GUIDELINES FOR WORKING
WITH NANOMATERIALS

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1. WHAT ARE NONOMATERIALS

Nanotechnology is described as science applied to the design, manufacture, and manipulation of matter at an atomic and molecular scale: in the range of 1 to 100 nanometres (1 metre = 1000mm = 1,000,000 microns = 1,000,000,000 nanometres). In comparative terms, a sheet of paper has a thickness of approximately 100,000 nanometres.

The most important characteristic of nanomaterials is that their properties change as their size decreases, that is, some nanomaterials increase their electrical and heat conductivity, while others increase their resistance. Some materials reveal different magnetic properties and may even change colour and reflectivity when size is reduced to this scale. Nanomaterials also have a larger surface relative to their mass, which increases their capacity to interact with other materials and makes them more reactive.

Thus, nanomaterials have properties that differ from the same materials on a larger scale. Because of these differences, nanomaterials offer new and exciting opportunities in fields such as engineering, information and communications technology, medicine, and pharmaceuticals. However, the same characteristics that confer unique properties are also responsible for their effects on human health and the environment.

The main organisations agree on their definitions of nanomaterials:

‘materials containing particles with one or more dimensions at the nanoscale, that is, from about one nanometre to 100 nanometres. The nanometre (nm) is equivalent to one billionth of a meter (1 nm = 10-9 m).’

According to the European Commission:

‘A nanomaterial is a natural, incidental, or fabricated material containing particles, in an unbound state, or as an aggregate or agglomerate – and where, for 50% or more of the particles in the distribution of numerical sizes, one or more external dimensions are in the range of 1 nm - 100 nm’.

In specific cases where environmental, health, safety, or competition concerns are justified, the 50% threshold for distribution of numerical size may be replaced by a threshold of between 1% and 50%.

In addition, the European Commission recommends that fullerenes, graphene flakes, and single-walled carbon nanotubes with one or more external dimensions of less than 1 nm should be considered as nanomaterials.

The European Commission recommends using this definition of a nanomaterial when adopting and implementing legislation, policies, and research programmes on nanotechnological products. Nanomaterials can be classified into three major categories:

- **Natural origin**: there are nanoparticles of biological origin (viruses and batteries); of mineral origin (sand and dust); and of environmental origin (smoke caused by forest fires or volcanic activity).
- **Unintentionally generated by human activity**, as unintended by-products of an industrial process, for example welding fumes or combustion products.
- **Generated** intentionally by human activity: including manufactured nanomaterials intentionally designed with specific properties (mechanical, electrical, optical, catalytic, etc.) that are often very different to the properties at non-nano size. These manufactured nanomaterials may be in the form of:
- Nano-objects: materials with one, two, or three external dimensions at the nanoscale, or with nanostructured material with an internal or surface structure at the nanoscale.

Nano-objects are termed:

- nanoplates,
- or nanofibers,
- or nanoparticles,

depending on whether they have one, two, or three external dimensions, respectively, at the nanoscale. Normally, during the production process of nano-objects, the primary particles, which are those generated initially in the process, tend to unite with each other to give rise to agglomerates or aggregates in which the external dimensions can reach sizes greater than 100 nm. Particles in agglomerates are weakly bonded and the resulting outer surface is close to the sum of the surface areas of the individual components. In contrast, particles in aggregates are tightly bound, or fused, and the resulting outer surface may be much less than the sum of the calculated surface areas of the individual components.

- Nanostructured materials: internal or surface structure at the nanoscale. These materials may have a grain sized distribution in which a significant fraction of the material is at the nanoscale, or have spaces and pores at the nanoscale or precipitates at the nanoscale (usually nano-objects embedded in a solid matrix). Also included in this group are surfaces that have been modified to produce morphological or chemical heterogeneities at the nanoscale.

- Nanostructured nanomaterials may be in the form of:
    - nanostructured powder, or
    - nanocomposites,
    - solid nanofoam, or
    - nanoporous material, or
      nanodispersed fluid.

Some of the most common types of manufactured nanomaterials, based on the classification proposed in the EU Commission working document are:

1. **Non-metallic inorganic nanomaterials:** mostly non-metallic oxides.
2. **Metals and alloys:** most metals and their alloys can be produced in nanometric dimensions (for example, nanowires and nanoparticles), with gold, silver, platinum, and palladium alloys being the most frequently manufactured.
3. **Carbon-based nanomaterials**:
    - **Fullerenes:** made only of an even number of carbon atoms which can oscillate from 28 to more than 100 atoms, and shaped as a hollow sphere. They have a structure made of hexagonal carbon rings that is similar to graphite, but also have pentagonal and heptagonal rings that enable the formation of three-dimensional structures. The best-known form of fullerenes contains 60 carbon atoms. Fullerenes are chemically stable and insoluble in aqueous solutions.
    - **Graphene:** has a bidimensional structure in the form of nanoplates – sheets of hexagonal networks of carbon atoms arranged in the same plane, as in graphite, and whose thickness is of the order of a nanometre.
    - **Carbon nanotubes:** Carbon nanotubes have a cylindrical structure and are composed of one or more graphene-like tubular sheets, called single-walled (SWCNT) or multi-walled carbon nanotubes (MWCNT). Diameters may range from about 1 nm for single wall to over 100 nm for multiple wall, and their length may exceed a few hundred micrometres. These nanotubes are highly resistant to deformation and stretching.
    - **Carbon nanofibres**: formed of sheets of graphene. Their cup-shaped structure means that some of their mechanical and electrical properties differ from carbon nanotubes.
    - **Carbon black:** an almost pure elemental carbon in the form of particles that is produced by incomplete combustion or the thermal decomposition of hydrocarbons under controlled conditions. Primary carbon black particles are less than 100 nm in size, but they tend to cluster, and this produces in larger agglomerates and aggregates.

4. **Nanopolymers:** polymeric materials with one or several dimensions on the nano scale.
5. **Dendrimers:** Nanometre-sized macromolecules with a three-dimensional branched structure composed of a nucleus, branches forming a dendritic matrix, and a periphery containing numerous functional groups.
6. **Quantum dots:** are nanocrystals of semiconductor materials from 2 nm to 10 nm is size. They are semiconductors with electronic, optical, magnetic, and catalytic properties.
7. **Nanoclays:** Ceramic materials of mineral silicates in the form of sheets. They can exist naturally or be synthesized for specific properties.

2. HEALTH EFFECTS

There is little scientific data on the health and safety effects of nanomaterials. For this reason, it must be considered that nanometric particles pose a different risk to that of the particles of the same composition of a non-nano size.

As particle size decreases, the specific surface area increases. Therefore, reactivity also increases. Because of this increase, nanometre-sized particles may cause adverse health effects that differ from those caused by non-nano-sized particles of the same chemical composition, since they may interact differently in the body.

If nanoparticles have physicochemical properties that differ from the same larger particles, then this may be accompanied by new toxicological properties. Therefore, the risks associated with nanomaterials are mostly related to particle size.

The toxicological properties of nanomaterials include:

1. **Translocation:** Given their nanometric dimension, nanomaterials can reach parts of biological systems that are normally inaccessible to larger particles. This implies a greater possibility of crossing the cellular boundaries, or of passing from the lungs to the bloodstream, and then on to all the organs of the body, or even by depositing in the nose, and passing directly to the brain. This process is known as translocation and nano-objects can generally be translocated much more easily than larger structures.
2. **Toxicity:** nano-objects have a much greater surface area than the same mass of larger particles. As the surface area is a toxicity factor, this clearly implies a possible increase in the toxic effects of nano-objects.

3. **Biospersistence:** some nano-objects (such as nanowires) show a high biopersistence aspect ratio, with a morphology and durability similar to asbestos fibres, so they are likely to remain in the lungs if inhaled, causing inflammation and ultimately illness.
4. **Solubility:** the reduction in size in some nano-objects has been shown to be related to increased solubility. This could lead to an increased bioavailability of materials that are considered insoluble, or poorly soluble, in large particle sizes.

The **toxicological effects of nanomaterials** in the organism mostly depend on:

1. **Factors related to exposure**: pathways into the body, duration, and frequency of exposure, and environmental concentration. The pathways into the organism may be:

   - *Inhalation* is the main pathway for nanomaterials into the body, as is generally the case for most chemical agents – and it is the most worrisome pathway from the perspective of occupational health. Depending on the size, shape, and chemical composition, particles can penetrate and remain in the various compartments of the respiratory system.
   - *Contact with skin* is a possible pathway for nanomaterials into the body. Factors to consider are the area and condition of exposed skin, as well as the physicochemical properties of the nanomaterial.
   - *The digestive tract* is the least likely pathway and is mainly associated with a lack of hygiene when handling nanomaterials.

2. **Factors related to the exposed worker**: individual susceptibility, physical activity in the workplace, place of deposition, and path followed by nanomaterials once they penetrate the body.
3. **Factors related to nanomaterials**: level of intrinsic toxicity.

There is only limited information available on the effects of nanomaterials on human health. The major health effects have been observed in the lungs. The cardiovascular system may also be affected. In addition, nanomaterials may reach other organs and tissues, such as the liver, kidneys, heart, brain, skeleton, and other soft tissues.

The Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) has assessed that there are health risks linked to several manufactured nanomaterials. However, not all nanomaterials necessarily have a toxic effect, and a case-by-case approach should be adopted.

3. SAFETY

Although there is little information on the safety hazards of nanomaterials, the risks of fire and explosion are of greatest concern.

Particle size or specific surface area is one of the factors involved in the ease of ignition and explosive violence of a dust cloud. Due to their smallness, they can remain **suspended in the air for long periods of time**, increasing the possibility of creating potentially explosive clouds of dust. Because of their **greater surface area**, nanoparticles can become easily **electrostatically charged** and so increasing the risk of ignition.

Nanomaterials particulates in the form of dust can pose explosion risks, while their corresponding materials may not. However, the quantities that are handled are small and this **greatly reduces** the risk of explosion.

Some nanomaterials are potentially explosive and, therefore, require special working conditions (inert atmospheres).

4. ENVIRONMENTAL LIMIT VALUES

The environmental limit values (ELV) are reference values for the concentrations of chemical agents in the air and represent the levels that it is believed most workers can be exposed to during their working lives without suffering adverse health effects. The ELVs established for some chemical agents (such as graphite, silica, titanium dioxide, and certain oxides) should not be used for nano forms because the characteristics may be different (even for the same chemical composition – as indicated in the previous point).

The difficulty in establishing ELVs for nanomaterials is explained by their wide heterogeneity, the continuous development of new nanomaterials, and especially, because of the lack of adequate toxicological information from epidemiological studies and long- term animal studies. In addition, the scientific community has not yet reached a consensus about which metric (number of particles, surface area, or mass of particles) is best related to the toxic effects of nanomaterials.

5. RISK EVALUATION

A risk assessment is made to estimate work-related risks with an identification and assessment of the risks. **The Prevention and Environmental Service of the Universitat de València will carry out the corresponding risk assessment**.

5.1. Hazard identification

Given the scarce existing information, the collection of information to identify the dangers should be centred in a search for data on characteristics and physical-chemical properties. Information can be obtained from labels (pictograms), safety data sheets, recommendations from the European Commission, and sources such as databases or scientific literature.

Safety data sheets may show no data on the substance at the nanometre scale, or the information on the physico-chemical characteristics may be insufficient. In these cases, **researchers should request from suppliers necessary and sufficient information** to enable, at least, a partial description of the potential risk profile.

It is recommended to obtain the following information:

- Classification of the nano form.
- Size distribution in number of particles.
- Specific surface area.
- Morphological information (shape and size, especially in the case of fibre, and in relation to the applicability of WHO criteria).
- Surface modification of nanomaterials.
- Biopersistence, solubility in water or biological media.
- Data on dust emission capacity.
- Flammability data.

In case of doubt, or a lack of information, an approach based on the 'precautionary principle' should be adopted, i.e. nanomaterials should be considered dangerous unless there is sufficient information to the contrary.

If a risk assessment is made only considering data on the substance in non-nano form, then this should be clearly reflected in the risk assessment.

The information collected on the potential hazards of nanomaterials should be evaluated in terms of quantity and quality, but it is accepted and reasonable to assume that all identified nanomaterials represent a potential danger equal to or greater than that of non-nano equivalent. Therefore, if the non-nano form of a substance is classified as carcinogenic, mutagenic, toxic for reproduction, or any other significant toxicity, it should be assumed that the nano form will also exhibit these properties unless shown otherwise. It must be considered that the properties and characteristics of nanomaterials cannot always be currently predicted from the same or similar substances.

5.2. Risk assessment

To estimate health risks, it is necessary to know the potential exposure of workers. The information that should be collected to measure exposure is:

- Processes can lead to the release of nanometric particles in the air, or their deposition on work surfaces (operations such as cutting, grinding, abrasion, or other releases of nanoparticles or materials containing nanoparticles).
- Tasks in which exposure may occur.
- Quantities used.
- What is the physical state of the nanomaterials at each stage of the process (dust, suspension, or liquid, and what link with other materials).
- Who is exposed in each task and individual factors (such as their health and personal susceptibility, gender, and pregnancy and breastfeeding status for women workers).
- What are the possible entry pathways.
- What is the frequency of probable exposure?
- At what concentration is exposure, and for how long.
- Control measures.

Work situations with a risk of exposure will mostly depend on the form in which the nano-materials are used (powder, solution, and so on) and the type of process (including equipment used and process variables).

If nanomaterials that present a risk of fire and explosion are identified, then it is necessary to analyse each part of the processes to estimate the possibility of generating flammable dust clouds, or explosive atmospheres, that could cause the nanoparticles to become dispersed in the air. The risk areas should be designated and classified according to the frequency and duration of a possibly explosive atmosphere.

However, in many applications, nanomaterials are used in such quantities that the minimum concentration of explosion would not be reached.

5.3. Updating risk assessment

Once the preventive measures have been established, their adequacy must be confirmed with periodic checks. The conclusions obtained in the risk assessment should be documented and recorded.

Users must inform the Prevention and Environmental Service of any changes, such as the incorporation of new nanomaterials, or new activities and processes, so that an adequate revision and risk assessment update can be made.

6. PREVENTIVE MEASURES

Exposure to nanomaterials may pose a risk to exposed workers and preventive measures must be taken to eliminate or reduce exposure.

Such preventive measures must be adapted to each working situation according to the nanomaterials used and the available information regarding exposure. To select these measures adequately, it is necessary to know the type of process, the characteristics of the nanomaterials present, the potential exposures (frequency and duration of operations), procedures, and characteristics of the workplace, etc.

When we prioritise preventive measure, we must consider the severity of the damage to health, the number of workers that could be exposed, the risks that can materialise in the short-term, and the risks that can be handled most easily. The establishment of preventive measures must be carried out in accordance with the general principles of preventive action, first choosing measures to combat the risk at source (the emission source); then measures to prevent transmission and dispersion; and, finally, protective measures for the worker.

Once the preventive measures have been established, their suitability must be checked through **periodic checks by the Prevention and Environmental Service.**

6.1. Prevention in design phase

This is the initial phase when risks can be avoided or reduced before the start of activities in which nanomaterials are used. To incorporate the most suitable measures, it is necessary to know exactly what types of exposures could be produced according to the activity. Some of the measures that can be taken when designing a process include:

- Limit the amounts of nanomaterial.

- Reduce the release of nanomaterials: reduce abrasive processes, work at lower pressures, and moderate temperatures.
- Design closed processes, avoid manual loading and unloading, and the transport of nanomaterial during processes. Isolate and automate processes that may release nanomaterials.

6.2. Preventive measures

Exposure to hazardous substances should be avoided whenever possible, preferably by eliminating the substance, avoiding exposure, or replacing the material with a lower risk material. If the use and generation of nanomaterials cannot be eliminated, or replaced by less dangerous materials and processes, then the exposure of workers should be minimised through technical control measures; organisational measures, and as a last resort, personal protective equipment.

In the application of preventive measures, a well-established control hierarchy should be followed:

1. Elimination/substitution: the potential hazards of nanomaterials can be eliminated either by avoiding their use, or by replacing the nanomaterials with a less hazardous material, considering the characteristics and conditions of use to ensure that the risk is reduced. Information should be sought on substitutes and possible alternatives. The guidelines of the European Commission 'Guidance on the Protection of the Health and Safety of Workers from the Potential Risks Related to Nanomaterial at Work' indicate that if the material is classified as carcinogenic or mutagenic, either at the nano-scale and at the macro-scale, its elimination or substitution must be a priority.
2. Modification of process: to minimise exposure, changes can be made to the working procedures, such as reducing the amount of nanomaterial, or replacing the powdered nanomaterials with a liquid or solid matrix medium.
3. Isolation/containment: operations involving the potential release of nanomaterials in the workplace should be made in separate facilities, or in facilities where the handling is performed in a protected area.
4. Technical control measures: creating a physical barrier between the worker and the nanomaterial to reduce the emission of the pollutant at the source of emission. Technical control measures include extraction systems.

The correct design of working areas and workflow are fundamental for safe operation – and the following aspects should be considered:

- Use working areas that position encased lighting as close as possible to the material under study.
- Use filtration collection systems with HEPA high-efficiency filters (class H14 or ULPA).
- Extraction ducts must be resistant to manipulated nanomaterials (since these can be more reactive than their non-nano equivalents). Special attention must be paid to the joints to avoid possible leakage.
- Use of adherent flooring outside the areas of use help prevent the dispersion of nanomaterials.

5. Organisational measures:

- Minimise the number of workers exposed.
- Reduce exposure time.
- Define and indicate working areas with pictograms showing the possible presence of nanomaterials and the protective measures to be used. NOTE: *Although there is no harmonised signal to indicate nanomaterials, several European organisations have proposed a sign for use in workplaces*.
- Minimise the volume of particulate nanomaterial in use at any given moment.
- Train and regularly inform workers exposed to potential risks about preventive measures. In addition, each worker must inform the **Prevention and Environmental Service** of any defect or deficiency in the control measures.
- Maintain cleanliness and tidiness in the workplace. Regularly clean floors, equipment, tools, and work surfaces using damp cloths, or a vacuum cleaner equipped with 'HPS' class H14 or higher (ULPA) H series HEPA filter. Do not use pressurised air, brooms, brushes, or powerful jets of water.

6. Other measures:

For nanomaterials that may create a fire and/or explosion, it is necessary to consider the provisions of Royal Decree 681/2003 on the health and safety of workers exposed to risks arising from explosive atmospheres in the workplace. To reduce the risk of fire and explosion, adequate protective measures must be taken, such as: install explosion-proof (and where applicable, vapour-proof) electrical installations and electrical equipment protected against dust; use intrinsically safe equipment; avoid situations in which static electricity can be generated; avoid sources of ignition; wear appropriate clothing and especially antistatic footwear; manipulate and store nanomaterials in controlled atmospheres; as well as employing measures to mitigate the effects of an explosion.

7. PERSONAL PROTECTION EQUIPMENT

Personal protective equipment (PPE) should be used as a last resort. All PPE must be CE marked and used wholly accordance with manufacturer's instructions. Effective protection is only achieved by use of the appropriate PPE (correctly adjusted, used, and maintained).

The minimum safety and health requirements for the use of PPE by workers are stated in Royal Decree 773/1997. This decree indicates in article 5.3 that PPE used in the workplace must meet the specific legal requirements for design and manufacture.

According to the 'Nanosafe' report of the European Integrated Project supported through the Sixth Framework Programme (PM6), published in January 2008, the following materials and recommendations are the most appropriate for exposure to nanomaterials:

✓ Protective clothing:

- Laboratory coat that is not cotton and has no pockets or folds.

✓ Respiratory protection:

- Well-adjusted self-filtering masks for FFP3-type particles.

✓ Skin protection:

- Gloves must meet EN 374 requirements.
- Latex, nitrile, or neoprene gloves are effective for handling nanomaterials. It is also recommended to use a double glove for full protection.
- The effectiveness of gloves for specific nanomaterials depends on the physical form of the nanomaterial in the workplace (dust, liquid, etc.); and this must be verified and confirmed with the glove supplier. The thickness of the glove material is an essential factor in determining the diffusion index of the nanomaterial.
- If working with other chemicals (such as solvents), choose a specific glove for these products.
- The frequency of replacement should be increased, when wear is detected, or tasks require continuous manual operations.
- Always remove gloves aseptically.

✓ Eye protection: depends on the task being performed and the form of the nanomaterials:

- When handling solids or dust-inducing operations, the use of universal glasses is recommended to avoid the risk of accidental hand-eye contact.

- If liquids containing nanomaterials (e.g. solutions or particles suspended in a liquid) are handled, the use of face shields with splash protection is recommended to avoid frontal exposure.

- Face shields and universal glasses do not offer adequate protection when there is exposure to nanomaterials as aerosols. In this case, it is advisable to wear full frame glasses together with a half mask.

Special attention should be paid to compatibility when simultaneously using eye and respiratory protection, so that the use of one does not interfere with the adjustment of the other, and reduce the protective capacity.

8. HEALTH MONITORING

Health monitoring an additional preventive measure and contributes to:

- identifying individual (early detection of health effects, identification of vulnerable workers, adaptation of the tasks to the individual) and group problems (diagnosis and detection of new risks).
- planning preventive action by setting priorities.
- evaluating existing preventive measures, since the appearance of an injury in a worker would highlight the inefficacy of existing measures.

Due to the current uncertainty about the effects on health of nanomaterials, it is vital to apply control measures with a periodic health monitoring of exposed workers, which will enable the early detection of any adverse effects, dysfunction, or symptoms.

Vigilance should be particularly high in the case of especially vulnerable individuals, or pregnant workers and nursing mothers. In addition to periodic monitoring, when a spillage, accidental emission, or similar, occurs it is advisable to conduct health examinations of the potentially affected individuals.

Current knowledge is insufficient to recommend specific medical examinations for workers exposed to nanomaterials, but special attention should be paid to organs that are known to be affected, or are suspected of being affected by nano-materials: such as the respiratory system; certain organs; or the skin. If necessary, perform complementary tests (pulmonary, renal, hepatic, or hematopoietic function tests). NIOSH published interim guidance in 2009 entitled 'Guidance for Medical Screening and Hazard Surveillance for Workers Potentially Exposed to Engineered Nanoparticles' for medical examinations and risk monitoring for workers potentially exposed to manufactured nanoparticles.

However, although there is no guarantee that current medical screening tests are the most suitable for workers exposed to nanomaterials, following monitoring protocols that exist for the same non-nano-sized substances is still recommended.

It is important to remember that for development of safe working practices, medical examinations should be a part of a comprehensive prevention management programme in the organisation. Likewise, to facilitate future epidemiological studies, a register of the exposure of all workers working with nanomaterials should be established (indicating the type(s) of nanomaterials, and the process phase in which workers may be exposed).

9. WASTE MANAGEMENT

There is a considerable lack of knowledge about the possible effects of nanomaterials on the environment and human health. No waste management standards, procedures, or strategies have been developed.

Adequate management of wastes generated in activities involving the use of nanomaterials should be ensured. Do not mix nano-materials with other wastes. The remains of pure nanomaterials, liquid suspensions, matrices with nanomaterials, contaminated objects or containers, ventilation filters, vacuum bags, disposable respiratory and skin protection materials, and other equipment should be managed as hazardous – unless it is certain that there are no potential hazards.

Therefore:

- Classify materials according to compatibility for segregation. These materials should be managed as: *Group 13: highly dangerous.* Materials must be accompanied by a safety data sheet or, failing that, the information available. More information.
- Place waste containers as near as possible to the area where the waste is generated.

- Residues should be placed in hermetically sealed containers and labelled with a complete description of the contents (and properties and characteristics).
- Materials must be stored in a well-ventilated place avoiding sources of heat, ignition, and flammable products.
- Collect materials that have been in contact with nanoparticles in watertight plastic bags: collect all rags, papers, masks, disposable work clothes, and other items contaminated with nanomaterials in sealable bags (this action should be performed under an extractive canopy hood) and when the bag is full it should be placed inside another bag or container, avoiding external contamination, and labelled in the same way as the containers.
- An authorised firm should be used for waste collection and transport. The indications provided by the authorised firm should be considered during the preparation of the internal procedure for waste management.
- Agree with the authorised firm to remove wastes from temporary storage with a periodicity of not more than six months.

10. WORK GUIDELINES

10.1. What to do after a spill

Spill control should be based on good working practices, together with reducing the risk of exposure, and assessing the importance of different pathways into the body.

Following an accidental release by a spillage of dust, everybody should be evacuated, and the spill area restricted until cleaned by trained personnel protected by the appropriate PPE (safety glasses, face mask P3 and FFP3, gloves and closable laboratory coat).

The guidelines to follow are:

- Use a vacuum cleaner equipped with a HEPA filter.
- Dampen the dust.
- Use wet wipes.
- Use adsorbents if the spill is liquid.
- Manage the material generated in cleaning the spill as waste (Group 13).
- Assess the need for the use of PPE. Inhalation and skin exposure will probably be the greatest risk.

10.2. Recommendations for storing nanomaterials

For storing nanomaterials, the following suggestions should be considered:

- Whether in solution or powder form, materials must be stored in containers that are preferably rigid, impermeable, closed, and labelled.
- The label must indicate the presence of nanomaterials and associated hazards.
- Storage must be in a cool, well-ventilated place away from sources of heat, ignition, or flammable products.

10.3. Guidelines for laboratory work

Some work procedures, such as those detailed below, can help minimise exposure to nanomaterials:

- Ensure tidiness and cleanliness.
- Use good laboratory practices.
- Do not store or consume food and drink in the workplace, and follow strict personal hygiene measures.
- Create separate work areas.
- Restrict entry to the work area to authorised personnel.
- Place signs.
- Keep normal and work clothes separately in lockers or dressing rooms.
- Ensure the cleanliness of work clothes.
- Remove protective clothing or laboratory coats to access other work areas such as administration offices, cafeteria, common rooms, etc.
- Reduce exposure time.
- Use specified PPE.
- Wash hands after removing gloves and before leaving the laboratory.
- Staff should avoid touching the face, or other parts of the body, with contaminated fingers. The use of PPE, such as masks, can help avoid the transfer of nanomaterials. Exposure by ingestion may be a consequence of hand-to-mouth contact, so all strategies to reduce skin exposure will also reduce exposure through ingestion.

- It is recommended working with nano-materials in the form of liquid suspension, gel, aggregates, agglomerates, or tablets.
- Regularly clean the working areas (including the floor), and as a minimum, clean these areas at the end of the working day using damp cloths, mops, or a high-efficiency vacuum. Avoid compressed air brushes and brooms, etc.
- If it is not possible to completely enclosure the work area, then localised extraction systems should be used, or negative pressure enclosures, or rooms equipped with localised exhaust ventilation. As a final option, use gas or laminar flow cabinets during manipulations of nano-materials.