GOBIERNO DE ESPAÑA
MINISTERIO DE TRABAJO Y ECONOMÍA SOCIAL
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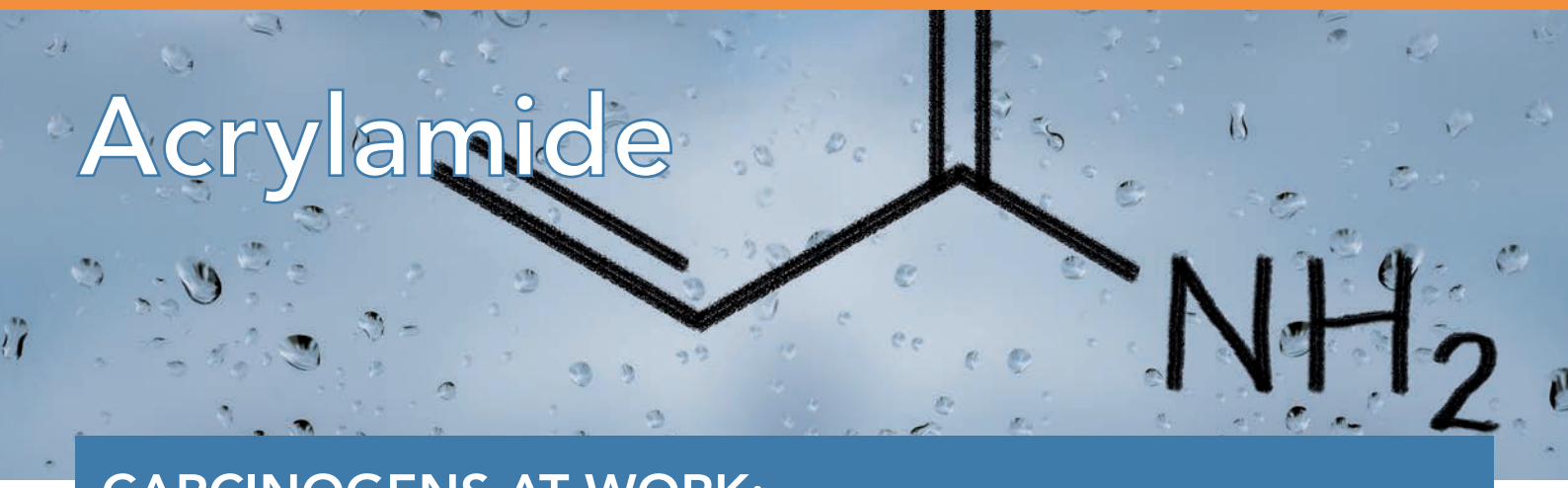

Acrylamide

CARCINOGENS AT WORK: Know to Prevent

Information about the substance and where it can be found

Acrylamide is an unsaturated amide which occurs as a white, odourless crystalline solid at room temperature and is highly soluble in water. Its origin is organic and anthropogenic, and it is mainly manufactured by the reaction of acrylonitrile using various techniques, such as catalytic hydration with copper metal or by enzymatic hydration processes using microorganisms. Thus, in Europe, 30-50% acrylamide is produced as an aqueous solution by catalytic hydration of acrylonitrile using either a low-temperature enzymatic process or a copper catalyst at 100-150°C. The substance is registered under REACH Reglament and is manufactured and/or imported into the EU; the quantities are between 100,000 to 1,000,000 tonnes per year (ECHA, 2022).

The properties of this vinyl monomer include improved aqueous solubility, adhesion and polymer bonding. Acrylamide is therefore mainly used as an intermediate in the manufacture of other organic substances such as polyacrylamides and acrylamide copolymers, which are used in numerous industrial processes, such as the production of paper, dyes and plastics, and in the drinking water, industrial and waste water treatment. Thus, polyacrylamides are useful as flocculants in wastewater treatment and drinking water purification.

Acrylamide also acts as a hardening agent in vinyl polymers, as an earth stabilising agent, as a thickener in cosmetics, in genetic engineering, in molecular biology and in electrophoresis. It is also used as a polymer or copolymer in applications such as glues for the paper and textile industries and in formulating sealing agents for dams, tunnels and sewers.

It is highly unstable in soil and water since it is a polar compound. Therefore, it does not accumulate in the soil and can be disposed of quickly. It is unlikely to be present and transported in the atmosphere over significant areas, due to its low vapour pressure.

Biodegradation is possible, as with polyacrylamide. Thus, a wide variety of micro-organisms can degrade acrylamide. However, there is a dwell time of several days before significant degradation occurs. In rivers and coastal

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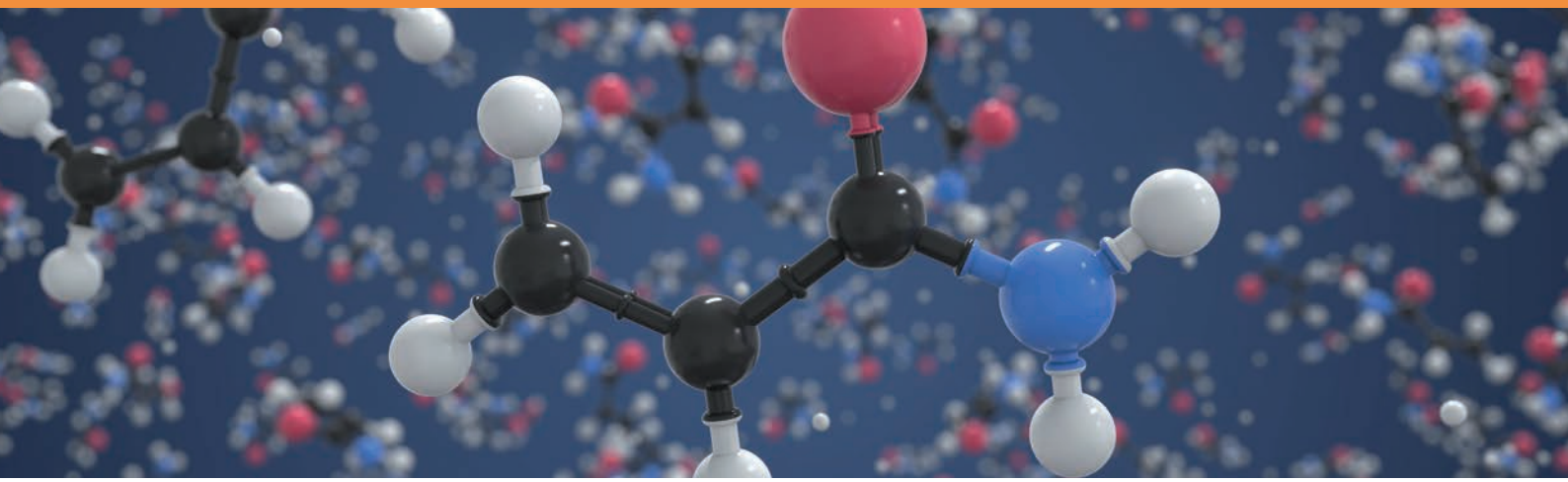


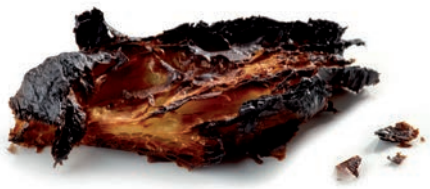
areas with low microbial activity, the dwell time for acrylamide may be in the order of days, weeks or months. The half-life in aerobic soil, which is of the order of several days at 20°C, increases as temperatures fall.

Acrylamide is unlikely to be removed during wastewater treatment and has been shown to be able to pass through water treatment plants without significant changes.

In the environment, the presence of acrylamide is associated with the degradation of polyacrylamide, for example, by degradation of building materials, etc., as a consequence of certain conditions such as heat or light, or even outdoor exposure, which can promote depolymerisation of polyacrylamide leading to the formation of acrylamide.

The residue of its monomeric form may be present as a contaminant in drinking water. Moreover, acrylamide has been identified in some food products cooked at high temperatures, above 120°C, as a result of the Maillard reaction.

The use of acrylamide in cosmetics, drinking water treatment and food packaging materials is regulated due to the potential risk of environmental contamination.



Acrylamide is mainly used as an intermediate in the manufacture of other organic substances such as polyacrylamides and acrylamide copolymers, which are used in numerous industrial processes.

Health effects

Acrylamide is classified as a Group 2A carcinogen by IARC, which means that it is a probable human carcinogen. Furthermore, it is classified according to *EC Regulation 1272/2008 on Classification, Labelling and Packaging of substances and mixtures* (CLP Regulation) as carcinogenic and mutagenic category 1B, as shown in Table 1.

Thus, acrylamide, according to the harmonised hazard classification criteria set out in Regulation (CLP), is toxic if swallowed, may cause genetic damage, may cause cancer, may cause damage to organs through prolonged and repeated exposure, is harmful in contact with skin, causes serious eye irritation, is harmful if inhaled, is suspected of damaging fertility or the foetus, causes skin irritation and may cause allergic skin reaction.

Some uses of this substance are restricted in Appendix XVII of *Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals* (REACH Regulation), and it is listed as a substance of very high concern (SVHC) and in the candidate list for REACH authorisation. The classification provided by manufacturers to the European Chemicals Agency (ECHA) in the REACH register identifies acrylamide as being suspected of causing harm to fertility and the foetus.

The IARC (iarc.who.int) is an autonomous agency of the World Health Organization of the United Nations. It seeks to promote international collaboration in cancer research. It runs studies that are widely recognised for their quality and independence.

Occupational exposure increases the risk of different types of cancer. In the human body, acrylamide is converted into a substance called glycinamide, which can cause mutations and DNA damage. High levels of occupational exposure to acrylamide can also cause neurological damage. However, studies on the effects of occupational exposure on the health of workers are currently limited and inconclusive, with most recent studies focusing on assessing the exposure of the general population to acrylamide as a result of its presence in drinking water and in certain foods or cosmetics.

Thus, while it has been extensively demonstrated in experimental animal studies that acrylamide is carcinogenic, epidemiological studies on possi-

Table 1
Harmonised hazard classification of acrylamide according to Regulation (EC) No 1272/2008 on Classification, Labelling and Packaging of substances and mixtures (CLP)

ACRYLAMIDE	
(N° CAS: 79-06-1; N° CE: 201-173-7)	
Classification	
Hazard class and category codes	**Hazard statement codes**
Carcinogenicity: Carc.1B	H350: May cause cancer
Germ cell mutagenicity: Muta.1B	H340: May cause genetic defects
Reproductive toxicity: Repr.2	H361f: Suspected of damaging fertility or the unborn child
Acute toxicity: Tox.ag.3 Tox.ag.3 Tox.ag.4	H301: Toxic if swallowed H332: Harmful if inhaled H312: Harmful to skin contact
Specific target organ toxicity — repeated exposure: STOT RE 1.	H372: Causes damage to organs
Eye irritation: Eye irrit. 2	H319: Causes serious eye irritation
Skin irritation: Irrit.cut.2	H315: Causes skin irritation
Skin sensitisation: Skin Sens. 1	H317: May cause allergic skin reaction
Labelling Pictograms and signal words	
Hazard	
	

ble health effects in workers exposed to acrylamide have not shown a significant increase in the risk of suffering cancer. Thus, although an increased risk of pancreatic cancer (almost doubling) was observed in a high proportion of exposed working people, the relationship between exposure and the observed response could not be determined (Klaunig, James E., 2008).

Despite the properties of acrylamide described in Table 1, and its potential carcinogenic and mutagenic effect, since the 1980s only two cohort studies of workers exposed to acrylamide in industrial applications have been reported in the literature, but, as indicated above, they show no conclusive results on the relationship between exposure and the occurrence of cancer (IARC, Monograph 60; Bušová, Milena et al., 2020). Thus, the EPA considers both studies inadequate to determine cancer risk due to the small study population and incomplete exposure data (EPA, 2000).

Other studies suggest that the combination of occupational exposure to acrylamide and other exposure factors, such as dietary intake, smoking or use of cosmetics, may have a significant effect on human health, with the risk being much higher in smokers. Smoking workers with occupational exposure to acrylamide would be the most vulnerable (Bušová, Milena et al, 2020).

With regard to symptoms and non-carcinogenic health effects, it should be mentioned that prolonged and repeated exposure to acrylamide through any route of entry can cause muscle weakness, incoordination, skin rashes, excessive sweating of hands and feet, cold hands, skin peeling, numbness, abnormal skin and muscle sensations, fatigue, as well as damage to the central and peripheral nervous system, with effects such as drowsiness and hallucinations in acute inhalation exposure.

Where the exposure can take place

It is estimated that around 54,000 workers in the EU are potentially exposed to acrylamide (The facts Acrylamide. Roadmap on carninogens, 2018).

The main routes of entry of acrylamide into the body at work are inhalation and dermal. In particular, inhalation of dry dust containing acrylamide monomer or polymer, at the production stages of both substances, or by dermal contact with both the monomer and acrylamide-containing solutions.

The main use of acrylamide (more than 99%) is in the production of polyacrylamides. Both the solid and liquid states of acrylamide are used to

Regulatory references

Royal Decree 1154/2020, amending Royal Decree 665/1997 of 12 May 1997 on the protection of workers from the risks related to exposure to carcinogens at work, which transposes *Directive 2017/2398* into Spanish law, included acrylamide as a carcinogen in its appendix III on occupational exposure limit values, this is understood as a substance or mixture that meets the criteria for classification as a carcino gen or germ cell mutagen of category 1A or 1B established in appendix I of *Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on the classification, labelling and packaging of substances and mixtures.*

manufacture various polymers in both states. One of the main uses of polyacrylamides is to treat drinking, waste and industrial water. In the water treatment process, to achieve an optimal and better formation of the flocculus, which in turn leads to greater efficiency in the decantation and filtration stages, and ultimately to a better quality of the treated water, flocculation aids such as polyacrylamides are frequently used. A very small fraction of the polymer polyacrylamide, known as residual acrylamide or acrylamide-free monomer, does not become part of the flocculus, is highly soluble in water and remains dissolved in it, that is, it becomes a contaminant of the treated water.

Acrylamide is also used in the synthesis of dyes, adhesives, in paper gumming and textile sizing and in pleated fabrics. In the metal industry, it is used for ore processing (as an agglomerant) and in civil engineering, to build dam and tunnel foundations. Polyacrylamides are widely used as reinforcing agents in papermaking processes in the paper industry *(Enciclopedia de Salud y Seguridad en el Trabajo. Amidas. (104.73)*

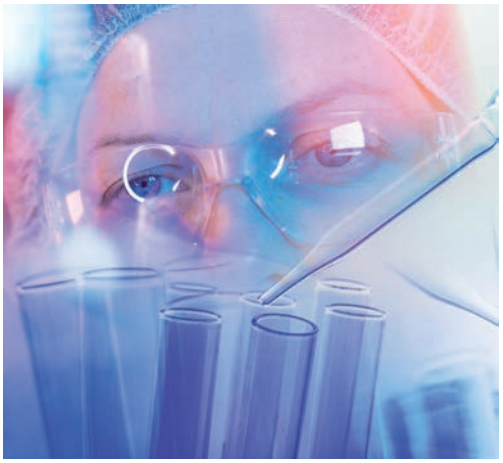
Acrylamide monomer is also used in the preparation of polyacrylamide gels for electrophoresis in hospitals, universities and research laboratories.

Acrylamide is also used in the formulation of agents such us grouts and fillers.

Table 2
Industries where there is a potential risk of exposure to acrylamide monomer or polymer. Source: Monograph 60-IARC. Acrylamide. Box1 (Adapted from US National Institute for Occupational Safety and Health (1976, 1993)

Exposure to acrylamide-monomer
Manufacture of acrylamide from acrylonitrile
Production of acrylamide polymers
Adhesives and grout manufacture
Biotechnology laboratories
Exposure to acrylamide-polymer
Drinking and waste water treatment
Manufacture of organic chemicals
Manufacture of inorganic chemicals
Adhesives and grout manufacture
Coatings
Manufacture of moulded parts
Textiles, looms and weaving mills
Iron and steel industry (blast furnaces, manufacture of metal parts)
Manufacture of water treatment flocculants
Production of paper and pulp
Production of wood and wood-based panels
Construction (soil and sand stabilisation)
Production of crude oil
Oil refineries
Mineral processing
Production of concrete
Production of sugar
Hospitals
Biotechnology laboratories

Exposure assessment



Royal Decree 665/1997 on the protection of workers from the risks related to exposure to carcinogens at work incorporated, by means of *Royal Decree 1154/2020* amending it, the occupational exposure limit value for acrylamide, which is shown in table 3. This Royal Decree involves the transposition into Spanish law of *Directive (EU) 2017/2398 of the European Parliament and of the Council of 12 December 2017 amending Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens at work*, which provides that acrylamide meets the criteria to be classified as a carcinogen (category 1B) under Regulation (EC) No 1272/2008 and is therefore a carcinogen within the meaning of Directive 2004/37/EC.

The Directive thus indicates that, on the basis of the available information, including scientific and technical data, it is possible to determine a limit value for that carcinogen. The Scientific Committee for Occupational Exposure Limits to Chemical Agents determined the possibility of a significant absorption of acrylamide through the skin and that it is therefore appropriate to set a limit value for acrylamide and to mention in a note the possibility of its significant absorption through the skin.

Accordingly, Royal Decree 665/1997 sets a limit value of 0.03 mg/m3 for acrylamide. For its part, the document "Occupational Exposure Limits for Chemical Agents in Spain, 2023", prepared by the INSST, includes Occupational Exposure Limit (OEL-8 hours) for acrylamide of 0.03 mg/m^3, in the same terms as established in Directive (EU) 2017/2398 and in Royal Decree 665/1997, with the notes and indications of danger shown in table 4.

To perform the quantitative assessment of exposure to acrylamide, and to verify compliance with the aforementioned binding occupational exposure limit values, the analytical methods used to determine environmental pollutants must meet the general requirements of the measurement procedures of the standard UNE-EN 482:2021, Workplace exposure - *Procedures for the determination of the concentration of chemical agents - Basic performance requirements.*

Table 3 Occupational exposure limit values. RD 665/ 1997				
Name of agent	EC No[1]	CAS No[2]	Occupational Exposure Limit (OEL-8 hours)[3]	Notations
Acrylamide	201-173-7	79-06-1	0,03 mg/m^3[4]	Skin[5]

Table 4 Occupational exposure limit values (OEL-8 hours)						
EC No	CAS No	Agente Químico	Limit Values		Notations	Hazard statement codes (H)
			OEL-8 hours	OEL Short- term		
201-173-7	79-06-1	Acrylamide	0,03 mg/m^3	-	C1B, M1B, Dermal Route, Sen, r, v, IVF[6]	350-340-361f-301-372-332-312-319-315-317

Source: "Límites de Exposición Profesional para Agentes Químicos en España 2022".

(1) The EC number is the EU's official substance number as set out in section 1.1.1.2 of Part 1 of appendix VI to Regulation (EC) No 1272/2008.

(2) CAS No: Chemical Abstracts Service registration number.

(3) Measured or calculated in relation to a time-weighted average with a reference period of eight hours.

(4) mg/m^3 = milligrams per cubic metre of air at 20°C and 101.3 kPa (760 mm mercury pressure).

(5) Potential significant contribution to total body burden via dermal exposure.

(6) C1B: presumed to be a human carcinogen, based on animal testing. RD 665/1997 applies. M1B: substances known or believed to induce heritable mutations in human germ cells. RD 665/1997 applies

M1B: substances known or believed to induce heritable mutations in human germ cells. RD 665/1997 applies.

Dermal route: Indicates that, in exposures to this substance, the contribution via the dermal route may be significant for the total body content if measures to prevent absorption are not taken. In these situations, the use of biological monitoring is advisable to quantify the overall amount of pollutant absorbed. For more information, see Chapter 5 of the document "Límites de Exposición Profesional para Agentes Químicos en España 2022".

Sen: Sensitising. See Chapter 6 of the Document "Occupational Exposure Limits for Chemical Agents in Spain 2022".

r: This substance is subject to restrictions on its manufacture, placement on the market and use as specified in "Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals" (REACH) of 18 December 2006 (OJEU L 369 of 30 December 2006). Restrictions on a substance may apply to all uses or only to specific uses. Appendix XVII of the REACH Regulation lists all restricted substances and specifies the uses that have been restricted.

v: Carcinogenic agent with binding limit value listed in Appendix III of RD 665/1997 and subsequent amendments.

IFV: Inhalable fraction and vapour. The IFV notation refers to chemical agents that can occur in the workplace, in the form of both particulate matter and vapour, whereby the two phases can coexist, both contributing to exposure.

Therefore, the assessment of exposure to chemical agents requires sampling and analytical methods to determine the concentration of pollutants in the air in the working environment.

The IARC's monograph 60 lists an analytical method for acrylamide in air samples described in 1992 by Cummins et al., based on air samples collected in a glass filter in solid sorbent tubes, which are desorbed with 5% methanol in water and are analysed by high-performance liquid chromatography with an ultraviolet detector.

OSHA has a reference method (PV2004) to determine acrylamide in air and its comparison with the reference value (0.03 mg/m^3 OSHA PEL). This method states that samples are collected using sampling tubes (OVS-7) of known air volume, which contain a filter of glass fibre and two sections of absorbent (XAD-7). The samples are desorbed with a 5% methanol solution and 95% water and analysed by high-performance liquid chromatography (HPLC) using an ultra-violet (UV) detector, as set out in the IARC method.

Furthermore, since the dermal contribution of acrylamide can be significant for the total body content if no measures are taken to prevent absorption (see "Remarks", table 3 and note "Dermal route", table 4), it is advisable to use biological monitoring to be able to quantify the overall amount of the contaminant.

Analysis of certain metabolites in urine samples can provide information about the total amount of acrylamide in the body, including the amount that may have entered through dermal absorption.

Biomarkers used in urine samples to determine acrylamide exposure include S-Carboxyethyl-cysteine (CEC), N-acetyl-S-(2-carbamoyl)-cysteine (AAMA), N-acetyl-S-(1-carbamoyl-2-hydroxyethyl)-cysteine (GAMA2) and N-acetyl-S-(2-carbamoyl-2-hydroxyethyl)-cysteine (GAMA3). (Huang, Y. et al, 2010; Peter J. Bull et al, 2005). However, no has yet been established for acrylamide biological limit value (BLV).

In any case, consideration must be given to the fact that certain factors such as smoking, environmental factors, water or food intake can contribute to the total body content found in the body.

Representativeness of the samples

Whenever a quantitative assessment of inhalation exposure to a hazardous chemical agent, a sampling strategy must be adopted to ensure the representativeness of the data obtained. The standard UNE-EN 689:2019+AC:2019 Workplace exposure - Measurement of exposure by inhalation to chemical agents - Strategy for testing compliance with occupational exposure limit values, proposes a possible strategy for comparing daily exposure with the occupational exposure limit values.

Controlling exposure

Measures to prevent exposure to carcinogens or mutagens must be implemented in order of priority according to their effectiveness. Articles 4 and 5 of Royal Decree 665/1997 set out the employer's obligations in this respect.

The first option should always be the replacement of the agent, and when this cannot be done, the possibility of working in a closed system should be considered.

Where it is also not possible to work in a closed system, all necessary measures must be taken to reduce exposure as far as technically feasible. Finally, where the above measures are not sufficient, personal protective equipment (PPE) must be used.

In sectors involving exposure to acrylamide, the measures to be applied may include, among others, the following: installation of self-contained unpacking equipment, isolation, closure and use of local exhaust ventilation in the cutting process during polymer manufacture, use of a fume hood/cabinet to weigh and decant solid acrylamide (powder) to prepare the electrophoresis gel and, where acrylamide is not used in closed systems such as laboratories or is present as an airborne contaminant in the workplace (such as in polymerisation drums and gel processing machinery), good local exhaust ventilation must be ensured (*Acrylamide technical fact sheet*, NSW Government).

1. Substitution

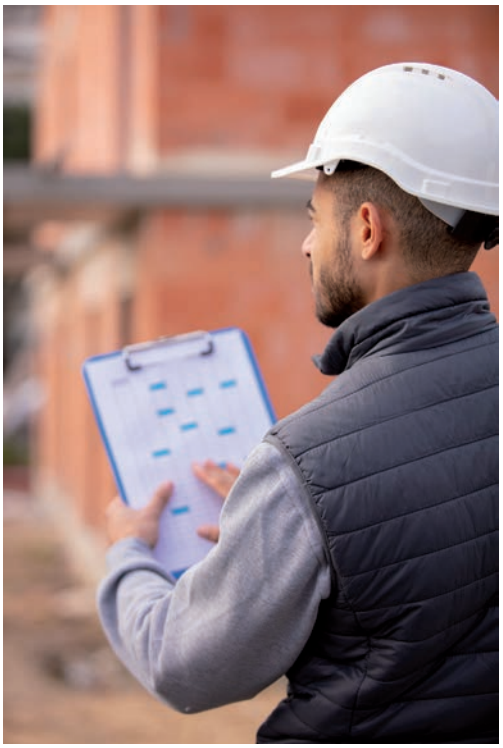
The priority measure, which is mandatory whenever it is feasible, when working with carcinogens or mutagens, is always substitution with another agent or another non-hazardous or less hazardous process. This is established in art. 4 of Royal Decree 665/1997.

Furthermore, art. 10 of RD 665/1997 provides that the employer must, upon request, give the labour and health authorities adequate information about the criteria and results of the process of substitution of the carcinogenic or mutagenic agents referred to in the aforementioned art. 4.

The substitution measure is the most difficult to apply, especially when a production process is already in place, and many variables must be taken into account, but it must be planned and implemented whenever possible, even if it is costlier, and it is necessary to keep abreast of technological advances in each sector related to possible substitutes.

Prioritisation of preventive measures for carcinogens:

1. Substitution
2. Closed system
3. Reduction of exposure to as low a level as is technically possible
4. Personal protective equipment



Substitution may be based on changing an agent to a less hazardous agent or changing procedures. In any case, the new risks that may be introduced by substitution must always be assessed.

A number of useful tools are available to assist in the process. On the SUBSPORTplus Substitution Support Portal, some applied experiences for the substitution of acrylamide and polyacrylamide in different sectors can be consulted, such as the study conducted for soil modification processes or soil treatments for civil or military applications, which can be done with a biopolymer instead of using petroleum-based chemicals such as polyacrylamide or asphalt emulsions (Griggs, Chris; 2010).

An example of such an alternative is the use of starch-based hydrogels to replace polyacrylamide for soil treatment. Polyacrylamide is used as a hydrogel for soil treatment in agriculture and other civil and military applications. These starch-based hydrogels are non-toxic like monomers or polymers and do not generate hazardous pollutants upon decomposition. However, they have a shorter life than polyacrylamide (Chalker-Scott, Linda et al, 2007).

Another example from the SUBSPORTplus substitution portal is the application of technological measures as an alternative to using polyacrylamide polymers in secondary wastewater treatment.

This alternative stabilises activated sludge during the secondary treatment of wastewater plants using only physical processes. This renders unnecessary polymers and strong acidic or alkaline substances generally used to treat this type of sludge and it considerably reduces the costs, energy and land use associated with conventional waste treatment.

While this option requires changes to the treatment facilities, the initial investment costs are balanced by reduced energy and chemical costs. The significant reduction in the amount of waste finally disposed of also reduces costs. By employing physical processes, the alternative eliminates the use of chemicals such as sulphuric acid or sodium hydroxide which are corrosive and polymers, such as polyacrylamide copolymers, which can decompose, leading to the formation of acrylamide (*Oxycair Technologies*, Canada. SUBSPORTplus substitute portal).

2. Closed system

Art. 5.2 of Royal Decree 665/1997 states that if it is not technically feasible to replace the carcinogen or mutagen, the employer shall ensure that the carcinogen or mutagen are produced or used in a closed system. It is therefore the first technological option for preventing and reducing exposure, to be designed preferably at negative pressure. This measure consists of

The INSST is responsible for drawing up non-binding Technical Guides to facilitate the application of the Royal Decrees implementing the Law on Prevention of Occupational Risks. In particular, it can be consulted on its website at www.insst.es in the section "Documentación > Material normativo > Guías técnicas > Específicas", the Technical Guide for assessing and preventing risks related to exposure to car cinogenic or mutagenic agents at work.

Appendix 3 of this Technical Guideline offers guidance on how to deal with the process of carcinogen or mutagen substitution.

preventing the dispersion of the agent in the air breathed by the worker by placing the process within a closed system with evacuation of the pre-treated air to a safe environment to prevent the agents from harming the environment or public health.

Closed, airtight systems not only eliminate exposure, but also prevent exposure to process intermediates. However, an adequate preventative and, where possible, predictive maintenance programme for these systems should be put in place to minimise potential failures that could lead to a risk of exposure.

INSST offers on its website access to the Chemical Agents Control Sheets (CAQF), developed by the Health and Safety Executive (HSE) of its COSHH Essentials model. The COSHH Essentials provide basic good work practice recommendations for different operations to control exposure to hazardous chemicals in the workplace. The 300 series: containment (closed systems) is particularly helpful in this case.

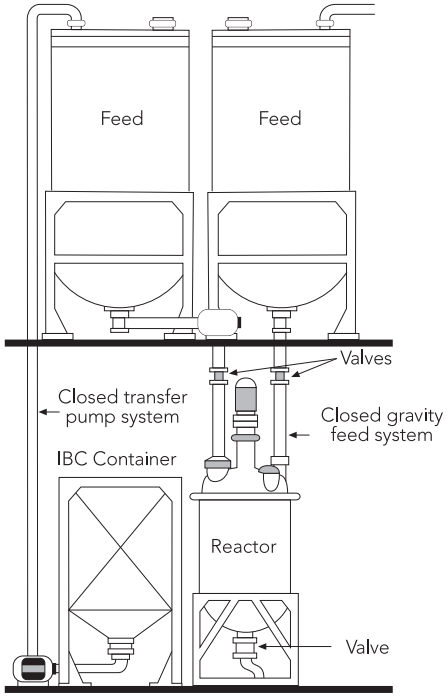
3. Reduction of exposure to as low a level as is technically possible

Art. 5.3 of Royal Decree 665/1997 provides that, when the application of a closed system is not technically possible, the employer shall ensure that workers' exposure is reduced to a level as low as technically feasible.

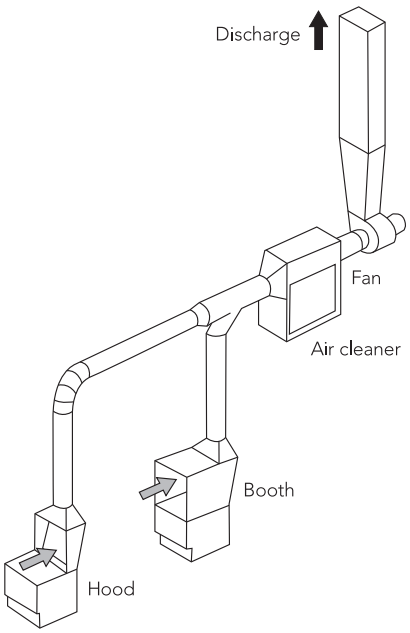
The aim is to implement technical and organisational measures so that exposure is reduced as much as technically feasible. This obligation implies that it is not sufficient to achieve exposure levels below the occupational exposure limit, but rather that it is necessary to go beyond it by applying all available measures.

Furthermore, Article 5.5 states that whenever a carcinogen or mutagen is used, the employer shall apply all the necessary measures set out in that Article. In general, these requirements are along the same lines as what should already be applied to conform to Royal Decree 374/2001, on the protection of the health and safety of workers against risks related to chemical agents at work, adding the express mention of installing devices that detect and alert in the event of situations that could generate abnormally high exposures, such as a failure in a local exhaust ventilation.

Measures to reduce exposure to as low a level as technically feasible include limiting the quantities of the carcinogen or mutagen in the workplace; designing work processes and technical measures such as to avoid or minimise the formation of carcinogens or mutagens; minimising the number of workers exposed or likely to be exposed; to dispose of carcinogens or mutagens at source by local exhaust ventilation or, where this



Example of a closed system design



Example of local exhaust ventilation system design

is not technically feasible, by general ventilation, under conditions which do not pose a risk to public health and the environment; to use the most appropriate measurement methods, in particular for the immediate detection of abnormal exposures due to unforeseen events or accidents; and to apply the most appropriate procedures and working methods.

100 series: General ventilation, 200 series: Technical Control and the 400 series: In particular, the CAQF contains relevant practical information that can assist in the implementation of these measures.

4. Personal protective equipment

As a general rule in prevention, PPE should be used as a last resort, only when all priority prevention measures have been implemented and are not sufficient.

The results of the risk assessment shall be the basis for determining the need for personal protective equipment as well as for selecting the most appropriate equipment. In addition, when selecting equipment, the anatomy of the workers who will be using it must be taken into account and, in the case of respiratory protective equipment based on facial adjustment, it is highly recommended that a fit test be carried out on each person.

The Safety Data Sheets (SDS) of the products and the International Chemical Safety Sheets (ICHS), available on the INSST website, provide relevant information regarding, among other issues, the individual protection measures to be taken in case of exposure to acrylamide.

Moreover, in the S series: Chemicals that cause damage by skin and eye contact, from the FCAQ, also contains specific guidelines for the selection of personal protective equipment (FCAQ S102), for the selection of protective gloves (FCAQ S101) and for skin and eye contact (FCAQ S200).

Since occupational exposure to acrylamide occurs mainly due to inhalation of dust and vapour and by dermal contact with the solid monomer and during the production of acrylamide and polyacrylamide, the personal protective equipment to be used, when the risk has not been eliminated, must be (Hazardous Substance Fact Sheet. Acrylamide. New Jersey Department of Health):

- **Respiratory protection:** When there is a risk of exposure above the VLA-ED® a supplied air respiratory protective system, of the SABA (Supplied Air Breathing Apparatus) type, with a full face-piece shall be used which, for added protection, may be used in combination with a self-contained breathing apparatus, of the SCBA (Self Contained Breathing Apparatus) type, both of which should be operated in pressure demand mode or another positive pressure mode.

Regulatory references

To select, use and maintain personal protective equipment, the requirements laid down in *Royal Decree 773/1997 on minimum health and safety provisions concerning the use by workers of personal protective equipment must be complied* with.

More information can be found in the Technical Guide for the use of personal protective equipment by workers, which was drawn up by the INSST to clarify the technical aspects set out in the Royal Decree.

- **Protective gloves and suit:** Dermal contact with acrylamide must be avoided by wearing gloves and protective clothing made of materials which are not permeable or degradable by acrylamide. The suppliers and manufacturers of this PPE can provide recommendations for the most suitable PPE for each operation. In general, Butyl, Nitrile, Neoprene and Viton are recommended for DuPontTychem® gloves and fabrics;Kappler® Zytron® 400; and Saint-Gobain ONESuit TEC, or equivalent, as amide protection materials.

  All protective clothing (suits, gloves, footwear and headgear) must be cleaned and available each day, and put on before any work is done.

- **Eye protection:** Eye protection with side shields or goggles must be worn. Contact lenses must not be worn when working with this substance.

Hygiene measures

Hygiene measures are particularly important in preventing exposure to carcinogens such as acrylamide. These measures have several objectives:

- To prevent the agent from penetrating through the skin in the event of accidental contact.
- To avoid prolonging exposure by contact with soiled protective clothing or equipment.
- To prevent secondary exposure of others who may come into contact with soiled clothing or surfaces.

Article 6 of Royal Decree 665/1997 sets out the personal hygiene and individual protection measures to be taken by the company, including the following:

- To prohibit eating, drinking and smoking in risk areas.
- To provide protective or other appropriate clothing.
- To have separate places for storing work clothes and street clothes.
- To have a designated place to store PPE, ensure that it is cleaned and checked for proper functioning.
- To provide appropriate and adequate toilets and washrooms.

Regulatory references

Royal Decree 1154/2020, amending Royal Decree 665/1997, on the protection of workers against risks related to exposure to carcinogens or mutagenic agents at work, specifies in article 6 that workers identified in the risk assessment as exposed shall have, during working hours, the time they need for personal hygiene, with a maximum of 10 minutes before lunch and another 10 minutes before leaving work. This time may under no circumstances accu mulate or be used for other purposes.

The employer is responsible for laundering decontaminating work clothes, and workers are strictly forbidden to take them home for this purpose.

Health surveillance

Carcinogens or mutagens are generally characterised by long-term effects or diseases with long latency periods. Thus, Royal Decree 665/1997 creates a right for workers who have been exposed to these agents to the extension of health surveillance beyond the end of the exposure or of the employment relationship.

In order for the health surveillance programme to be adjusted to the risks arising from the presence of chemical agents in the workplace, the employer must provide information about these risks and safety data sheets to the basic health unit (BHU). In the absence of specific guidelines and action protocols, this BHU, based on the risk assessment and the effects of acrylamide, will draw up a protocol and document the method and criteria used for the aforementioned health surveillance (INSST, 2018).

There is currently no protocol for specific health surveillance of workers for acrylamide exposure.

Other preventive measures

In work involving the risk of exposure to acrylamide, another series of preventative measures established in Royal Decree 665/1997 must be complied with, such as the following:

- Accidental and non-regular exposures (article 7).
- Obligations with regard to documentation (article 9).
- Information to the competent authorities (article 10).
- Consulting, informing and training workers (articles 11 and 12).

Regulatory references on health surveillance

Health surveillance activities shall be conducted according to the conditions and characteristics set out in:

- Article 8 of RD 665/1997.
- Article 22 of the LPRL.
- Royal Decree 843/2011, of 17 June, setting out the basic criteria for organising resource to conduct the prevention services health activities.

This health surveillance must be performed (Royal Decree 665/1997, art. 8):

- Before the beginning of the exposure.
- At regular intervals, as often as medical expertise dictates.
- When it is necessary because a disorder has been detected in one of the company s workers with similar exposure, which may be due to exposure to carcinogenic or mutagenic agents.

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