayed, and it is important to keep the patient under observation. Gastric lavage should be applied, followed by supportive treatment. This may involve ventilatory support for respiratory distress, anticonvulsants, and pressor agents for hypotension.

There is no specific antidote.

4.3 Health Surveillance Advice

Control of exposure by containment and good working and hygiene practices is most important. When monitoring the health of workers, skin inspection for trophic changes is inappropriate for exposure control, because it depends on the detection of an early disease state. Neurological examinations are inappropriate for the same reason.

Skin inspection, neurophysiological studies, and clinical examinations are only indicated where: the best achievable engineering controls cannot comply with prescribed atmospheric exposure limits; exposure control is

dependent on personal protective equipment; or these examinations are required by law or for other reasons unrelated to occupational health care.

4.4 Explosion and Fire Hazards

4.4.1 *Explosion hazards*

Acrylamide vapour does not form explosive mixtures with air. Milled solid acrylamide could possibly form an explosive dust cloud.

4.4.2 *Fire hazards*

Acrylamide is combustible in the solid form, but does not represent a fire hazard. However, acrylamide gives off toxic and irritant fumes when heated in a fire. Solutions heated in a fire may undergo spontaneous exothermic polymerization, leading to vaporization of water, and possible rupture of containers. Acrylamide decomposition products include ammonia, hydrogen, and carbon monoxide.

4.4.3 *Prevention*

Solid acrylamide should be handled in such a way that particles do not become airborne. Ensure that solutions are stabilized and properly stored. In a fire, keep drums and tanks cool using a water spray.

4.4.4 *Fire-extinguishing agents*

There are no special requirements. The type of fire-extinguishing agent will be dictated by the other materials involved.

4.5 Storage

Solid acrylamide should be stored in a cool, dry place in light-proof containers, or in the dark. Solutions are normally stabilized (see section 1.2).

Loss of dissolved oxygen, as by blanketing or purging with an inert gas, may impair stabilization by copper sulfate. Prevent contact with bases, oxidizing materials, initiators, and reducing agents.

4.6 Transport

In case of accident, stop the engine. Remove all sources of ignition. Keep bystanders at a distance and divert other traffic. In case of spillage or fire, use methods advised in sections 4.7 and 4.4, respectively. Notify the police and fire brigade immediately. In case of symptoms, follow the advice in the Summary of Chemical Safety Information (section 6).

4.7 Spillage and disposal

4.7.1 *Spillage*

Wear rubber boots, an apron, chemical gauntlets, and a combined dust/organic vapour respirator. If eye protection is not provided by a full-face mask, chemical goggles should be worn.

(*a*) *Solid acrylamide*. Shovel spilled material into sealable containers.

(*b*) *Acrylamide solution*. Minimize spread, dilute with an equal quantity of water to reduce reactivity, and absorb in earth, sand, or other absorbent medium. Shovel the absorbent into sealable containers. Do not allow spilled material to dry out.

Flush the area with copious amounts of water; prevent direct access of run-off to water-courses.

4.7.2 *Disposal*

Acrylamide should be handled with care, because of its toxicity.

The advice given by the International Register of Toxic Chemicals is:

"*Treatment and disposal methods*
Recommendable

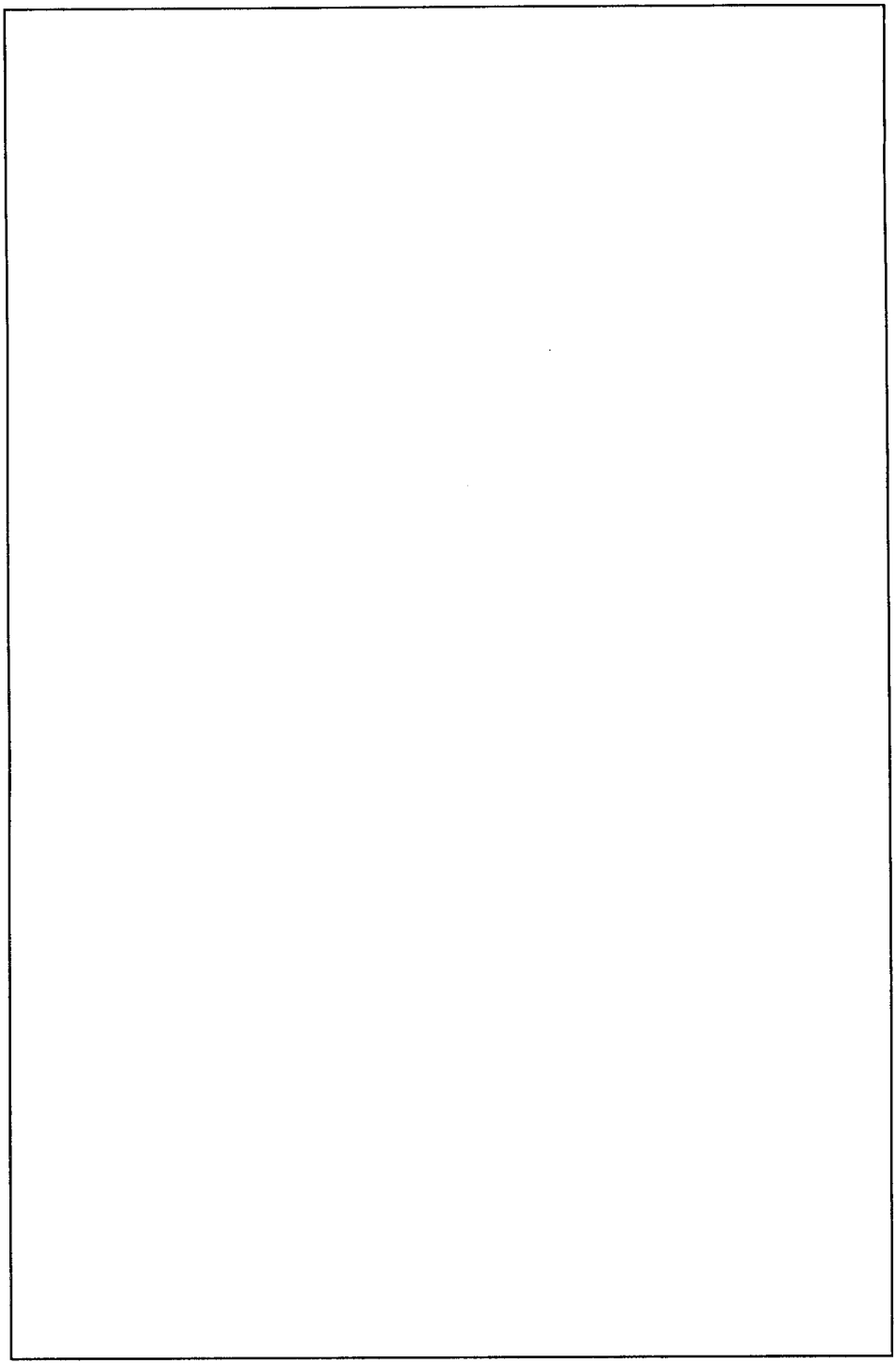
Incineration (with provision for scrubbing of nitrogen oxides from flue gases)
Hydrolysis
Discharge to sewer
Landfill."

"*Peer review*

Handle with care: highly toxic through cyanide effect. Potentially polymerized and then landfill. Dissolve or suspend in much water, and wash down sewer. Hydrolyse with hot sodium or calcium hydroxide solution (care ammonia released) and wash down sewer with copious amounts of water. (Peer review conclusions from an IRPTC Expert Consultation – May 1985)."

5. HAZARDS FOR THE ENVIRONMENT AND THEIR PREVENTION

The emission of significant quantities of acrylamide into surface water could lead to oxygen depletion, because of biodegradation processes. The compound will not pose a significant hazard for aquatic or terrestrial life, except in the vicinity of sites of accidents or inappropriate disposal. Contamination of soil, water, and the atmosphere can be avoided by proper methods of storage, handling, transport, and waste disposal.



6. SUMMARY OF CHEMICAL SAFETY INFORMATION

This summary should be easily available to all health workers concerned with, and users of, acrylamide. It should be displayed at, or near, entrances to areas where there is potential exposure to acrylamide, and on processing equipment and containers. The summary should be translated into the appropriate language(s). All persons potentially exposed to the chemical should also have the instructions in the summary clearly explained.

Space is available for insertion of the National Occupational Exposure Limit, the address and telephone number of the National Poison Control Centre, and for local trade names.

SUMMARY OF CHEMICAL SAFETY INFORMATION

ACRYLAMIDE (MONOMER)

2-propen(e)amide; acrylic (acid) amide; ethylene carboxamide; propenoic acid amide

$CH_2 = CH\text{-}C(=O)NH_2$

CAS registry no. 79-06-1

PHYSICAL PROPERTIES		OTHER CHARACTERISTICS
Relative molecular mass	71.08	Colourless, odourless solid with flake- or leaf-like crystals on recrystallization from benzene or a 50% aqueous solution; on heating or exposure to UV radiation, polymerization occurs; solutions are stabilized with antioxidant, and acrylamide should be stored in a cool dark place in a light-proof container
Melting point (°C)	84.5	
Boiling point (°C)		
3.33 kPa (25 mmHg)	125	
at ambient pressure	polymerizes	
Water solubility at 30 °C (g/litre)	215.5	
Relative density (d 30/4)	1.122	
Relative vapour density	2.47	
Vapour pressure		
(Pa at 84.5 °C)	213 (solid)	
(kPa at 125 °C)	3.33 (solid)	
(kPa at 20 °C) (50 & 30% solutions)	2	
Flash-point	None	

HAZARDS/SYMPTOMS	PREVENTION AND PROTECTION	FIRST AID
SKIN: Vapour and solutions are irritant; acrylamide is readily absorbed through unbroken skin	Handle mechanically, where possible, in proper enclosures or cabinets with exhaust ventilation; where appropriate, wear clean, impervious gloves and apron to deflect splashes; wear freshly laundered clothes; remove and wash them thoroughly after contamination	Remove contaminated clothing immediately; wash contaminated skin thoroughly with clean running water while rubbing with a clean cloth; continue for at least 10 minutes
EYES: Irritant and lacrimatory	Ensure vapour concentrations are below occupational exposure limits; wear chemical goggles, or face visor, when handling solutions	Irrigate eyes with potable water or sterile eye-wash solution for at least 15 minutes
INGESTION AND SYSTEMIC ABSORPTION BY OTHER ROUTES: Possibility of delayed peripheral neuropathy, liver, and kidney damage; acrylamide is considered to be a possible human carcinogen	Do not eat, drink, or smoke while handling chemicals, and use good work and personal hygiene practices	Do not induce vomiting; obtain medical advice

SUMMARY OF CHEMICAL SAFETY INFORMATION

SPILLAGE	STORAGE	FIRE AND EXPLOSION
SOLID: Wear rubber gloves and boots; shovel material into a sealable container; wash contaminated area with copious amounts of water SOLUTIONS: Wear rubber gloves and boots; absorb spillage in earth or sand, and shovel into a sealable container; wash contaminated area with copious amounts of water; dispose of drummed material as hazardous chemical waste; notify authorities if acrylamide enters water-courses	Store solids and stabilized liquids in a cool, dark place, in light-proof containers	Solid acrylamide is combustible and dust explosions are possible; exothermic polymerization may occur on heating; in fires, keep containers cool with water spray; fire-fighting media are dictated by the other materials involved
WASTE DISPOSAL		**LABELLING**
Incinerate or bury in an approved landfill, or hydrolyse		United Nations: 2074 Class 6.1 A

7. CURRENT REGULATIONS, GUIDELINES, AND STANDARDS

The information given in this section has been extracted from the International Register of Potentially Toxic Chemicals (IRPTC) legal file. A full reference to the original national document from which the information was extracted can be obtained from IRPTC. When no effective date appears in the IRPTC legal file, the year of the reference from which the data are taken is indicated by (r).

The reader should be aware that regulatory decisions about chemicals, taken in a certain country, can only be fully understood in the framework of the legislation of that country. Furthermore, the regulations and guidelines of all countries are subject to change and should always be verified with appropriate regulatory authorities before application.

7.1 Exposure Limit Values

Some exposure limit values are given in the table on pages 28–31.

7.2 Specific Restrictions

Maximum permitted acrylamide monomer content in polymers used for various purposes are specified in national regulations. Some of these are listed in the table of Exposure Limit Values on pages 28–31.

7.3 Labelling, Packaging, and Transport

For transport purposes, acrylamide is classified in United Nations Hazard Class 6.1 (poisonous substance) and Packing Group 111 (substance presenting minor danger).

CURRENT REGULATION, GUIDELINES, AND STANDARDS

EXPOSURE LIMIT VALUES

Medium	Specification	Country/ organization	Exposure limit description	Value (mg/m^3)	Effective date
AIR	Occupational	Argentina	Maximum permissible concentration (MPC)		1979
			Time-weighted average (TWA)	0.3	
			Short-term exposure limit (STEL)	0.6	
			(skin absorption)		
		Australia	Threshold limit value (TLV)		1983
			Time-weighted average (TWA)	0.3	
			(skin absorption)		
		Belgium	Tolerable limit value (TLV)		1988
			Time-weighted average (TWA)	0.3	
			(skin absorption)		
		Canada	Threshold limit value (TLV)		
			Time-weighted average (TWA)	0.3	1980
			Short-term exposure limit (STEL)	0.6	
		Finland	Maximum permissible concentration (MPC)		1988
			Time-weighted average (TWA)	0.3	
			Short-term exposure limit (STEL)	0.6	

Germany, Federal Republic of	Maximum worksite concentration (MAK) (Carcinogenic material Group III AZ; proven in animal experiments: skin absorption)	no value assigned	1989
Hungary	Maximum allowable concentration (MAC) Time-weighted average (TWA) Short-term exposure limit (STEL) (30 min)	0.3 1.5	1978
Italy	Threshold limit value (TLV) (skin absorption)	0.3	1985
Japan	Maximum allowable concentration (MAC) Time-weighted average (TWA) (skin absorption)	0.3	1987
Netherlands	Maximum limit (MXL) Time-weighted average (TWA) (skin absorption)	0.3	1989
Romania	Maximum permissible concentration (MPC) Time-weighted average (TWA) Ceiling value	0.3 0.5	1983
Sweden	Hygienic limit value (HLV) Time-weighted average (TWA) Short-term exposure limit (STEL) (STEL = 15-min TWA) (skin absorption)	0.3 0.9	1988

CURRENT REGULATION, GUIDELINES, AND STANDARDS

EXPOSURE LIMIT VALUES (*continued*)

Medium	Specification	Country/ organization	Exposure limit description	Value (mg/m^3)	Effective date
AIR	Occupational (*continued*)	Switzerland	Maximum worksite concentration (MAK) Time-weighted average (TWA) (Carcinogen: skin absorption)	 0.3	1987
		United Kingdom	Guidance limit Time-weighted average (TWA) Short-term exposure limit (STEL) (STEL = 10-min TWA) (skin absorption) Proposed change to Maximum Exposure Limit (MEL) of 0.3 mg/m^3 (8-h TWA) in 1990	 0.3 0.6	1989
		USA (NIOSH/ OSHA)	Permitted exposure limit (PEL) Time-weighted average (TWA)	0.3 0.3	1987
		USA (ACGIH)	Threshold limit value (TLV) Time-weighted average (TWA) (skin absorption) (suspected human carcinogen)	 0.3	1989

		USSR	Maximum allowable concentration (MAC) Ceiling value (vapour)	0.2	1985
		Yugoslavia	Maximum allowable concentration (MAC) Time-weighted average (TWA) (skin absorption)	0.3	1971
SURFACE WATER	Environmental	USSR	Maximum allowable concentration (MAC)	10 (0.01 mg/litre)	1983
STEAM (acrylamide sodium acrylate resin)	Food contact	USA	Maximum permissible concentration (MPC) of acrylamide-sodium acrylate resin used as a boiler-water additive in the preparation of steam that will contact food	0.05%	1981
POLY-ACRYLAMIDE SOLUTIONS	Food contact	USA	Maximum permissible concentration (MPC) in polyacrylamide used to wash, or in lye-peeling of, fruits and vegetables	0.2%	1983
POLY-ACRYLAMIDE	Food additive (various applications)	USA	Maximum permissible concentration (MPC)	0.05%–0.2%	1983

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