

UNEP/WHO/ILO INTERNATIONAL PROGRAMME ON CHEMICAL SAFETY

Health and Safety Guide No. 104

ACRYLIC ACID

HEALTH AND SAFETY GUIDE



UNEP

UNITED NATIONS
ENVIRONMENT PROGRAMME



INTERNATIONAL
LABOUR ORGANISATION



WORLD HEALTH
ORGANIZATION

WORLD HEALTH ORGANIZATION, GENEVA 1997

Other HEALTH AND SAFETY GUIDES available:
(continued on the inside back cover)

- Acetaldehyde (No. 90, 1995)
Acrolein (No. 67, 1992)
Acrylamide (No. 45, 1991)
Acrylonitrile (No. 1, 1986)
Aldicarb (No. 64, 1991)
Aldrin and dieldrin (No. 21, 1988)
Allethrin (No. 24, 1989)
Amitrole (No. 85, 1994)
Ammonia (No. 37, 1990)
Arsenic compounds, inorganic, other than arsine (No. 70, 1992)
Atrazine (No. 47, 1990)
Barium (No. 46, 1991)
Benomyl (No. 81, 1993)
Bentazone (No. 48, 1990)
Beryllium (No. 44, 1990)
Brodifacoum (No. 93, 1995)
Bromadiolone (No. 94, 1995)
1-Butanol (No. 3, 1987)
2-Butanol (No. 4, 1987)
tert-Butanol (No. 7, 1987)
Camphechlor (No. 40, 1990)
Captafol (No. 49, 1990)
Captan (No. 50, 1990)
Carbaryl (No. 78, 1993)
Carbendazim (No. 82, 1993)
Chlordane (No. 13, 1988)
Chlordecone (No. 41, 1990)
Chloroform (No. 87, 1995)
Chlorothalonil (No. 98, 1995)
Cresols (No. 100, 1996)
Cyhalothrin and lambda-cyhalothrin (No. 38, 1990)
Cypermethrin (No. 22, 1988)
Deltamethrin (No. 30, 1989)
1,2-Dichloroethane (No. 55, 1991)
2,4-Dichlorophenoxyacetic acid(2,4-D) (No. 5, 1987)
1,3-Dichloropropene
1,2-dichloropropane, and mixtures of 1,3-dichloropropene and 1,2-dichloropropane (No. 76, 1992)
Dichlorvos (No. 18, 1988)
Difenacoum (No. 95, 1995)
Diflufenuron (No. 99, 1995)
Dimethoate (No. 20, 1988)
Dimethyl sulfate (No. 29, 1989)
Dimethylarsinic acid, methanearsonic acid, and salts (No. 69, 1992)
Dimethylformamide (No. 43, 1990)
Diquat (No. 52, 1991)
Endosulfan (No. 17, 1988)
Endrin (No. 60, 1991)
Epichlorohydrin (No. 8, 1987)
Ethylene oxide (No. 16, 1988)
Fenitrothion (No. 65, 1991)
Fenvalerate (No. 34, 1989)
Folpet (No. 72, 1992)
Formaldehyde (No. 57, 1991)
Heptachlor (No. 14, 1989)
Hexachlorobutadiene (No. 84, 1993)
Hexachlorocyclohexanes, alpha- and beta- (No. 53, 1991)
Hexachlorocyclopentadiene (No. 63, 1991)
n-Hexane (No. 59, 1991)
Hydrazine (No. 56, 1991)
Hydroquinone (No. 101, 1996)
Isobenzan (No. 61, 1991)
Isobutanol (No. 9, 1987)
Isophorone (No. 91, 1995)
Kelevan (No. 2, 1987)
Lindane (No. 54, 1991)
Magnetic fields (No. 27, 1990)
Methamidophos (No. 79, 1993)
Methanol (No. 105, 1997)
Methomyl (No. 97, 1995)
Methyl bromide (Bromomethane) (No. 86, 1995)
Methyl isobutyl ketone (No. 58, 1991)
Methyl parathion (No. 75, 1992)
Methylene chloride (No. 6, 1987)
Mirex (No. 39, 1990)
Monocrotophos (No. 80, 1993)
Morpholine (No. 92, 1995)
Nickel, nickel carbonyl, and some nickel compounds (No. 62, 1991)
Paraquat (No. 51, 1991)
Parathion (No. 74, 1992)
Pentachlorophenol (No. 19, 1988)
Permethrin (No. 33, 1989)

IPCS

Health and Safety Guide No. 104

**ACRYLIC ACID
HEALTH AND SAFETY
GUIDE**

This is a companion volume to
Environmental Health Criteria 191: Acrylic acid

Published by the World Health Organization for the International Programme on Chemical Safety (a collaborative programme of the United Nations Environment Programme, the International Labour Organisation, and the World Health Organization) and produced within the framework of the Inter-Organization Programme for the Sound Management of Chemicals

WORLD HEALTH ORGANIZATION, GENEVA 1997

This report contains the collective views of an international group of experts and does not necessarily represent the decisions or the stated policy of the United Nations Environment Programme, the International Labour Organisation, or the World Health Organization.

WHO Library Cataloguing in Publication Data

Acrylic acid: health and safety guide.

(Health and safety guide ; no. 104)

- 1.Acrylates - adverse effects - toxicity
- 2.Environmental exposure 3.Occupational exposure I.Series

ISBN 92 4 151104 4 (NLM Classification: QV 50)
ISSN 0259-7268

The World Health Organization welcomes requests for permission to reproduce or translate its publications, in part or in full. Applications and enquiries should be addressed to the Office of Publications, World Health Organization, Geneva, Switzerland, which will be glad to provide the latest information on any changes made to the text, plans for new editions, and reprints and translations already available.

© World Health Organization 1997

Publications of the World Health Organization enjoy copyright protection in accordance with the provisions of Protocol 2 of the Universal Copyright Convention. All rights reserved.

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by the World Health Organization in preference to others of a similar nature that are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

The Federal Ministry for the Environment, Nature Conservation
and Nuclear Safety (Germany) provided
financial support for, and undertook the printing of, this publication

Printed by Wissenschaftliche Verlagsgesellschaft mbH · D-70009 Stuttgart 10

CONTENTS

	Page
INTRODUCTION	5
1. PRODUCT IDENTITY AND USES	7
1.1 Identity	7
1.1.1. Primary constituent	7
1.2 Physical and chemical properties	8
1.3 Analytical methods	9
1.4 Production and uses	9
2. SUMMARY AND EVALUATION	10
2.1 Human exposure	10
2.2 Kinetics and metabolism	10
2.3 Effects on animals	10
2.4 Effects on humans	11
2.5 Effects on the environment	11
3. CONCLUSIONS AND RECOMMENDATIONS	13
4. HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION	14
4.1 Main human health hazards, prevention and protection, first aid	14
4.1.1 Advice to physicians	14
4.1.1.1 Symptoms of poisoning	14
4.1.1.2 Medical advice	14
4.1.2 Health surveillance advice	15
4.2 Safety in use	15
4.3 Explosion and fire hazards	16
4.4 Storage	17
4.5 Transport	17
4.6 Spillage and disposal	17
4.6.1 Spillage	17
4.6.2 Disposal	18

CONTENTS

5. HAZARDS FOR THE ENVIRONMENT AND THEIR PREVENTION	20
5.1 Hazards	20
5.2 Prevention	20
6. SUMMARY OF CHEMICAL SAFETY INFORMATION	21
7. CURRENT REGULATIONS, GUIDELINES AND STANDARDS	25
7.1 Previous evaluations by international bodies	25
7.2 Exposure limit values	25
7.3 Specific restrictions	25
7.4 Labelling, packaging and transport	28
BIBLIOGRAPHY	29

INTRODUCTION

The Environmental Health Criteria (EHC) monographs 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 Director
International Programme on Chemical Safety
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

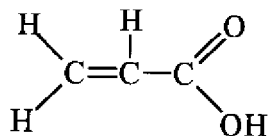
1.1. Identity

1.1.1 Primary constituent

Common name:	Acrylic acid
CAS name:	2-Propenoic acid
CAS registry number:	79-10-7
EEC No:	607-061-00-8
DOT UN:	22-18-29
RTECS Number:	AS 4375000
Synonyms:	acroleic acid 2-propenoic acid vinylformic acid propene acid ethylenecarboxylic acid UN 2218 propenoic acid ethene carboxylic acid

Chemical formula: $C_3H_4O_2$

Chemical structure:



Relative molecular mass: 72.06

Conversion factors: $1 \text{ ppm} = 3.0 \text{ mg/m}^3$; $1 \text{ mg/m}^3 = 0.33 \text{ ppm}$

PRODUCT IDENTITY AND USES

1.2 Physical and Chemical Properties

Acrylic acid is a colourless liquid with an irritating acid odour at room temperature and pressure. Its odour threshold is low (0.20-3.14 mg/m³). It is miscible in water and most organic solvents.

Acrylic acid is commercially available in two grades: technical grade (94%) for esterification, and glacial grade (98-99.5% by weight and a maximum of 0.3% water by weight) for production of water-soluble resins. Acrylic acid polymerizes easily when exposed to heat, light or metals, and so a polymerization inhibitor is added to commercial acrylic acid to prevent the strong exothermic polymerization. The inhibitors that are usually used in acrylic acid preparations are the monomethyl ether of hydroquinone (methoxyphenol) at 200 ± 20 ppm, phenothiazine at 0.1% and hydroquinone at 0.1%. Methylene blue at 0.5 to 1.0% and N,N'-diphenyl-*p*-phenylenediamine at 0.05% can also be used.

Acrylic acid preparations containing polymerization inhibitors are reasonably stable when stored at 15-25 °C and handled according to the supplier's recommendations. Heat can cause vigorous polymerization in some circumstances. Acrylic acid reacts readily with free radicals and electrophilic or nucleophilic agents. It may polymerize in the presence of acids (sulfuric acid, chlorosulfonic acid), alkalis (ammonium hydroxide), amines (ethylenediamine, ethyleneimine, 2-aminoethanol), iron salts, elevated temperature, light, peroxides, and other compounds that form peroxides or free radicals. In the absence of inhibitor, peroxides are formed when oxygen is sparged into acrylic acid. This mixture can undergo violent polymerization if heated to 60 °C.

The presence of oxygen is required for the stabilizer to function effectively. A head space containing sufficient air should always be maintained above the monomer to ensure inhibitor effectiveness. Dissolved oxygen takes part in the inhibition reaction and therefore is gradually consumed. The level of dissolved oxygen should periodically be replenished. This can be accomplished by thoroughly aerating the liquid phase, i.e. recirculation of the inventory in tanks or agitating drums (rotating).

Acrylic acid must never be handled under an inert atmosphere.

PRODUCT IDENTITY AND USES

Freezing of acrylic acid occurs at 13 °C. Rethawing under inappropriate temperature conditions is another frequent reason for acrylic acid polymerization. During the crystallization process the inhibitor and oxygen concentrate in the mother liquor. Therefore no mother liquor should be withdrawn from a partially frozen container. This may result in a severe deficiency of the inhibitor system in the crystalline matrix. If direct heat is applied, polymerization will start immediately, often with great violence. Under no circumstances must steam be used to thaw frozen acrylic acid, nor must thawing be carried out at temperatures above 35 °C.

Acrylic acid is a strong corrosive agent to many metals, such as unalloyed steel, copper and brass. Frequently the hydrolysis of such metallic materials generates a deep discoloration in acrylic acid. Polyvalent metal salts formed during hydrolytic reactions could also induce polymerization. Therefore, under no circumstances should acrylic acid be stored or transported with equipment which contains the above-mentioned metals. Acrylic acid does not affect stainless steel.

1.3 Analytical Methods

Acrylic acid residues in air and other media can be quantified by means of gas chromatographic, high performance liquid chromatographic and polarographic techniques. The detection limits of these methods was found to be 14 mg/m³ (14 ppm) in air and down to 1 mg/kg or 1 mg/litre (1 ppm) in other media.

1.4 Production and Uses

The worldwide production of acrylic acid in 1994 was estimated to be approximately 2 million tonnes. Acrylic acid is used primarily as a starting material in the production of acrylic esters; as a monomer for polyacrylic acid and salts, as a co-monomer with acrylamide for polymers used as flocculants, with ethylene for ion exchange resin polymers, with methyl ester for polymers, and with itatonic acid for other copolymers.

2. SUMMARY AND EVALUATION

2.1 Human Exposure

No data on general population exposure are available. However, consumers may be exposed to unreacted acrylic acid in household goods such as polishes, paints and coatings, adhesives, rug backing, plastics, textiles and paper finishes. A potential source of internal exposure to acrylic acid may result from metabolism of absorbed acrylic acid esters. Acrylic acid also occurs in wastewater effluent from its production. It is estimated that thousands of workers could be exposed to acrylic acid, but exact figures are not available.

2.2 Kinetics and Metabolism

Inhalation and contact with skin are important routes of occupational exposure.

Regardless of the route of exposure, acrylic acid is rapidly absorbed and metabolized. It is extensively metabolized, mainly to 3-hydroxypropionic acid, CO₂ and mercapturic acid, which are eliminated in the expired air and urine. Owing to its rapid metabolism and elimination, the half-life of acrylic acid is short (minutes) and therefore it has no potential for bioaccumulation.

2.3 Effects on Animals

Although a wide range of LD₅₀ values has been reported, most data indicate that acrylic acid is of low to moderate acute toxicity by the oral route, and of moderate acute toxicity by the inhalation and dermal routes.

Acrylic acid is corrosive or irritant to skin and eyes. It is unclear what concentration is non-irritant. It is also a strong irritant to the respiratory tract.

Positive and negative skin sensitization results have been reported with acrylic acid, but it appears that the positive results may be due to an impurity.

In drinking-water studies on rats the no-observed-adverse-effect level (NOAEL) was 140 mg/kg body weight per day for decreased body weight gain in a 12-month study and 240 mg/kg bw per day for histopathological

SUMMARY AND EVALUATION

changes in the stomach. A chronic drinking-water study on rats showed no effect at the highest dose tested (78 mg/kg body weight per day). For inhalation studies a lowest-observed-adverse-effect level (LOAEL) of 15 mg/m³ (5 ppm) was observed in mice exposed to acrylic acid for 90 days, based on very mild nasal lesions in females at this level. Nasal effects in rats were observed at 225 mg/m³ (75 ppm), but not at 15 or 75 mg/m³ (5 or 25 ppm).

Available reproduction studies indicate that acrylic acid is not teratogenic and has no effect on reproduction.

Both positive and negative results have been obtained in *in vitro* genotoxicity tests. An *in vivo* bone marrow chromosome aberration assay was negative, and no firm conclusions can be drawn from an *in vivo* DNA binding study or from a dominant lethal assay.

Available data do not provide evidence for an indication of carcinogenicity of acrylic acid, but the data are inadequate to conclude that no carcinogenic hazard exist.

2.4 Effects on Humans

There have been no reports of poisoning incidents in the general population. No occupational epidemiological studies have been reported.

Because acrylic acid toxicity occurs at the site of contact, separate guidance values are recommended for oral and inhalation exposure. Guidance values of 9.9 mg/litre for drinking-water and 54 µg/m³ for ambient air for the general population are proposed.

2.5 Effects of the Environment

No quantitative data on environmental levels of acrylic acid in ambient air, drinking-water or soil have been reported.

Acrylic acid is miscible with water and, therefore, would not be expected to adsorb significantly to soil or sediment. Under soil conditions, chemicals with low Henry's Law constants are essentially non-volatile. However, the vapour pressure of acrylic acid would suggest that it may volatilize from surfaces and dry soil. Acrylic acid may be formed by hydrolysis

SUMMARY AND EVALUATION

of acrylamide monomer from industrial waste in soil, especially under aerobic conditions.

The toxicity of acrylic acid to bacteria and soil microorganisms is low.

Acrylic acid emitted into the atmosphere will react with photochemically produced hydroxyl radicals and ozone, resulting in rapid degradation. There is no potential for long-range atmospheric transport of acrylic acid because it has an atmospheric lifetime of less than one month.

When released into water, acrylic acid readily biodegrades. The fate of acrylic acid in water depends on chemical and microbial degradation. When added to water acrylic acid is rapidly oxidized, and so it can potentially deplete oxygen if discharged in large quantities into a body of water. Acrylic acid has been shown to be degraded under both aerobic and anaerobic conditions.

On the basis of the low octanol-water partition coefficient of acrylic acid, bioconcentration in aquatic organisms is unlikely. There have been no reports of biomagnification of acrylic acid in food chains.

Algae are the most sensitive group of aquatic organisms studied, with EC_{50} values, based on growth, ranging from 0.04 to 63 mg/litre, and a no-observed-effect concentration (NOEC) for the most sensitive species of 0.008 mg/litre. EC_{50} values (based on immobilization) for *Daphnia magna* were 54 mg/litre (24 h) and 95 mg/litre (48 h). Acute toxicity studies with fish have yielded results ranging from 27 mg/litre (96-h LC_{50}) for the rainbow trout to 315 mg/litre (72-h LC_{50}) for the golden orfe. The 96-h NOEC for acrylic acid toxicity to rainbow trout was found to be 6.3 mg/litre based on a lack of sublethal/behavioural responses.

No data on the effects of acrylic acid on terrestrial organisms have been reported.

3. CONCLUSIONS AND RECOMMENDATIONS

The risks associated with occupational exposure to acrylic acid are low, as long as good industrial practice is followed. There is a lack of quantitative data on the levels of exposure to acrylic acid. However, no obvious adverse effects in the general population have been identified.

Acrylic acid poses minimal risk for the general environment, except in the case of uncontrolled discharge.

It is recommended that exposure of the general public to acrylic acid in the ambient air and drinking-water does not exceed the guidance values given in the Environmental Health Criteria No. 19 Acrylic Acid (IPCS, 1997). These are as follows:

- Inhalation exposure: $54 \mu\text{g}/\text{m}^3$
- Oral exposure via drinking-water: 9.9 mg/litre.

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

4.1. Main human health hazards, prevention and protection, first aid.

Additional details are given in the Summary on Chemical Safety Information (section 6)

4.1.1 *Advice to physicians*

4.1.1.1 *Symptoms of poisoning*

The principal hazard of acrylic acid is its corrosive effect on tissues. Both vapour and liquid can be irritating or corrosive to the mucous membranes, skin and eyes. The severity of these effects is dependent on the duration of contact, which, if prolonged, may result in blisters and burns. Blister formation can appear as late as 24 h after exposure. Severe corneal burns could occur to the eyes. Permanent tissue damage may result if prompt and appropriate emergency response is not provided. First aid recommendations are given in section 6.

Inhalation of concentrated vapours and mist could produce moderate to severe irritation of the respiratory tract. High concentrations could result in pulmonary oedema while lower concentrations could produce nasal and throat irritation. Lacrymation may also result from inhalation exposure.

Although ingestion is not an expected route of human exposure, swallowing of acrylic acid may cause severe irritation or burning of the mouth, throat, oesophagus or stomach.

No serious health effects have been reported to result from single exposure or repeated exposure at low concentrations of acrylic acid.

4.1.1.2 *Medical advice*

In order to minimize possible consequences of accidents, all personnel assigned to handle acrylic acid must be aware that prompt and appropriate response (see following sections) is essential. First aid must be rendered immediately. The installation of a sufficient number of emergency showers and eye washes is a prerequisite for the proper management of incidents.

HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

If even minute quantities of acrylic acid enter the eyes, they must be irrigated by means of an eye wash with copious amounts of lukewarm water for at least 15 min. In order to secure the complete removal of the acid, the assistance of a helper is strongly advised. The eyelids should be held wide open and away from the eye balls. Immediate help of an eye specialist should be sought. Oil or oily ointments should not be applied unless recommended by a physician.

In the event that skin contact with acrylic acid has occurred, all clothing should be completely removed under an emergency shower. Washing with water should be continued until all odour has disappeared, in any case not less than 15 min. The advice of a physician should be sought. Contaminated clothing must never be reused unless properly laundered. Leather wear must be disposed off.

A person who has suffered from inhalation of acid fumes should be removed at once from the contaminated area and made to lie down in fresh air without moving. If the patient is unconscious, he should be placed on his side in a stable position. A physician and ambulance should be summoned immediately. If available, pure oxygen should be administered by means of a respirator, but only by a person who is authorised for such duty by a physician.

If acrylic acid is ingested, the patient should be made to drink large amounts of water. Vomiting should not be induced. A physician and ambulance should be summoned immediately.

4.1.2 *Health surveillance advice*

Pre-employment and annual general medical examinations are advised for regularly exposed workers.

4.2 Safety in Use

Acrylic acid should only be handled in well-aerated and well-ventilated places. If exposure to concentrated vapour can not be excluded (as in the case of an accident), self-contained breathing apparatus or air supply masks must

HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

be worn. Care must be taken when using filter-type masks to ensure that the filter capacity is not exceeded for the intended time of use and expected concentration.

In areas where a release of acrylic acid is possible, eye protection devices, face shields, neoprene gloves and rubber boots should be worn. A chemical suit with a self-contained breathing apparatus is strongly recommended if larger spills or emissions have to be cleared. Appropriate protective clothing should be worn for work involving breaking or entering into a closed acrylic acid system. Owing to its vapour pressure, the concentration of acrylic acid in closed rooms can reach high values.

If clothing or shoes have accidentally been contaminated with acrylic acid, they must be removed immediately. Contaminated leather shoes or other leather goods must be discarded.

For timely and appropriate emergency response, it is advisable to provide complete sets of safety protection equipment near places where accidents with acrylic acid are possible.

4.3 Explosion and Fire Hazards

Acrylic acid has a flash point of 54-68 °C and does not form explosible vapour mixtures at ordinary ambient temperatures. However, ignition may occur if excessive amounts of mist or aerosols have formed in air. Ignition sources can include spark discharges from static electricity, and this can occur when acrylic acid is flowing through or being discharged from a line. During transfer from one container into another, the containers should be electrically interconnected and properly grounded. Splashing into a tank should be avoided by using a dip tube.

Since acrylic acid and water are miscible in any proportion, water can be used to extinguish fires. Small fires can be fought with carbon dioxide or dry chemical extinguishers, whereas for larger fires foam (alcohol or universal type) can be used.

If a fire occurs in or close to a tank farm containing acrylic acid, tanks and pipes should be cooled by spraying with water in order to prevent the acid from polymerizing.

HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

4.4. Storage

Acrylic acid should be stored in a detached, cool, well-ventilated, non-combustible place and its containers should be protected against physical damage. Acrylic acid can be stored only in vessels lined with glass, stainless steel, aluminum or polyethylene. In order to inhibit polymerization during transport and storage, 200 ppm MeHQ (the monomethyl ether of hydroquinone) is commonly added to acrylic acid by the manufacturer. The presence of oxygen is required for the inhibitor to be effective. A major concern during the storage of acrylic acid is the avoidance of elevated temperatures as well as freezing, since both can lead to a failure of the inhibitor system. Ideally acrylic acid should be stored within a temperature range of 15 to 25 °C.

Acrylic acid and its solutions should be kept out of reach of children and unauthorized persons as well as away from food, drink and animal feed. If any container in the store is leaking, appropriate precautions should be taken (see section 6) and personal protective equipment used.

4.5. Transport

Acrylic acid is shipped in containers in compliance with regulations according to ADR/RID/GGVS/GGVE, Class 8 Packing Group B specifications. Acrylic acid is commonly shipped in steel drums with polyethylene inserts or in self-supporting high-density polyethylene drums impermeable to ultraviolet light. White polyethylene containers are translucent to ultraviolet light and therefore may promote polymerization. Stainless steel ISO containers are recommended for the transport of quantities of acrylic acid up to 1 tonne.

4.6. Spillage and disposal

4.6.1. Spillage

Before dealing with any spillage, appropriate personal protective equipment should be used (see section 6).

HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

Small spills of up to 5 litres can be absorbed in commercially available clean-up kits (using sand or clay). If a wastewater sewer is close by, the spill can also be washed down with water provided that it is not a storm-sewer or ditch that is routed to surface water.

Large spills should be contained, if possible, within a diked area. A temporary dike can be arranged by stacking sand bags or similar devices. Avoid run-off into storm sewers routed to public surface water. If possible, the material should be recovered in appropriate containers for reuse or disposal. If a wastewater sewer is available, the acid or remainders can also be sparingly washed down after dilution and neutralization prior to being discharged to a water-treatment plant. During all handling operations of large spills a chemical suit with a self-contained or air-supplied breathing device must be worn.

In the event of accidental spillage of acrylic acid to surface water or to a municipal sewer system, the pollution control agencies must be notified promptly.

Spills of the monomer may be diluted and washed into a biological treatment plant after notification of the person in charge. The biodegradability of the material in diluted form is good (> 70% Zahn-Wellens static test OECD 302 B). However, acrylic acid may be toxic to the system if the bacteria have not been conditioned properly to this material. Accordingly, the initial feed rate should be low with a stepwise increase if a significant amount is to be fed into the biological treatment plant. The maximum concentration should not exceed 1000 mg per litre. It should be kept in mind, however, that large quantities may affect the optimal acidity of the milieu and may therefore need to be neutralized by the simultaneous addition of sodium hydroxide.

4.6.2. Disposal

State laws and local regulations governing waste disposal make it essential for producers, suppliers, hauliers and users of acrylic acid to be fully aware of viable options for the ultimate disposal of materials containing acrylic acid. Materials to be disposed of may be residues from production or cleaning operations as well as waste material from spills.

HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

Acrylic acid is a highly corrosive material. Accordingly it should always be handled with appropriate safety equipment.

Solid materials containing acrylic acid, such as absorbents or polymeric material, can be disposed of by incineration. Disposal in landfills must be thoroughly checked with the authorities and should be practiced only as a last resort.

For the disposal of waste materials originating from laboratory samples, great care must be taken to keep the monomer separated from incompatible material, such as peroxides, which may initiate polymerization.

5. HAZARDS FOR THE ENVIRONMENT AND THEIR PREVENTION

5.1. Hazards

Most of the available data indicate that acrylic acid has low toxicity for mammals and aquatic organisms. Algae are the most sensitive group of aquatic organisms. Acrylic acid is miscible with water and therefore would not be expected to adsorb significantly to soil or sediment. If released on land or into water, acrylic acid should readily biodegrade although no rate data are available. Acrylic acid is unlikely to pose a problem in the general environment.

5.2. Prevention

Because of its action as a strong irritant to mucous membranes and explosive properties of its mixtures with air, it is essential that concentrations of acrylic acid in the ambient air be kept as low as possible. Care should be taken during any manipulations with any acrylic acid containers. Any effluent containing acrylic acid should be properly treated, and any acrylic acid spillage should be protected from all possible ignition sources.

6. SUMMARY OF CHEMICAL SAFETY INFORMATION

This summary should be easily available to all health workers concerned with, and users of, acrylic acid. It should be displayed at, or near, entrances to areas where there is potential exposure to acrylic acid, 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 Centre, and for local trade names.

SUMMARY OF CHEMICAL SAFETY INFORMATION

ACRYLIC ACID

CAS no. 79-10-7;

Chemical formula: $C_3H_4O_2$

PHYSICAL PROPERTIES

Relative molecular mass	72.06
Melting point (°C)	12.3-14
Boiling point (°C)	141.3-141.6
Flash point, open cup (°C)	54.4-68.3
Autoignition temperature (°C)	390-446
Flammable limits	
lower	2.0%
upper	8.0%
Specific gravity (20 °C)	1.0497-1.0511 g/ml
Relative vapour density (air = 1 at 20 °C)	2.5
Vapour pressure (39 °C)	10 mm Hg
Octanol/water partition coefficient (log K_{ow} at 20-25 °C)	0.161-0.46
Henry's law constant	3.2×10^7 atm x m ³ /mol
Solubility in water	miscible
Solubility in organic solvents	
alcohol	miscible
chloroform	miscible
benzene	miscible
acetone	soluble (> 10 %)

OTHER CHARACTERISTICS

Watery, colourless liquid with an irritating acrid odour; polymerizes on heating or in the presence of oxygen, acids, alkalis, amines, iron salts, light or other compounds forming peroxides or free radicals; during polymerization a large amount of heat may be released; owing to photochemical attack, decomposes in the atmosphere; when heated, toxic gases are generated, which can form an explosive mixture; miscible with water and soluble in many organic solvents; corrosive to many metals

HAZARD/EFFECTS	PREVENTION AND PROTECTION	FIRST AID
<p>GENERAL: Strong irritative liquid and vapours</p>	<p>Prevent any spill; avoid inhalation of vapour; if you feel unwell seek medical advice; keep out of reach of children.</p>	
<p>SKIN: liquid is a primary irritant, may cause burns by splash contact</p>	<p>Avoid contact: wear neoprene gloves, acid goggles or face shield; safety footwear of chemical resistant material should be worn over leather safety shoes; safety shower may be required</p>	<p>Remove contaminated clothes and wash exposed area thoroughly with plenty of water and soap; a physician should be consulted if irritation or pain persists</p>
<p>EYES: splashes may cause burns, corneal damage and blindness; vapour may cause lacrimation and strong irritancy</p>	<p>Avoid contamination with liquid or exposure to vapour; use acid goggles or face shield; safety fountain may be required</p>	<p>If even minute quantities of acrylic acid enter the eyes, rinse them with copious amounts of lukewarm water for at least 15 min; immediate help of an eye specialist should be sought</p>
<p>INHALATION: mild inhalation effects may occur from acute exposure</p>	<p>Avoid exposure to vapour; wear chemical respirator at ambient temperature to avoid inhalation of noxious fumes; suitable protective clothing and self-contained respiratory protective apparatus should be available for those who may have to rescue people overcome by fumes</p>	<p>Move victim to fresh air, provide all emergency medical care; if the victim is not breathing, give artificial respiration; if breathing is difficult, give humidified oxygen; call a physician and ambulance immediately</p>
<p>INGESTION: strong irritant to mucous membranes of alimentary tract</p>	<p>Do not eat, drink or smoke during work</p>	<p>If victim is conscious, give large amounts of water to drink; do not induce emesis as acrylic acid is a corrosive material; obtain medical advice immediately</p>

<p>ENVIRONMENT: High concentrations in surface waters may be toxic to aquatic organisms; algae are the most sensitive group of aquatic organisms</p>	<p>Avoid spillage into the environment</p>
<p>SPILLAGE</p>	<p>STORAGE</p> <p>Store in detached, well-ventilated cool and dry place; substance should be stored only in glass, stainless steel, aluminum or polyethylene-lined equipment; care should be taken that uninhibited acrylic acid vapour does not polymerize in the vents of flame arresters of storage tanks, resulting in stoppage of vents</p>
<p>Absorb spilled liquid with sand, clay or other non-combustible material; alternatively dilute the spillage with water and neutralize with sodium hydrogen carbonate, crushed limestone or lime; use appropriate personal protective equipment (goggles, gloves, boots etc.)</p>	<p>FIRE AND EXPLOSION</p> <p>Acrylic acid is flammable and may be ignited by heat, sparks or flames; when heated, toxic vapours are generated; use water spray, alcohol foam, dry chemicals or carbon dioxide to extinguish fires</p>
<p>WASTE DISPOSAL</p>	<p>NATIONAL INFORMATION</p>
<p>Burn at high temperature (up to 1600 °C) in liquid injection incinerator, rotary kiln incinerator or fluidized bed incinerator</p>	<p>National occupational exposure limit: National Poisons Control Centre: Local trade names</p>

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 and other UN sources. The intention is to give the reader a representative but non-exhaustive overview of current regulations, guidelines and standards. 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 the appropriate regulatory authorities before application.

7.1 Previous Evaluations by International Bodies

The carcinogenicity of acrylic acid has been evaluated by the International Agency for Research on Cancer. Data on the carcinogenicity of the compound for humans were considered inadequate. There was inadequate evidence for carcinogenicity in animals. Therefore, acrylic acid is not classifiable as to its carcinogenicity to humans.

7.2 Exposure Limit Values

Regulatory standards established by national bodies in different countries and the European Union are summarized in the legal file of the International Register of Potentially Toxic Chemicals. Exposure limit values in some countries are shown in the table.

7.3 Specific Restrictions

In the USA acrylic acid as a commercial chemical product is classified as a toxic waste subject to regulation and notification requirements.

In the European Economic Community preparations that contain acrylic acid at concentrations greater than 25% should be considered as corrosive and at concentrations of 2-25% as irritant. Member States should ensure that dangerous preparations containing acrylic acid are not placed on the market unless their packages, fastenings and labels comply with requirements laid down (section 7.4).

CURRENT REGULATIONS, GUIDELINES AND STANDARDS

EXPOSURE LIMIT VALUES

Medium	Specification	Country/organization	Exposure limit description	Value (mg/m ³)
AIR	Occupational	Australia	Threshold limit value (TLV) Time-weighted average (8-h TWA)	30
		Belgium	Time-weighted average (TWA)	5.9
		Denmark	Time-weighted average (TWA)	30
		France	Threshold limit value (TLV)	5.9
		Italy	Time-weighted average (TWA)	5.9
		Netherlands	Time-weighted average (TWA)	5.9
		Poland	Maximum allowable concentration - TWA - Ceiling value	20 50
		Sweden	Hygienic limit value (HLV) - Time-weighted average (8-h TWA) - Short-term exposure limit (STEL)	30 45

Medium	Specification	Country/organization	Exposure limit description	Value (mg/m ³)
		Switzerland	TWA	30
		United Kingdom	Time-weighted average (8-h TWA) Short-term exposure limit (STEL) (10-min TWA)	60
		USA (OSHA)	Permissible exposure limit (PEL) - Time-weighted average (TWA)	30 (skin)
		USA (ACGIH)	Threshold limit value (TLV) - Time-weighted average (TWA)	59 (skin)
		Former USSR	Maximum allowable concentration (MAC) - Ceiling value (short-term)	5

CURRENT REGULATIONS, GUIDELINES AND STANDARDS

In Canada, the maximum amount of acrylic acid that may be transported on a passenger aircraft, train or road vehicle is one litre. The maximum amount that may be transported on a cargo aircraft is 30 litres.

7.4 Labelling, Packaging and Transport

Acrylic acid has been classified in the European Community under Council Directive 67/548/EEC (as amended for the seventh time in Council Directive 92/32/EEC) and appears in Annex 1 under EEC No 607-061-00-8. Acrylic acid is classified as both flammable with risk phrase R11 (flammable) and corrosive with symbol C and risk phrase R34 (causes burns). It is also labelled with the following safety phrases: S26 (in case of contact with eyes, rinse immediately with plenty of water and seek medical advice), S36 (wear suitable protective clothing) and S45 (in case of accident or if you feel unwell seek medical advice immediately, show the label where possible). The following phrases also apply if the substance is sold to the general public or is likely to be used in places where the public has access: S1 (keep locked up) and S2 (keep out of reach of children).

BIBLIOGRAPHY

ACGIH (1990) 1990-1991 Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, American Conference of Government Industrial Hygienists.

CEC/IPCS (1993) International Chemical Safety Card 688 Acrylic acid. Luxembourg, Commission of the European Communities.

CHRIS (1989) CHRIS Hazardous Chemical Data, US Department of Transportation, US Coast Guard, Washington, DC (CD-ROM Version). Denver, Colorado, Micromedex, Inc.

Clayton G.D. and Clayton F.E. (Eds) (1982) Patty's industrial hygiene and toxicology, Vol 2 Toxicology, 3rd ed, New York, John Wiley and Sons.

Finkel A.J. (1983) Hamilton and Hardy's Industrial Toxicology, 4th ed., Boston, John Wright, PSG Inc.

Fire Protection Guide on Hazardous Materials, 7th ed. (1978) Boston, National Fire Protection Association.

Hamilton A. & Hardy H.L. (1974) Industrial Toxicology, 3rd ed. Massachusetts, Publishing Sciences Group, Inc, Action.

HSDB (1989) Hazardous substances data bank. National Library of Medicine, Bethesda, Maryland (CD-ROM Version). Denver, Colorado, Micromedex, Inc.

IPCS (1997) Environmental Health Criteria 191: Acrylic acid. Geneva, World Health Organization.

ITI (1985) Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan, International Technical Information Institute.

BIBLIOGRAPHY

Kirk-Othmer Encyclopedia of Chemical Technology (1978-1984) 3rd ed. V.1-26, New York, J. Wiley and Sons.

NIOSH (1985) Pocket Guide to Chemical Hazards. Cincinnati, Ohio, National Institute for Occupational Safety and Health.

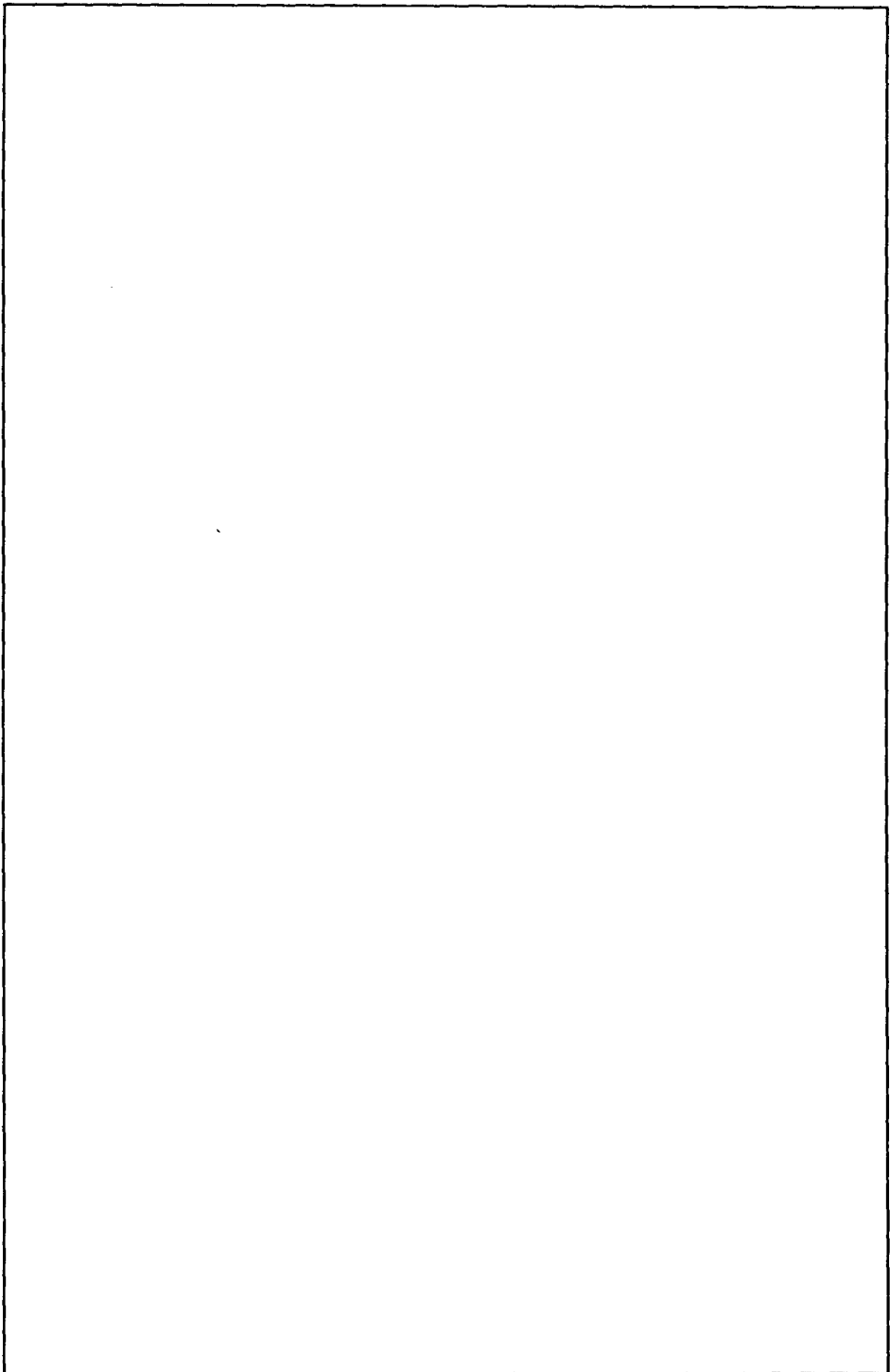
OHM/TADS (1989) Oil and Hazardous Materials/Technical Assistance Data System. US Environmental Protection Agency, Washington, DC (CD-ROM Version). Denver, Colorado, Micromedex, Inc.

OSHA (1989) Department of Labour, Occupational Safety and Health Administration: 29 CFR Part 1910; Air Contaminants; Final Rule. Federal Register; 54(12): 2332-2983.

RTECS (1988) Registry of toxic effects of chemical substances. National Institute for Occupational Safety and Health, Cincinnati, Ohio (CD-ROM Version). Hamilton, Ontario, Canadian Centre for Occupational Safety and Health.

Sax N.I. and Lewis R.J. (1987) Hawley's Condensed Chemical Dictionary, 11th ed. New York, Van Nostrand Reinhold Co, pp 18-19.

Sax N.I. and Lewis R.J. (1989) Dangerous properties of industrial chemicals, 7th ed. New York, Van Nostrand Reinhold, pp 71-72.



IPCS

Other HEALTH AND SAFETY GUIDES
available:
(continued from inside front cover)

Phenol (No. 88, 1995)
d-Phenothrin (No. 32, 1989)
Phosphine (No. 28, 1989)
Phosphorus trichloride and phosphorus
oxychloride (No. 35, 1989)
Polybrominated biphenyls (PBBs)
(No. 83, 1993)
Polychlorinated biphenyls and
polychlorinated terphenyls (PCBs and
PCTs) (No. 68, 1992)
Propachlor (No. 77, 1992)
Propylene oxide (No. 15, 1988)
Pyrrolizidine alkaloids (No. 26, 1988)
Quintozene (No. 23, 1988)
Resmethrins (No. 25, 1989)
Rotenone (No. 73, 1992)
Tecnazene (No. 12, 1988)
Tetrachloroethylene (No. 10, 1987)
Tetradifon (No. 11, 1987)
Tetramethrin (No. 31, 1989)
Thallium and Thallium compounds
(No. 102, 1997)
Tri-alleate (No. 89, 1994)
Trichlorfon (No. 66, 1991)
Trimellitic anhydride (No. 71, 1992)
Vanadium (No. 42, 1990)
Vinylidene chloride (No. 36, 1989)
Warfarin (No. 96, 1995)
White Spirit (Stoddard solvent)
(No. 103, 1997)

To obtain further copies of monographs in this series, or the Users' Manual for the IPCS Health and Safety Guides, please write to the Office of Distribution and Sales, World Health Organization, 1211 Geneva 27, Switzerland (Fax No: 4122 7914857; E-mail: publications@who.ch)

ISBN 92 4 151104 4