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ACRYLAMIDE

CAS No: 79-06-1

EINECS No: 201-173-7

Summary Risk Assessment Report

2002 **Special Publication I.01.70**

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SUMMARY RISK ASSESSMENT REPORT

Final report, 2002

United Kingdom

This document has been prepared by the UK rapporteur on behalf of the European Union. The scientific work on the environmental part was prepared by the Building Research Establishment (BRE), by order of the rapporteur.

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(The last full literature survey was carried out in 1995 - targeted searches (for example on grouting) were carried out subsequently, and information found through scanning certain sources has also been included).

PREFACE

This report provides a summary, with conclusions, of the risk assessment report of the substance acrylamide that has been prepared by the United Kingdom in the context of Council Regulation (EEC) No. 793/93 on the evaluation and control of existing substances.

For detailed information on the risk assessment principles and procedures followed, the underlying data and the literature references the reader is referred to the comprehensive Final Risk Assessment Report (Final RAR) that can be obtained from the European Chemicals Bureau[1]. The Final RAR should be used for citation purposes rather than this present Summary Report.

[1] European Chemicals Bureau – Existing Chemicals – http://ecb.jrc.it

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1 GENERAL SUBSTANCE INFORMATION

1.1 IDENTIFICATION OF THE SUBSTANCE

CAS-No.: 79-06-1
EINECS-No.: 201-173-7
IUPAC name: acrylamide
Molecular formula: C_3H_5NO
Structural formula $CH_2 = CH - CONH_2$
Molecular weight 71.09
Synonyms: 2-propenamide, acrylic acid amide, ethylene carboxamide, propenoic acid amide, vinyl amide

1.2 PHYSICO-CHEMICAL PROPERTIES

The physico-chemical properties of acrylamide are shown in **Table 1.1**.

Table 1.1 Properties of acrylamide

Property	Value
Physical State	white crystalline solid at ntp.
Melting Point	84 - 84.5°C
Boiling Point	125°C at 25 mmHg (3.3 kPa) 103°C at 0.67 kPa bpt. not applicable at normal pressure due to polymerization.
Density	1.127 $g \cdot cm^{-3}$ at 30ºC
Partition Coefficient Log P_{ow}	- 0.67 to -1.65
Vapour Pressure	0.9 Pa at 25°C 4.4 Pa at 40°C 9.3 Pa at 50°C 213 Pa at 84.5°C (mpt) with 5% $CuCl_2$
Solubility	2,155 $g \cdot l^{-1}$ at 30°C
Flash Point	n/a – however can polymerize exothermically above mpt
Autoignition	as above
Explosivity	as above
Oxidising Properties	not an oxidising agent

1.3 CLASSIFICATION

Classification and labelling according to the 28th ATP of Directive 67/548/EEC[2]:

Classification

Carc.Cat. 2; R45	May cause cancer
Muta.Cat. 2; R46	May cause heritable genetic damage
Repr.Cat. 3; R62	Possible risk of impaired fertility
T; R25-48/23/24/25	Also toxic: danger of serious damages to health by prolonged exposure through inhalation, in contact with skin and if swallowed
Xn; R20/21	Also harmful by inhalation and in contact with skin
Xi; R36/38	Also irritating to eyes and skin
R43	May cause sensitisation by skin contact

Note D
Note E

Specific concentration limits: None

Labelling

T;
R45-46-20/21-25-36/38-43-48/23/24/25-62
S53-45

S53	Avoid exposure – obtain special instructions before use
S45	In the case of accident of if you feel unwell seek medical advice immediately (show the label where possible)

No classification for the environment.

[2] The classification of the substance is established by Commission Directive 2001/59/EC of 6 August 2001 adapting to the technical progress for the 28th time Council Directive 67/548/EEC on the approximation of the laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances (OJ L 225, 21.8.2001, p.1).

2 GENERAL INFORMATION ON EXPOSURE

Three companies are reported as producing acrylamide within the EU (UK, Germany and the Netherlands) while a further two companies are involved in the import of acrylamide. Total EU production of acrylamide is estimated at between 80,000-100,000 tonnes. Acrylamide is usually made as a 30-50% aqueous solution although a crystalline form is produced at one European production plant. Small amounts of acrylamide powder are imported into the EU for production of polyacrylamides. Acrylamide is also exported outside the EU but the majority of EU acrylamide production is used within the EU.

Approximately 99.9% of acrylamide in the EU is used in the production of polyacrylamides. About 80-90% of polyacrylamide is used in wastewater treatment and paper and pulp processing. Other uses include crude oil production, cosmetic additives and soil and sand stabilisation. About 0.1% of the acrylamide produced in the EU is used to produce polyacrylamide electrophoresis gels, which are used as a research tool for separating nucleic acids in research establishments, universities and hospitals. The degradation of polyacrylamide to release free monomeric acrylamide is reported to be unlikely.

Acrylamide can also be used in the formulation of grouting agents. Acrylamide grouts are no longer thought to be produced within the EU but are imported from outside the EU. The major end-uses of acrylamide grouts are sewer line sealing and manhole sealing; minor uses are for structural water control and for geotechnical applications. A derivative of acrylamide, N-methylolacrylamide (NMA) may also be used in grouting applications. NMA has the potential to regenerate acrylamide but the extent to which this happens in practice is not known and is dependent on the environmental conditions.

3 ENVIRONMENT

3.1 EXPOSURE ASSESSMENT

The major relevant fate and behaviour characteristics of acrylamide are that:

- it is readily biodegradable;
- it has a high-water solubility (2,155 g/l at 30ºC) and low-vapour pressure (0.9 Pa at 25ºC);
- it has a low log K_{ow} value (around -1.0); and
- it has an estimated atmospheric half-life of 8.3 hours.

Acrylamide has a low potential for bioaccumulation based upon measured levels in fish (bioconcentration factors <1) and the low log K_{ow}. Uptake is rapid upon exposure, then slows to a steady state. Elimination is biphasic with most of the acrylamide being lost in an unchanged form.

Acrylamide is relatively mobile in most soil types and adsorption to soil and sediment particles and sludges is very low. It degrades in soil at a rate dependent on soil type, pH and temperature.

Acrylamide is unlikely to volatilise from surface water (the calculated Henry's Law constant is $2.97 \cdot 10^{-5}$ Pa $\cdot m^3 \cdot mol^{-1}$ at 25°C). Its half-life in the troposphere is short enough that it is unlikely to be transported to the stratosphere. It may be precipitated in rainwater, but the amounts are likely to be small due to the low emissions to air and rapid degradation in air.

The main sources of environmental exposure of acrylamide are its production, the production and use of polyacrylamide, and uses of acrylamide- and NMA-based grouts. Emissions have been estimated using information from Industry in conjunction with the methods in the EU Technical Guidance Document (TGD). Release to water is the most important environmental exposure route, and it is predicted that most of the acrylamide released will remain in the water compartment.

Predicted environmental concentrations (PECs)

Concentrations in water and air were estimated according to the methods in the TGD, and these are summarised in **Table 3.1** (concentrations in soil are expected to be small due to low adsorption to soil particles and biodegradation).

Table 3.1 Summary of PECs for acrylamide

Scenario	PEC_{water} (µg/l)	PEC_{air} (mg/m³)
Acrylamide production (including polyacrylamide production)	0.05-<10	$7.6 \cdot 10^{-6}$-2.3 $\cdot 10^{-6}$
Polyacrylamide use as a coagulant and flocculent in the pulp and paper industry	0.87	No direct emissions to air and indirect emissions from sewage treatment plant are zero.
Polyacrylamide use as a drainage aid in pulp and paper production	4.98	
Polyacrylamide used to treat wastewater (discharge to wastewater treatment plant)	5.39	
Use of NMA based grouts (sewer repair)	3.9	
Regional	0.05	$3.56 \cdot 10^{-11}$
Continental	0.007	$7.11 \cdot 10^{-13}$

A PEC has not been estimated for use of grouts in construction, but following incidents in Scandinavia measured levels are available for use in the risk characterisation (acrylamide was detected in water downstream of the construction sites at levels up to 92 mg/l).

The PEC for sewage treatment plants is calculated as 0.039 mg/l to 0.195 mg/l. The $PEC_{sediment}$ has been derived from the PEC_{water} using an equilibrium partition coefficient method and the highest value calculated is 0.005 mg/kg.

A number of measured levels of acrylamide in surface water are available and these are generally below the level of detection (typically <1 μg/l). Higher levels have been observed near production plants and in waters from processes using polyacrylamide. The PECs are generally higher than these measured levels, probably due to the assumptions made in calculating the PECs.

Acrylamide has a low potential for accumulation in biota and food products. Only drinking water is considered relevant for estimating exposure of man via the environment. The human dose of acrylamide is calculated to be 0.0036 μg/kg bodyweight/day, via drinking water treated with polyacrylamide flocculant.

3.2 EFFECTS ASSESSMENT

Surface water

Acute toxicity test results are reported for fish, aquatic invertebrates, algae and microorganisms. The lowest 96-hour LC_{50} reported for fish is 100 mg/l (bluegill sunfish *Lepomis macrochirus*). The lowest 48-hour EC_{50} for invertebrates is 98 mg/l (*Daphnia magna*). The lowest 72-hour EC_{50} for algae (*Selenastrum capricornutm*) is 33.85 mg/l (growth inhibition). Longer-term studies are also reported for fish, a marine invertebrate and freshwater algae. However, the long-term studies on fish are not judged acceptable for use in the risk assessment. A 28-day NOEC of 2.04 mg/l was reported for the saltwater shrimp *Mysidopsis bahia*. A 72-hour NOEC of 16 mg/l (growth inhibition) was obtained for *Selenastrum capricornutm*. Some data are available for amphibians, and a field study has been conducted.

Based upon all of the available data a $PNEC_{aquatic}$ of 20.4 μg/l is derived using an assessment factor of 100 (applied because the most sensitive species in the long-term studies is not the most sensitive species in the acute studies).

Sediment

No toxicity test results are available for sediment organisms with acrylamide. Using the equilibrium partitioning approach the risk characterisation result for sediment will be essentially the same as for surface water. Therefore a separate PNEC has not been derived for sediment organisms.

Wastewater treatment plant

A $PNEC_{microorganisms}$ of 200 μg/l is derived using an assessment factor of 10 with a NOEC of 2 mg/l inferred from the results of an OECD 301D biodegradation test.

Terrestrial compartment

Acrylamide shows a slight toxic effect on plant growth at a concentration of 10 mg/kg soil. No effect on seed germination is observed at this level. There are also limited short-term data for effects on plants in hydroponic exposures. These results are not sufficient to allow a PNEC to be derived, so instead the equilibrium partitioning method is used. The PNEC of 20 μg/l for the aquatic compartment is used directly to compare to concentrations in soil pore water.

Atmosphere

Acrylamide is not known to contribute to the formation of low-level ozone or contribute to ozone depletion. The predicted atmospheric concentrations are all very low. Neither biotic nor abiotic effects are considered likely.

Secondary poisoning

Acrylamide is not accumulative or persistent in the environment. It is therefore unlikely to accumulate in the food chain and so an assessment for secondary poisoning has not been carried out. However, acrylamide may have a direct effect if exposure occurs through drinking contaminated water. For example, cattle exposed to acrylamide and NMA following grout application incidents in Scandinavia displayed a range of adverse symptoms.

3.3 RISK CHARACTERISATION

The risk characterisation is performed by comparing the PEC with the relevant PNEC for each environmental compartment/end-point. A ratio above 1 indicates a concern.

Consequently there is a possible risk to the aquatic ecosystem from use of acrylamide- or NMA-based grouts for construction applications. Contamination of drinking water from this use may also cause adverse effects on non-aquatic organisms (**conclusion (iii)**). The potential risk to the terrestrial ecosystem from this use cannot be determined on the basis of available information (**conclusion (i)**).

Risks to the aquatic compartment (including sediment), wastewater treatment plant, the atmosphere and the terrestrial compartment from the production and all other uses of acrylamide in the EU (including grout use in pipeline and sewer repairs and manhole sealing operations) are predicted to be low (**conclusion (ii)**).

4 HUMAN HEALTH

4.1 HUMAN HEALTH (TOXICITY)

4.1.1 Exposure assessment

Occupational exposure

During manufacture of solid acrylamide and its subsequent use in polymer manufacture, exposure will be to dust and to vapour from sublimation of the solid. These situations will include bagging of solid acrylamide and during bag opening at polyacrylamide plants. Other situations where exposures to acrylamide dust are likely include cleaning filters, spillages or maintenance, or during the use of aqueous acrylamide if it is allowed to dry out. The majority of exposures will be during the manufacture and use of the 50% aqueous solution owing to its large market share. During the use of aqueous acrylamide, exposure will be to vapour from the solution. It is unlikely that the generation of aerosol will occur during any of its uses.

During the use of polyacrylamides, occupational exposure may occur to residual monomer. This may be to dust or vapour arising from solid grades or vapour from liquid grade polymers. Occupational exposure to residual acrylamide from the polymer may also occur at the polymer production plant during packaging.

Occupational exposure to acrylamide may occur during the preparation of electrophoresis gel packs at laboratory suppliers. Exposure may also occur during the preparation and use of the gels by research establishments, hospitals, universities etc.

Occupational exposure to acrylamide may occur during the large- and small-scale use of acrylamide grouts. Dermal exposure in large-scale use can result from injecting grout in the tunnels and from leakage water. Inhalation exposure to acrylamide/NMA can occur during the grouting process. Dermal exposure in small-scale use will occur where workers come into contact with surfaces contaminated directly by the solid or solutions or by condensed vapour; or as a result of direct contact on to the skin. Inhalation exposure to acrylamide/NMA can occur during the grouting process.

In general, airborne exposure (inhalation) during manufacture averages about 0.2 mg/m^3 8-hour TWA and about 0.05 mg/m^3 8-hour TWA during its use in polymer manufacture. Occupational exposure to acrylamide during the use of polyacrylamides was found to be significantly lower than the above figures, primarily due to restrictions on the level of residual monomer in the polymer. Exposures at the one producer of electrophoresis gels who submitted data were about 0.03 mg/m^3 (not 8-hour TWAs). Results of <0.005 mg/m^3 and 0.067 mg/m^3 (not 8-hour TWAs) were obtained for the laboratory weighing out of acrylamide to make gel plates. Occupational exposure data available for the use of acrylamide grouts in Swedish tunnels exceeded the Swedish occupational exposure limit of 0.03 mg/m^3 (8-hour TWA). The available data suggest that inhalation exposure even after injection ceased, had the ability to exceed 0.012 mg/m^3 (8-hour TWA) acrylamide. The highest occupational exposure value during sewer work was 0.12 mg/m^3 (not 8-hour TWA).

Consumer exposure

Within the EU, there is no direct consumer exposure to acrylamide monomer; consumer exposure occurs from use of polyacrylamide and the levels of residual monomer in the polymer are the important issue. Degradation of the polymer to produce acrylamide monomer is very unlikely. The only point of concern is therefore the level of the free monomer already present in the product. The residual level of monomer in polyacrylamide is kept below 0.1% w/w in the EU and most values are much lower than this, due to the fact that within the EU any preparation containing more than 0.1 % w/w acrylamide was classified as a Category 2 carcinogen. For classification, see Chapter 1.

Consumer exposures to acrylamide in polyacrylamide may result from the use of cosmetics and soil conditioners. The use of polyacrylamide in soil conditioners could produce a maximum exposure of 5 μg of acrylamide monomer per event. The use of polyacrylamide in cosmetics may result in a heavy user of the cosmetics having a potential daily exposure to 67 μg of acrylamide monomer.

Humans exposed via the environment

Acrylamide enters the environment directly via industrial emissions, but also indirectly through the addition of polyacrylamide as a flocculating agent to drinking water. In calculating the indirect exposure via the environment, drinking water is assumed to produce the only significant intake. The estimated daily dose through intake of drinking water is 0.0036 μg/kg/day.

In addition, the use of grouts for sewer repairs and construction may lead to elevated levels of acrylamide in drinking water. It should be noted that these are local exposure scenarios. Based on model predictions the dose of acrylamide from drinking water sources in the locality of a sewer repair site would be 0.11 μg/kg/day. A number of measurements of acrylamide in surface water and groundwater have been made following recent tunnelling incidents in Scandinavia. A worst-case assumption would be that water from these sources is used for drinking water. The highest concentration of acrylamide in surface water following the tunnelling incident in Sweden was 92 mg/l. This would give a predicted dose of 2.62 mg/kg/day. Ninety days after the incident the highest concentration measured was 0.1 mg/l, which would give a predicted dose of 2.86 μg/kg/day. The highest groundwater concentration following the tunnelling incident in Sweden was 5.1 mg/l. This would give a predicted dose of 0.15 mg/kg/day.

Combined exposure

Human exposure to acrylamide indirectly via the environment from sources other than using grouts in large-scale operations is clearly negligible. In addition, exposure via consumer products is also very small. The most significant route of exposure is in occupational settings, the contribution from the environment and from consumer products is negligible in comparison and does not add significantly to the overall body burden.

4.1.2 Effects assessment

The data available on the toxicokinetics of acrylamide suggest that it is well-absorbed by all routes of exposure. Once absorbed, either the parent molecule or metabolites appear to be widely distributed including distribution to male reproductive organs or across the placenta to a developing fetus. Acrylamide or metabolites have been shown to alkylate a DNA-associated protein in developing spermatids, although there was a low level of binding to DNA itself. Metabolism is thought to involve direct conjugation with glutathione, and may proceed via an epoxide intermediate. Elimination of acrylamide or its metabolites is rapid and extensive, occurring mainly via the urine but also via faeces and exhaled CO_2.

Upon single exposure, acrylamide is toxic or harmful by all routes of administration. The principal effects prior to death relate to neurotoxicity, although severe effects on spermatid development were also noted. Acrylamide is a skin irritant, with skin peeling being a particular problem. Data are limited, but suggest that it should be considered as an eye irritant. There is clear evidence for skin sensitisation potential, but no data available regarding respiratory sensitisation.

The principal effect observed as a result of repeated exposure, by all routes, is peripheral neuropathy including effects such as loss of use of limbs, tremor, loss of balance and loss of axons and ganglion cells, as well as other degenerative changes in peripheral and optic nerves, and degeneration of the lateral geniculate nucleus. However, the dose-response information from humans is inadequate and the clearest information available is from rodent studies. Histopathology has indicated peripheral nerve lesions at 2 mg/kg/day, and no effects at 0.5 mg/kg/day in a 2-year rat study. Additionally, degeneration of spermatids and spermatocytes was observed amongst animals receiving approximately 36 mg/kg/day for 8 weeks, although this study was not designed to identify a NOAEL.

Acrylamide is a direct-acting mutagen *in vitro* and there is also a large body of evidence clearly demonstrating that acrylamide is genotoxic *in vivo* to both somatic cells and germ cells (inducing heritable mutations).

Acrylamide is carcinogenic in animals producing increased incidences in a number of benign and malignant tumours in a variety of organs (e.g. thyroid, adrenals, testicular mesothelioma). The tumour types observed show a possible relationship with disturbed endocrine function and raise the possibility of a hormonal mechanism. There is also a suggestion of acrylamide-induced tumours in brain and spinal cord. Overall, genotoxic activity cannot be discounted from contributing to tumour formation and there are no mechanistic arguments to indicate that these findings would be restricted to animals and not humans.

In animals, impaired fertility was demonstrated in male rats exposed to 15 mg/kg/day or more for 5 days. The impaired fertility may have been associated with effects on sperm count and sperm motility. In other studies impaired copulatory ability, and hence impaired fertility, possibly arose as a secondary result of neurotoxic effects (such as impaired hind limb function). No effects on fertility were observed in a 2-generation reproduction study in which male and female rats of each generation received 5 mg/kg/day for 10-11 weeks.

There was no evidence of selective developmental toxicity at exposure levels in rats or mice that were not associated with maternal toxicity. Studies have attempted to investigate whether or not acrylamide could induce toxicity in rat pups during lactation. However, the dose level used induced significant effects in dams and on lactation such that no conclusions could be drawn with respect to acrylamide-specific effects mediated via breast milk.

4.1.3 Risk characterisation

Workers

The key toxicological endpoints for acrylamide are neurotoxicity, genotoxicity, carcinogenicity and reproductive toxicity.

For neurotoxicity and reproductive toxicity following acrylamide exposure, NOAELs can be identified from the animal studies. For neurological damage, a reliable NOAEL in rats of 0.5 mg/kg/day has been identified, with a LOAEL of 2 mg/kg/day for slight neurological effects (histopathological changes in the absence of any clinical signs of neurotoxicity). The NOAEL for neurotoxicity is 10-fold lower than the NOAEL for reproductive effects hence controlling for neurotoxicity should adequately control for reproductive effects. The exposure assessment indicates that the highest levels of exposure are likely to be associated with monomer manufacture, polymer manufacture and use of acrylamide grouts in large- and small-scale applications. Exposure during monomer manufacture and polymer manufacture gives rise to estimated total body burdens (from inhalation and dermal exposure) of 0.07 mg/kg/day and 0.1 mg/kg/day respectively. A 5- to 7-fold difference is obtained between these estimated exposures and the NOAEL of 0.5 mg/kg/day for neurotoxic effects and the exposures are 20- to 30-fold lower than the LOAEL of 2 mg/kg/day for neurotoxic effects where only slight effects were observed histopathologically. These margins offer reasonable reassurance that the risk of neurotoxicity arising from occupational exposure to acrylamide is low and **conclusion (ii)** is reached.

It is not possible to estimate reliably the exposure during the use of acrylamide grouts in large-scale applications, and therefore the level of risk is uncertain. However, workers were exposed to levels giving rise to neurotoxic effects, consistent with those caused by acrylamide, and therefore these levels give cause for concern, for neurotoxicity and for other adverse effects (**conclusion (iii)**). Exposures during the use of acrylamide grouts in small-scale applications result in an estimated body burden of 0.45 mg/kg. The MOS for neurotoxicity is low and indicates a cause for concern for human health (**conclusion (iii)**). The MOS for reproductive toxicity is higher but it is also judged to be a cause for concern given uncertainties in the dose-response relationship for effects on fertility and in exposure estimates (**conclusion (iii)**).

For mutagenicity and carcinogenicity (which might involve a genotoxic mechanism) it is not possible to reliably identify a threshold level of exposure below which there is no increased risk and the magnitude of the risk of cancer at occupationally relevant exposure levels is not clear. Therefore, **conclusion (iii)** is reached for these endpoints for all occupational exposure scenarios. There should be a requirement to reduce exposure to acrylamide as far as is reasonably practicable.

Consumers

The estimated consumer exposure results in a total body burden of 0.001 mg/kg/day. This is 500-fold lower than the NOAEL of 0.5 mg/kg/day for neurotoxic effects and 2000-fold lower than the LOAEL of 2 mg/kg/day where only slight effects were observed histopathologically. These margins offer good reassurance that the risk of neurotoxicity arising from consumer exposure to acrylamide is low.

For mutagenicity and carcinogenicity (which might involve a genotoxic mechanism) it is not possible to reliably identify a threshold level of exposure below which there is no increased risk. It is evident that the levels of exposure involved are very small and therefore the risk of cancer and mutagenicity to consumers is probably very small.

However, it is plausible that a threshold may exist. It is evident that the levels of exposure involved are very small and therefore the risk of cancer and mutagenicity to consumers is probably very small.

The issue of tolerable levels of acrylamide in cosmetics has recently been addressed by the SCCNFP, and maximum levels for the concentration of residual acrylamide in polyacrylamide contained in cosmetic products have now been recommended. The SCCNFP opinion is that these concentrations arising from the low residual level of acrylamide in polyacrylamide do not pose a significant cancer risk.

Thus overall, **conclusion** (**ii**) is reached for the risk characterisation for consumers in relation to neurotoxicity and reproductive toxicity.

In relation to mutagenicity and carcinogenicity, although thresholds cannot be reliably identified, the risks are considered to be very low, **conclusion** (**iiia**) is reached.

Humans exposed via the environment

For scenarios excluding the use of grouts in large-scale operations, the exposure assessment indicates that the estimated indirect exposure via the environment from drinking water is very small. A difference of approximately 4 or more orders of magnitude is obtained between these estimated exposures and the NOAEL of 0.5 mg/kg/day for neurotoxic effects and a difference of 5 or more orders of magnitude between exposures and the LOAEL of 2 mg/kg/day where only slight effects were observed histopathologically. These margins offer good reassurance that the risk of neurotoxicity arising from indirect exposure via the environment from these drinking water sources is low (**conclusion (ii)**).

For mutagenicity and carcinogenicity (which might involve a genotoxic mechanism), although it is plausible a threshold may exist, it is not possible to reliably identify a threshold level of exposure below which there is no increased risk. It is evident that the levels of exposure involved are very small and therefore it is concluded that there would be a negligible residual risk, **conclusion** (**iiia**) is reached.

In relation to the use of acrylamide grouts in large-scale operations, the exposure assessment indicates that the worst-case estimated local exposure would be 2.62 mg/kg/day. The differences between this estimated worst-case exposure and the NOAEL and LOAEL for neurotoxic effects are very small. The margins of safety are also too small for reproductive toxicity. These risk characterisations indicate a cause for concern for human health and **conclusion** (**iii**) is reached.

For mutagenicity and carcinogenicity (which might involve a genotoxic mechanism) it is not possible to identify a threshold level of exposure below which there is no increased risk. It is evident that the levels of exposure involved are excessive for these endpoints and therefore the risk of carcinogenicity and mutagenicity is a cause for concern leading to a **conclusion** (**iii**).

Combined exposure

Human exposure to acrylamide indirectly via the environment from sources other than using grouts in large-scale operations is clearly negligible. In addition, exposure via consumer products is also very small. The most significant route of exposure is in occupational settings, the contribution from the environment and from consumer products is negligible in comparison and does not add significantly to the overall body burden.

4.2 HUMAN HEALTH (PHYSICO-CHEMICAL PROPERTIES)

There is no classification with regard to the following, flammability (autoignition 394°C), explosive properties and oxidising properties; these properties are not considered to pose a hazard. It is noted that acrylamide should be stored, transported and handled under the correct conditions. The recommended conditions for acrylamide dry crystals are to avoid direct sunlight; crystal temperatures above 50°C; and initiators such as bisulphites, peroxides, reducing agents, oxidising agents and redox systems. For aqueous solutions of acrylamide the recommended conditions are to store below 32°C and above the crystallisation point. Avoid contamination with iron or rust, initiators such as bisulphites, peroxides, reducing agents, oxidising agents and redox systems and prevent the loss of dissolved oxygen. A general warning to this effect is recommended, and is currently in practice (**conclusion (ii)**).

5 RESULTS

Approximately 99.9% of acrylamide in the EU is used in the production of polyacrylamides that are used in wastewater treatment, paper and pulp processing, crude oil production, cosmetic additives, and soil and sand stabilisation. About 0.1% of the acrylamide produced in the EU is used to produce polyacrylamide electrophoresis gels. Acrylamide can also be used in the formulation of grouting agents. The major end uses of acrylamide grouts are sewer line sealing and manhole sealing; minor uses are structural water control and geotechnical applications. A derivative of acrylamide, N-methylolacrylamide (NMA) may also be used in grouting applications.

5.1 ENVIRONMENT

Releases of acrylamide to the environment (particularly water) may occur from its manufacture and all uses.

Conclusion (i) There is need for further information concerning the toxicity of the substance to terrestrial organisms.

This conclusion applies to the terrestrial ecosystem for use of acrylamide-based grouts in construction applications. Both the PEC and the PNEC for this use could be refined. However, the control strategy for the aquatic ecosystem is also expected to remove any risk to the terrestrial ecosystem, and hence no specific activity is considered necessary at this time. Any further information and/or testing requirements should await the outcome of the risk reduction measures on releases to the environment.

Conclusion (ii) There is at present no need for further information and/or testing and for risk reduction measures beyond those which are being applied already.

This conclusion applies to the aquatic and terrestrial ecosystems (production of acrylamide, production of polyacrylamides, use of polyacrylamides and use of acrylamide based grouts in pipeline and sewer repairs and manhole sealing operations), microorganisms in the sewage treatment plant, atmosphere and accumulation via the food chain (secondary poisoning).

Conclusion (iii) There is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account.

This conclusion applies to the aquatic compartment for use of acrylamide based grouts in construction applications, and to indirect exposure of other organisms through contaminated water from the same use.

5.2 HUMAN HEALTH

5.2.1 Human health (toxicity)

5.2.1.1 Workers

In view of the carcinogenic and mutagenic nature of acrylamide and in view of the low MOS values obtained for neurotoxicity and reproductive toxicity in some exposure scenarios **conclusion (iii)** is reached.

Conclusion (iii) There is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account.

This conclusion applies to

- concerns for mutagenicity and carcinogenicity as a consequence of exposure arising from production of the substance, use as an intermediate in the chemical industry for the production of polyacrylamide, use of polyacrylamide, use of polyacrylamide gels for electrophoresis and use of acrylamide based grouts (small and large scale applications),
- concerns for neurotoxicity and reproductive toxicity as a consequence of exposure arising from the small- and large-scale use of acrylamide based grouts.

5.2.1.2 Consumers

Polyacrylamide enters a range of consumer products such as soap, shaving foam and hair gels, and gardening products. There are no measurements available, but estimations of consumer exposure lead to values approximately 50 times lower than those encountered occupationally with the major contribution thought to arise from the use of polyacrylamide in cosmetics. Although thresholds cannot be reliably identified, the risk of mutagenicity and carcinogenicity is considered to be very low, therefore **conclusion (iiia)** applies.

Conclusion (iiia) Risks cannot be excluded for all other exposure scenarios, as the substance is identified as a non-threshold carcinogen. The adequacy of existing controls and the feasibility and practicability of further specific measures should be considered. However, the risk assessment indicates that risks are already low. This should be taken into account when considering the adequacy of existing controls and the feasibility and practicability of further specific risk reduction measures.

5.2.1.3 Humans exposed via the environment

In relation to scenarios except where grouts have been used, acrylamide enters the environment directly via industrial emissions but also indirectly through the addition of polyacrylamide as a flocculating agent to drinking water. Although some measured data are available, these are not considered to be entirely adequate and the risk characterisation with respect to human health is based on the use of modelling techniques. The estimated exposures, for reasonable worst-case scenarios are low.

In relation to the use of acrylamide grouts in large-scale operations, the estimated exposures for reasonable worst-case scenarios are high. Thresholds for genotoxic and carcinogenic effects cannot be reliably identified, and these exposure levels give rise for concern. There is further concern for the threshold effects of neurotoxicity and reproductive toxicity. The result of the assessment of indirect exposure via the environment for the large-scale use of grouts is that **conclusion** (**iii**) applies.

Conclusion (iii) There is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account.

In relation to the use of acrylamide grouts in small-scale operations, the estimated exposures for reasonable worst-case scenarios are low. Although there may be some residual risk of mutagenicity and/or carcinogenicity this is likely to be very low. The result of the assessment of indirect exposure via the environment for scenarios except the large-scale use grouts is that **conclusion (iiia)** applies.

Conclusion (iiia) Risks cannot be excluded for all other exposure scenarios, as the substance is identified as a non-threshold carcinogen. The adequacy of existing controls and the feasibility and practicability of further specific measures should be considered. However, the risk assessment indicates that risks are already low. This should be taken into account when considering the adequacy of existing controls and the feasibility and practicability of further specific risk reduction measures.

5.2.1.4 Combined exposure

Human exposure to acrylamide indirectly via the environment from sources other than using grouts in large-scale operations is clearly negligible. In addition, exposure via consumer products is also very small. The most significant route of exposure is in occupational settings, the contribution from the environment and from consumer products is negligible in comparison and does not add significantly to the overall body burden.

5.2.2 Human health (risks from physico-chemical properties)

Conclusion (**ii**) is reached because there are no risks from physicochemical properties arising from the use of acrylamide.

Conclusion (ii) There is at present no need for further information and/or testing and for risk reduction measures beyond those which are being applied already.