GUIES DE COMPRA VERDA A LA UNIVERSITAT: MATERIAL DE LABORATORI

Green Procurement Guide at Universities: Laboratory Material

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PREFACE

The *Universitat Autònoma de Barcelona* (UAB) is especially concerned with the environmental impact linked to its work. Because of their nature, and the desire of the institution itself, practical experimental teaching and research are paramount in the work of the UAB. Both activities often require the use of laboratories.

Our university is a pioneer in the management of separate collection of laboratory waste. This began in the faculty of Sciences in the early 1990s. In recent years, there has been constant work done on the prevention of workplace risks, as shown by the creation of the "Environment Health and Safety Office" in 1995, which has since become the Prevention and Environment Service (SEPMA).

The UAB has worked with various institutions towards the prevention of risks and environmental protection. In 1996, a technical prevention note (TPN) was published with the *National Institute for Occupational Health and Safety* (NIOHS) of the *Ministry of Labour and Social Affairs* on waste management in universities. A manual for Good Environmental Practices in Laboratories (GEPL) was produced with the Department of the Environment and Housing of the Autonomous Regional Government of Catalonia. Its aim was to raise awareness among research staff and inform them of the practices that can be implemented in the design and management of laboratories in order to improve their environmental impact. It is now being published by the Spanish Conference of University Presidents for Spanish universities.

Numerous green purchasing guides for office material and services such as cleaning, photocopies and restoration have appeared in recent years. Even sustainable construction has come under scrutiny. However, there have been very few recommendations for green purchasing as applied to laboratories, except for the recommendations included in the GEPL manual.

Laboratories are workplaces aimed at obtaining experimental results at a certain standards. The purchasing of laboratory material is therefore governed by the specific nature of the work done. The end result is the main priority of the work, and environmental considerations are often set aside in favour of practical results.

This limits the scope for introducing green purchasing criteria, and is possibly for this reason that it has not been one of the traditional focus points for the development of green purchasing criteria. A further effort is therefore necessary to minimise the environmental footprint of this work. Green purchasing criteria can be very useful when purchasing glassware and another non-reactive materials which are frequently used and are in most research and teaching laboratories.

Because the recommendations and tools at the disposal of the readers of this guide are beyond the scope of what is strictly the university field, and are applicable to other research and teaching institutions and businesses and organisations, the support of the by Catalan Waste Agency of the Dept. of the Environment and Housing is acknowledged. I am very grateful for its co-operation.

Manuel Sabés i Xamaní

UAB Vice-Chancellor's Commissioner for Environmental Policy

A. INTRODUCTION: THE ENVIRONMENT AND THE LABORATORY

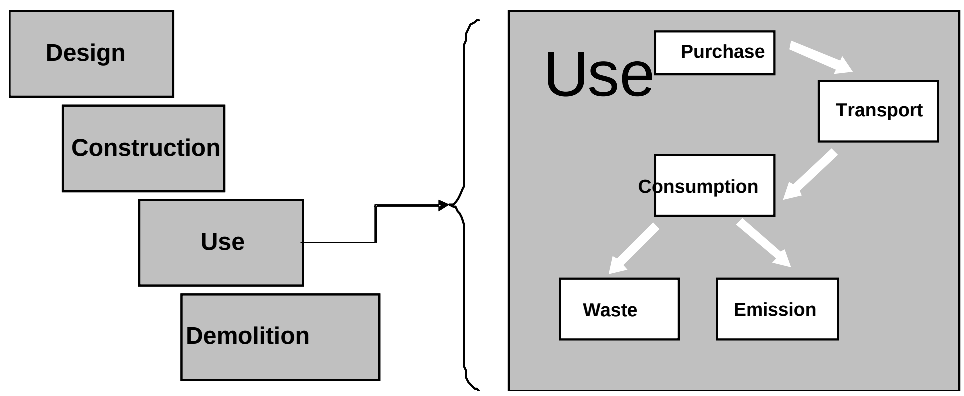
An important part of the environmental impact generated by laboratories is associated with the use of the premises and the type of work done there, as well as the products necessary for carrying it out. A green purchasing strategy for products and materials could therefore be one of the cornerstones of a policy for environmental prevention in the laboratory.

Laboratories have a life cycle, during which certain types of environmental impact occur. This impact could be in the immediate surroundings or further away. It is therefore necessary to be aware of both variables in order to be able to classify the impact associated with the existence of a laboratory in an appropriate manner.

A.1. THE ENVIRONMENTAL IMPACTS DURING THE LIFE CYCLE OF A LABORATORY

The classic approaches to analysing product life cycles could be adapted to the life of a laboratory. There are basically 4 stages in the life cycle of laboratories: design, construction, use and demolition.

Figure 1: The life cycle of laboratories



A.1.1. Design

The design phase of laboratories is one of the most important in preventing the impact associated with their construction and use. It is in this phase when decisions are taken regarding the amount and the materials which will be used in its construction, such as the insulating material, the coatings of the floor and walls and even the furniture and basic apparatus needed.

Obviously, laboratories must be designed in accordance with the work to be carried out there. A practical teaching laboratory is not the same as one that is to be used for research. Even different levels of teaching and research require different installations and equipment.

A.1.2. Construction

The construction of the laboratory will have an environmental impact that is temporary, associated with the use of raw materials and energy consumption, which could be hidden over time by the impact of the use phase, due to the substances and materials used in its daily work.

A.1.3. Use and maintenance

From a functional point of view within a university, laboratories may be for research or teaching. Depending on the type of laboratory, the work normally done in them normally uses chemical products, biological agents, and radioactive isotopes. Handling these materials requires auxiliary products such as glassware, personal protective equipment and special machinery, which obviously have an environmental impact during their life cycle.

Despite the wide variety of types of laboratory, there is material can be found in the vast majority of non-specialist laboratories, and in many specialist laboratories. These are:

Inventory control	**Durability/use**	Less durable
Perishable material	▪ material with a short life (normally disposable) and which is used continually: gloves, sample bags, pipette tips, indelible marker pens...	
	• laboratory material, known as *labware*. This basically includes all *glassware*, tools and basic instruments.	
Material which can be inventoried	▪ Furniture and laboratory apparatus which are also common in this type of installation. These include laboratory tables, cupboards, ovens, refrigerators and scales. Many of these materials can be found in situations other than laboratory experimentation, but those for use in this field are usually made to stricter standards, and comply with safety characteristics regulations and increasingly, energy efficiency criteria.	More durable

The environmental impact associated with the use of a laboratory depends on the equipment and auxiliary materials necessary for practical work there, and the radioactive isotopes, biological agents, chemical products and substances used, and finally, the experience and training of the personnel involved.

Cleaning in laboratories is also an aspect for consideration in terms of their environmental impact. Obviously, the degree of tidiness and the type of products used will depend on the type of laboratory and the experiments carried out there. The cleaning products used have an environmental impact which can be passed on to the atmosphere in the laboratory itself or to the drainage network. Particular attention should therefore be paid to this aspect in laboratory management.

In research laboratories, environmental and health risks are the result of the uncertainty surrounding the results of the experiments carried out there. In teaching laboratories, risks basically arise from the level of experience and training of the students. It is therefore important to reduce as much as possible the uncertainties surrounding the work done there and to ensure appropriate training of those working there and to adopt the habit of working with standardised procedures and working protocols.

A.1.4. Demolition

The demolition of a laboratory is very rare. Because they are generally part of a building with other services, when they are closed the areas are refitted and used for other purposes. The dismantling of a laboratory leads to the generation of various types of waste: rubble, electric and electronic apparatus, furniture and special waste, each of which must be managed appropriately.

A.2. THE TERRITORIAL EXTENT OF THE ENVIRONMENTAL IMPACT ASSOCIATED WITH THE LABORATORIES

Laboratories basically have an environmental impact on their immediate surroundings. When they are built, they are usually built with material from the area, and when energy sources are used and products purchased this is usually from nearby distributors. The majority of emissions are thereby released into the immediate surroundings or taken to the nearest treatment plants.

Because of its specialist nature, laboratory material may be the material that has the greatest environmental impact in spatial terms. Laboratory work requires the use of very specific materials which are often manufactured in specialist plants. These plants may be a very long way away. The environmental impact associated with transportation of products from their production plants is neglected due to the requirements of looking for a specific quality level in the product, material or equipment.

The location of the supplier, despite being important from the point of view of environmental impact, is a criterion not normally taken into consideration in overall laboratory management, as the search for standards and the specific nature of the products take priority over transport minimisation criteria.

If the aim is to reduce the environmental impact associated with work in laboratories, it is advisable not to focus efforts on the impact associated with transport, as it is a very inflexible variable, with highly specialised suppliers who often have no effective competition.

B. OBJECTIVE OF THE GUIDE

The guide was conceived to facilitate the inclusion of environmental considerations when purchasing the materials most commonly used in laboratories, i.e. making greener purchases. The selection of these products is biased towards material that is commonly found in a university laboratory, especially a teaching laboratory, despite it being possible to use many of the patterns for research or industrial laboratories.

This guide aims to be another tool helping those using laboratories to consider the impact of their work. There is little space given to providing guidelines on the impact associated with laboratory design, as its specific nature would need space that is not available in this manual. Instead, the guide focuses on analysing a good purchasing policy for certain products which could make the laboratory a more sustainable work and learning area.

In order to reinforce this practical dimension, this guide analyses five groups of disposable products which are frequently used in all types of laboratories and which are very specific to them:

- Glassware (pipettes, flasks, Erlenmeyer flasks etc.)
- Disposable gloves
- Plastic bags for keeping samples
- Indelible marker pens
- Detergents or other cleaning products

Products which despite being very frequently found in laboratories are not specific to them, such as computers and paper (which were discussed in guide 1 of this series) have not been included.

C. WHAT IS GREEN PROCUREMENT?

Green procurement means purchasing products and services that are environmentally friendly, i.e. purchasing products providing the required levels of quality and service which at the same time generate less overall environmental impact.

C. 1. THE PARTIES INVOLVED IN THE PROCESS

The success of a green purchasing policy for laboratory material at the *Universitat Autònoma de Barcelona* is dependent on the involvement of all those involved in the purchasing process:

- The **members of the university community – teaching and research staff, administrative and services staff and students –** who purchase laboratory material and use it, and who are responsible for its management after it becomes waste.
  The commitment of the **university's governors** is critical in adopting policy agreements covering all the university's departments, research centres and services which have a laboratory.
  Among those in the university community are the **general purchasing managers** or those of the various departments, research centres, services and administrative managers, who channel the orders of the university community and agree on the financial - and often on the logistical - conditions of the purchases made. The **environmental offices** are responsible for establishing criteria and providing technical advice to other university units when purchasing laboratory material.

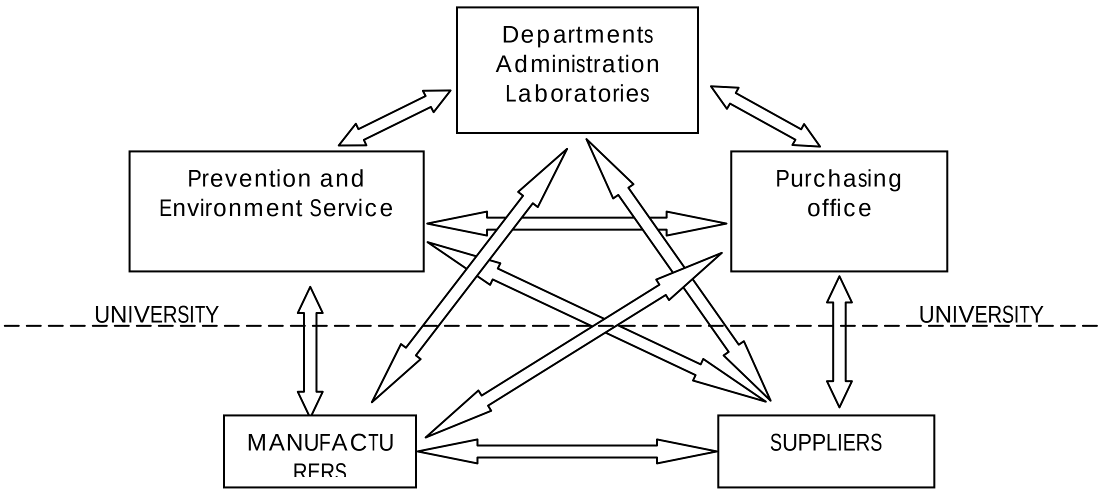
- The **suppliers** of laboratory material and products to the university, which must include environmentally friendly products in their catalogues and

- The **manufacturers** of laboratory material and products, who must develop less harmful alternatives.

Unlike office material or other products at university where the purchaser contacts the distributor to obtain the products desired, purchasing laboratory material takes place in a different way. In many cases, laboratory users need specific material and contact the manufacturer of the products directly in order to negotiate the price and the supply conditions. In other cases, there is a relationship with the manufacturer through the supplier, who sells one or several brands, and with the UAB central purchasing office, when the costs of the operation exceed the legal limits for a purchase and become a purchase by means of a negotiated procedure or a public tender.

The flow of information which takes place between the various agents involved in purchasing office material at the UAB is shown in the following diagram:

Figure 2: Information flow between the agents involved in purchasing laboratory material at the UAB



C 2. WHAT NEEDS TO BE PURCHASED?

The first thing to consider when green purchasing laboratory material is to consider the need to purchase the product (Is it really necessary? Are there any alternatives?) If the product is necessary, the second step is the selection of products based on environmental criteria. After the product has been selected, the purchase is made in amounts and dimensions that meet the needs.

- Only **really necessary products which are**
- **Environmentally friendly** should be bought
- **in amounts appropriate to needs.**

Selecting environmentally friendly products is not easy, as clear criteria must be defined for consideration when comparing products (the use of renewable resources, energy consumption, waste production, etc.) and the environmental information that products contain is often not very clear or insufficient.

C.2.1. What environmental information can be found on products?

As mentioned above, one of the most important problems when selecting environmentally friendly products arises from the coexistence on the market of a wide variety of environmental labels and logos, and other graphic information which may lead to confusion.

The type of labels that can be found on the laboratory products considered in this guide can be classified into four major groups:

- **Ecological labels**: these are labels certified by an independent body (not by the company itself) which ensure that the products meet a series of environmental criteria that make them preferable to the others. These criteria are based on the entire life cycle of the products (from the extraction of the raw materials which they consist of, their production and use, to their management as waste) and are in the public domain (they can be consulted on the websites listed at the end of this guide). However, these labels are not compulsory, but are entirely voluntary. The most common are:

Figure 3: The most common ecological labels on products

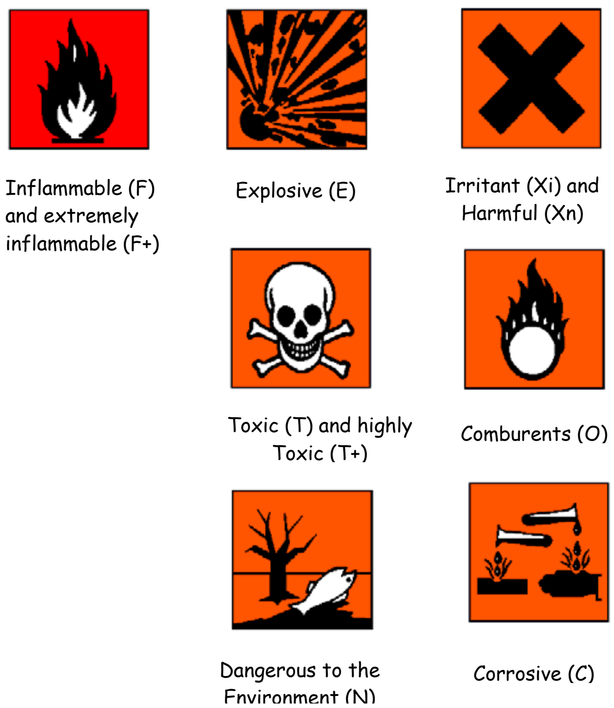
ECOLOGICAL LABEL	AWARDED BY	Products where it can be found
Environmental Quality Guarantee Logo	Environmental Quality Office. Autonomous Regional Government of Catalonia Department of the Environment	Bags of refuse, mineral oils, paper for drying hands, rolls of paper, tap flow restrictors...
European Ecolabel	European Commission	Paints, detergents, computers, electrical goods...
Nordic Ecolabelling, Nordic Swan	Nordic Eco-labelling Association (Denmark, Finland, Norway, Sweden and Iceland)	Stickers, detergents and soaps. Batteries, photocopiers, printers, faxes, computers ...
Blue Angel	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany)	Batteries, paper, computers, lubricants, labels, toner, rubbish bags......

- **Environmental declarations**: are labels with environmental information or logos added by the companies themselves, in order to show the environmental specifications of their products. As far as the material found in a laboratory is concerned, most of them are used to refer to the composition of paper, and are explained in depth in guide number 1 of this series. However, in the detergents sector, a product's biodegradability has recently begun to be displayed, using the following word:

The term **biodegradable** means that the product (a detergent or other product) breaks down safely and relatively quickly, using biological means, into naturally occurring raw materials and disappears into the environment.

- **Safety pictograms** give information related to the danger or safety guarantees of the products being worked with. In the laboratory, these include the following:

Figure 4: Safety pictograms for chemical products and gloves



Danger pictograms for **chemical products.** This information is important both when handling products and when managing them as waste (see the Waste Incompatibility table in section C.4)

Pictograms of **gloves** as safety equipment (the complete codes are in Appendix 1)

- **Other labels** do not refer to strictly environmental characteristics of the material but they are found on some products, and may lead to confusion. They often only refer to the characteristics of the packaging of the product and not to the product itself. Examples of this are:

Figure 5: Other labels found on the products

	The **green circle** (regulated by law) which means that the producer of the packaging has contributed financially to an integrated waste management system (IMS) in order to finance the collection and treatment as waste of the packaging.
	**SIGRE Mark** (regulated by law). This is the recycling system for medicines and medicine containers.
	**Identification of the materials** showing the type of material used to manufacture the product (steel, aluminium, plastic, cardboard, etc.)
 	The **Moebius band** which shows that the product can be recycled if empty or that it has been manufactured with recycled material (in which case a percentage will appear inside).
	Other **environmental education pictograms** such as this one, which only shows consumers that the product should be disposed of properly.

C.2.2. How can green products be selected?

The choice of more environmentally friendly laboratory glassware and auxiliary disposable material must be made by comparing the products available, considering pre-established environmental requirements and criteria. Section D of this guide shows the recommended criteria for purchasing a good group of products: Glass instruments (pipettes, flasks, etc.), gloves, indelible marker pens, plastic bags for keeping samples and detergents.

Official ecological labels or certificates from recognised bodies are useful for checking compliance with environmental criteria. If the manufacturer's information is not available, they will be the only means of doing so.

C. 3. HOW SHOULD PRODUCTS BE USED?

Purchasing products while considering their environmental aspects is important, but so is using them taking their environmental variable into account. Some products used in the laboratory have their greatest environmental impact during the mining of the raw materials of which they are made or during their management as waste. However, others, such as detergents, have the most impact during their use, which is associated with cleaning instruments.

What should therefore be considered when using laboratory materials and products?

- They should always be used in a conscious manner, thinking of savings. If an ecological detergent is bought, it should not be poured down the drain using more than the amount necessary for cleaning the instruments!

- Try to keep products (especially glass instruments) in optimum conditions for as long as possible. Apart from savings on resource consumption, possible accidents in the laboratory are prevented!

C. 4. WHAT SHOULD BE DONE WITH WASTE?

Law 6/1993 concerning waste in Catalonia defines waste as “any substance or object which the owner intends or is obliged to dispose of" (Art. 3.)

Waste is an intrinsic and involuntary result of any activity, and experiments are no exception to the rule. The special laboratory waste generated at universities are typically:

- Generated in small amounts, with industrial volumes not generated, and the most significant amounts being those generated by pilot plants.

- Highly varied. Practical and research lines are very varied in university laboratories. Whether a material is considered waste is not determined strictly by its composition, as any material can become waste.
- Generated in very varied centres. Waste can be found in clinical laboratories, health and veterinary centres, photographic laboratories, experimental science laboratories and even in non-experimental centres, such as artistic creation areas.
- Difficult to manage. The procedures for their disposal in the laboratory must be carried out *ad hoc* and their transfer to external treatment plants entails prior reconditioning.

Correct management of laboratory waste will reduce the environmental impact of this type of premises. To do so, it is necessary to have and use special containers for the selective separation of different types of waste, so that they can be environmentally managed in the most appropriate manner.

For practical purposes, a distinction can be made between the two types of waste generated in the laboratory:

- **Non-special waste** (without biological, chemical or radioactive contamination) which can be assimilated into urban waste and must be taken to the appropriate containers for glass, paper/cardboard, batteries etc. around the campus or to the general refuse if they are common waste.

- **Special waste** is classified and coded and must be deposited in separate containers.

Glass warrants special consideration. It is included in the category of special waste, depending on its level of contamination with chemical products, biological agents or radioactive isotopes; and whether it is broken or could cause cuts or wounds.

Treatment of glass as waste:

- Glass contaminated with chemical products that is not broken is collected in a special 90, 120- or 200-litre container with a spring shut mechanism.
- Non-contaminated and broken glass is collected in a separate container.
- If the glass to be disposed of is contaminated with cytostatic products (liquid or solid waste considered carcinogenic, mutagenic or teratogenic), it must be disposed of in a cytostatics container.
- Sharp-edged material contaminated with biological products or pathogens must be stored in the biorisks container.
- Finally, small pieces of sharp-edged glass and non-contaminated Pasteur pipettes are treated as broken glass.

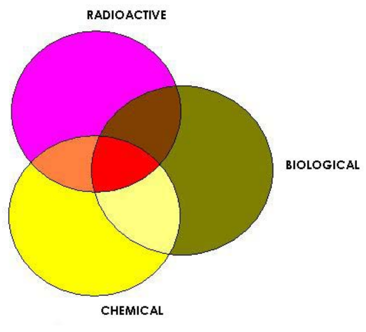
C.4.1. Classification of special waste at the UAB

The UAB has had a selective collection system for special laboratory waste since the early 1990s, and authorised managers are responsible for its removal and treatment [1].

Waste is classified using two basic criteria:

- the compatibility between the waste in the same classification group and
- its final treatment.

Different types of contamination of waste



The risks arising from waste management dependent on the type of contamination associated with it. Despite most waste having a single type of contamination, the combination of various types increases risk levels in the handling and treatment of waste. It is therefore important to try and avoid cross-contamination and, if it occurs, action should be taken with the support of the risk prevention and environmental offices.

Considering these two criteria, the UAB has established the following classification for special laboratory waste:

Table 1: Classification of special waste at the UAB

CHEMICAL WASTE	Halogenates Non-halogenates Aqueous solutions Acids Bases Contaminated mineral oils Solids Special chemicals Contaminated glass Photographic developers Photographic fixatives
BIOSANITARY WASTE	Health biorisks Health cytostatics Samples of specific risk material Ruminant corpses Uncontaminated experimentation animals Livestock droppings
RADIOACTIVE WASTE	Radioactive

The SEPMA website gives a detailed description of the products included in each classification group as well as their markings in the laboratory.

C.4.2. Waste incompatibility

When storing laboratory waste, attention should be paid to danger pictograms, as storing some substances together is dangerous and/or incompatible.

Figure 6: Chemical waste incompatibility

							
	+	-	-	-	-	+	O
	-	+	-	-	-	-	-
	-	-	+	-	-	+	+
	-	-	-	+	-	-	-
	-	-	-	-	+	O	-
	+	-	+	-	O	+	+
	O	-	+	-	-	+	+

Legend:

+ can be stored together

+ cannot be stored together

0 Preventative measures must be taken

D. WHAT ENVIRONMENTAL CRITERIA SHOULD BE CONSIDERED IN THE PURCHASE, USE AND MANAGEMENT OF...

As mentioned above, green purchasing of laboratory products and materials is not enough for their good environmental management. Apart from purchasing more environmentally friendly material, making good use of and good management of waste is important.

This section lists a series of practical environmental recommendations for the purchase, use and where appropriate, disposal as waste of glass instruments and other auxiliary laboratory materials.

In specific terms, there are recommendations for:

- ⇨ D.1. Glass instruments (pipettes, flasks, precipitate glasses, etc.)
- ⇨ D.2. Disposable gloves
- ⇨ D.3. Indelible marker pens
- ⇨ D.4. Plastic bags for keeping samples
- ▪ D.5. Detergents or other cleaning products

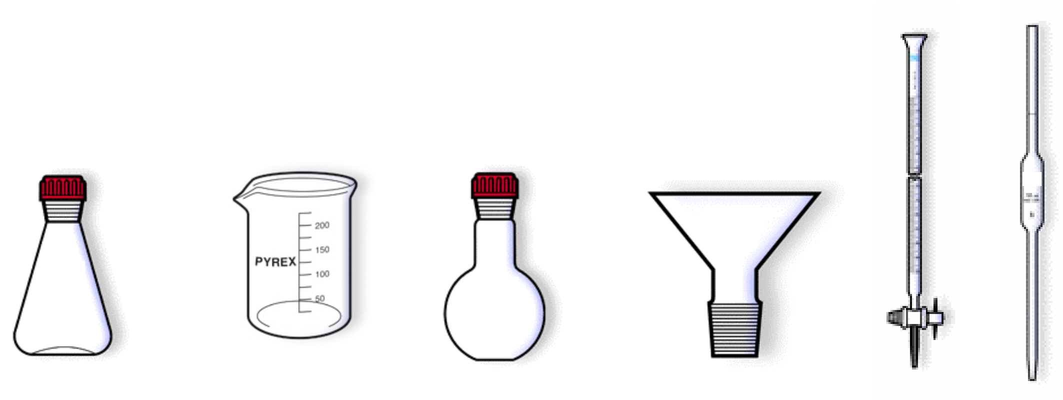
At the beginning of each subsection there is relevant information for each product category such as aspects related to their environmental impact, their identification using the information provided by the manufacturer, and their maintenance and management as waste in cases where this is important in their environmental impact.

At the end of the section is a table showing recommendations for purchase, use and management as waste of the products listed in the previous subsections (D1-D5).

D.1. GLASS INSTRUMENTS

Glass is the most commonly used material in the laboratory, due to its resistance to scratching, corrosive agents and high temperatures, its transparency, which shows what is happening inside it, the fact that it does not conduct electricity and its low price. These characteristics make it ideal for manufacturing the instruments used in laboratories such as flasks, precipitate glasses, pipettes, etc.

Figure 7: Examples of glass instruments normally used in a laboratory



Erlenmeyer flask — Precipitate glass — Flat-bottomed flask — Funnel for solids — Burette — Pipette

Despite its positive properties, glass is generally fragile and breaks easily after a slight impact. Furthermore, not all types of glass are appropriate for use in the laboratory, because they do not withstand the action of some strong reagents or are sensitive to extreme temperatures, among other factors.

Basically, there are two types of glass in a laboratory:

- Moulded glass
- Brand name or borosilicate glass (such as PYREX™ or DURAN™)

Moulded glass can be identified easily because it has no marking or engraving on its surface. It has lower thermic resistance than brand name glass and in fact, is not suitable for being heated directly over a flame and does not withstand tolerate sudden temperature changes. It is soluble in fluorhydric acid and is damaged by contact with some warm salt solution.

Table 2: Composition of the most commonly used glass equipment in laboratories

Composition	Basic brand name glass	Superior brand name glass	Pyrex™ glass		Duran™ glass
SiO_2	52%	75%	80%	85%	81%
KOH	13%	12%	1.15%	-	-
PbO	35%	13%	-	-	-
B_2O_3	-	-	13%	11.8%	-
Al_2O_3	-	-	2.25%	2%	2%
NaOH	-	-	3.50%	-	-
Fe_2O_3	-	-	0.05%	-	-
CaO	-	-	-	0.3%	-
B_2O_3	-	-	-	-	13%
NaO_2/K_2O	-	-	-	-	4%
Others	-	-	-	0.6%	-

Source: www.computerhuesca.es

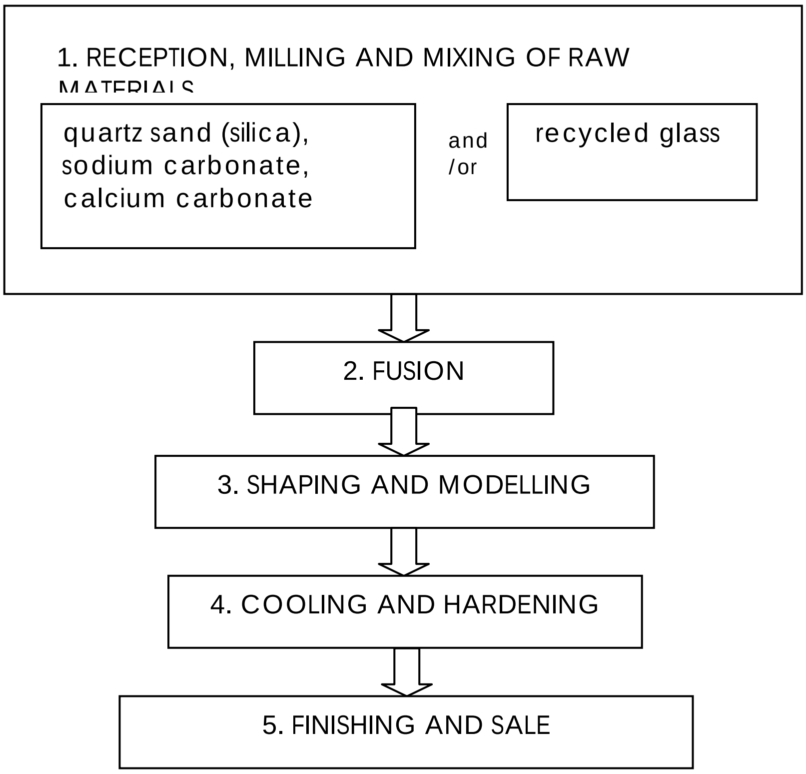
Branded glass (borosilicate) is the most commonly used type of glass in laboratories due to its high resistance to temperature (400 500ºC), to corrosion by liquids, acids, solvents and gases, and because it has a very low expansion coefficient.

It is increasingly common to find laboratory tools manufactured with plastic. When choosing them, it is necessary to consider the environmental impact of this material as a petrol byproduct (see section D.4), and their properties in terms of stability, resistance, safety etc. which are different to those of glass (there is a table with the physical characteristics of the main types of plastic in Appendix 5).

D.1.1. The environmental impact of glass

The manufacture of glass products includes five main phases which are shown in the figure below:

Figure 8: Main phases in the production of glass products



Source: Own research based on data from [12] and [13].

The raw materials for glass are very plentiful on Earth, and there are no significant problems from the point of view of exhausting resources. However, glass is a material which does not lose its properties in the recycling process, as is the case with other materials such as plastics.

The greatest impact associated with the glass industry is related to its ovens, which must reach temperatures of 1,500ºC in order to melt the minerals. To do so, they use fossil fuels such as natural gas and petrol which emit sulphur, nitrogen and carbon oxides when they are burnt with the raw materials used.

The glass industry is responsible for 0.7% of the sulphur, nitrogen and carbon oxide emissions in the European Union as a whole.

D.1.2. Glass recycling

The use of recycled glass as a raw material in the glass industry significantly reduces its environmental impact. As well as saving raw materials, this reduces the amount of energy necessary to operate the ovens, extending their working life, due to the lower operating temperatures needed to melt recycled glass instead of minerals.

A ton of recycled glass enables 1.2 tonnes of raw materials to be saved.

Energy consumption is reduced by approximately 68% for each tonne of recycled glass and around 35 litres of petrol are saved.

Source: SINIA, 1999 [12].

D.1.3. Recommendations for use to lengthen the working life of glass instruments

While it is true that recycled glass leads to a lower environmental impact than that of new glass, it is also true that it still requires a great deal of energy for its manufacture.

It is therefore preferable to maximise the working life of glass instruments. To do so, the material should be treated carefully and thought should always be given to the specifications of the various types of glass in order to handle it correctly. Some recommendations are listed below:

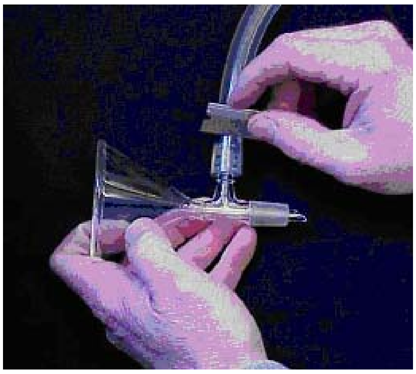
Before starting to use it...

- Remember the basic safety rules for working in a laboratory. Above all, use the appropriate clothing and PPE for the type of work being done with glass material.
- Ensure that the material is in good condition before starting practical work. Do not use it if it is cracked, scratched or if any bump can be seen, because it may break while being used.
- Ask for the auxiliary parts that may lengthen the life of the product before replacing it with a new one (such as rubber joints or plastic lids for burettes)

During experiments...

General precautions:

- Do not pick up precipitate glasses, glass bottles, etc. by the neck or rim. This creates a tension which may cause it to break. It should be picked up by the base and sides.
- Use appropriate covers for the instruments being used (test tubes, jars, etc.) and the appropriate sizes. Do not use excessive force when putting them on, as they could break. It is better to cut rubber tubes away from glass material with a covered razor blade when they need to be separated instead of exerting force them to remove them.



Separating the glass tube with a razor blade is a good idea, but gloves should be used!

- Do not use glasses with thick sides or precipitate jars or standard flasks with a capacity of over 5 litres.
- When shaking solutions in glass containers such as precipitate jars, use Teflon magnets or sticks with polished ends to avoid breaking or weakening the glass.
- Avoid using fluorhydric acid, hot phosphoric acid and hot strong alkalis in Pyrex™ containers. Despite this glass being highly resistant, these compounds may cause corrosion.

▪ Do not mix concentrated sulphuric acid with water in a glass cylinder, as the heat of the reaction may break the seal of the tube's base.

If frosted glass has to be used:

- Lubricate the surface of the ground glass in order to prevent leaks while it is being used and to make its separation easier. Use silicon-free laboratory grease and apply a fine coating around the entire connection.
- If frosted glass is stuck, take the following steps:
  - Always use thick protective gloves and safety goggles. Force should never be used.
  - Turn the male part very carefully inside the female to separate them.
  - If the joint is dry, try lubricating it. Hold the connection in a vertical position and add oil to the top of the male part. Wait until the oil has penetrated the joint before trying to separate them.
  - If it is possible to use temperature (if there are no volatile liquids) heat the outer part of the female part underneath the hot water tap. Hold the joint under the tap for a few minutes before trying to separate them.

If volumetric glass has to be used:

- Do not expose it directly to heat, such as heating plates or Bunsen burner flames.
- Pyrex™ glass may be steam sterilised at 121ºC and cleaned in a laboratory material cleaner without losing its precision.
- Do not suck on the pipette with your mouth; use pears, bottle nipples or pipette aspirators.
- If strong corrosive acids, etc. are used, use volumetric material manufactured with chemically resistant Pyrex™ glass.
- Do not use scratched, cracked or broken pieces.

If working with heat:

- The maximum recommended temperature for Pyrex™, Quickfit™, Duran™ or other brands of glass is 500 ºC (for short periods). However, at temperatures above 150ºC, care should be taken that heating and cooling take place gradually, slowly and uniformly, to avoid accidents. The main safety problems arising from working with glass at high temperatures is that its external appearance does not differ due to the working temperature. Glass should be left to cool after removing it from the autoclave, and in working procedures it is always necessary to make sure that the glass can be handled by using gloves.

- If a heating plate is used, make sure that the base of the plate is bigger than the base of the container that is to be heated. If the plate is still hot, do not place the cold container on top of it. It must be heated gradually.
- For safety reasons, place the heating plate in a tray which can collect the liquid in the event of breakage.
- If a Bunsen burner is used, use a gentle flame and a metal gauze with a ceramic centre to disperse the flame.
- When steam sterilising Pyrex™ glass containers (such as screw-on lids), always keep them loose. Otherwise, this may lead to differences in pressure and the glass breaking as a result.
- Care should be taken when heating liquids with a high level of viscosity. These may act as a thermic insulator and create "hot spots" and even break the glass.
- Stir the solution frequently to obtain a uniform distribution of heat, regulate stirring and check frequently that it is being done correctly, to ensure that it continues throughout the entire process.
- Containers should be heated gradually and rapid boiling should be avoided.

If pressure is to be applied or a vacuum created:

- Always use an appropriate safety screen.
- Never use cracked or scratched glass as its resistance is seriously affected.
- Do not use flat-bottomed containers, such as *Erlenmeyer flasks* or bottles, to create the vacuum, as there may be an implosion. The exceptions are recipients with especially thick walls, such as filter flasks and desiccators.
- Avoid the tension caused by that clamps are too tight.

Review of the instruments

- Do not subject glass to sudden changes in pressure; always apply gradual pressure and vacuum gradients.

After the experiment is over...

- Clean the glass immediately after using it to prevent hardened dry deposits from forming.
- Do not use worn out brushes, because the metal points may scratch the glass.
- Use a phosphate-free biodegradable detergent, especially for use in the laboratory (see detergents section)

D.1.4. Waste management recommendations

Used or broken glass must be free of any type of chemical or biological contamination. If this is not possible, it must be placed in an appropriate hard container with a spring-closing mechanism.

An autoclave is necessary for biological decontamination. However, this is not enough for biological agents classified as high risk.

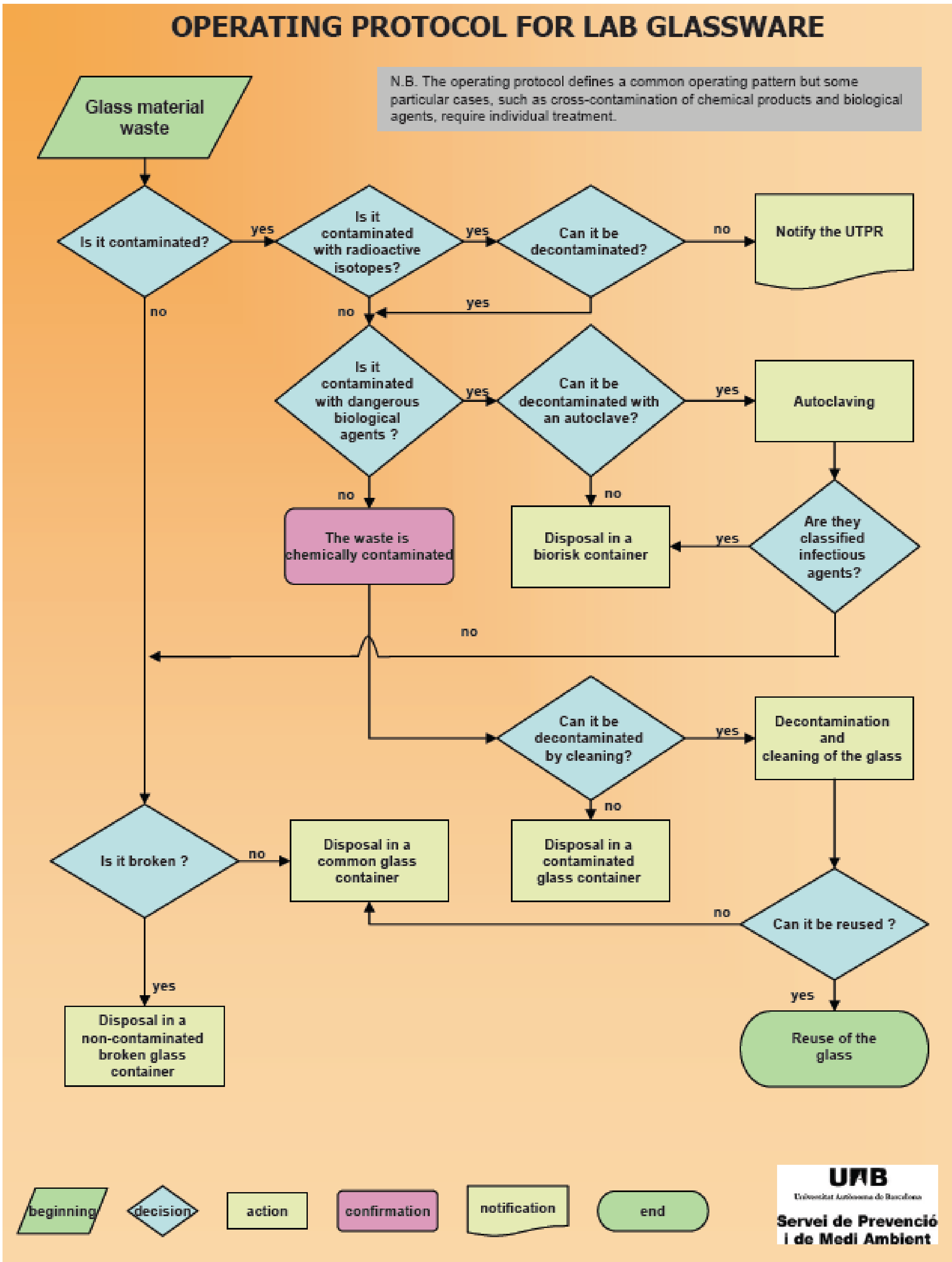
Working with an autoclave

Most chemical decontamination procedures for glass are carried out by cleaning with detergent, rinsing with water and final rinsing with distilled water. Before anything else, make sure that the inside of the glass is free of remains. Make sure beforehand that the product that the receptacle contained does not react violently with water. In this case, cleaning the glass will require another neutralising agent.

It is important to distinguish between containers for storage of chemically contaminated glass depending on its fragility, and whether it it broken or intact. If possible, a container should be used for broken or very fragile chemically contaminated glass and another container for intact chemically contaminated glass.

The UAB waste classification in section C.4 of this guide specifies the level of disintegration of glass as waste. In case of doubt, especially when dealing with glass contaminated with biological agents, it is better to contact the offices co-ordinating the removal of waste to establish a specific procedure for separating glass in the laboratory.

Figure 9: Protocol for the management of laboratory glass as waste



Source: Own research

D.2. DISPOSABLE GLOVES

Disposable gloves (made of latex, nitryl, PVC or other materials) are commonly used in laboratories and, in fact, are part of the Personal Protective Equipment (PPE) for preventing risks that may be a threat to health or safety.

The conditions that PPE must comply with before being sold are regulated by Royal Decree 1407/1992 of 20 November.

The presence of this label on the product or its packaging shows that the manufacturer declares that the PPE (gloves, in this case) comply with the stipulations of the applicable legislation in this area.

Current regulations oblige manufacturers to provide purchasers with an information sheet showing all its characteristics; instructions for use, maintenance, cleaning, checks, expiry dates, etc. The sheet must be written in Spanish and its contents must be very clear. As a result, in the event of doubt regarding the properties of the product, you can contact the supplier or manufacturer of the product.

You can also consult the list of gloves recommended by SEPMA in terms of workplace safety on the service's website (www.uab.cat/sepma).

D.2.1. Glove materials and the environment

There are gloves made from various materials on the market: latex, nitryl, PVC, PE, vinyl, etc. Apart from mechanical resistance to traction and perforation, each of these materials gives the gloves different impermeability properties for different chemical products. As a result, the choice in each case will be determined by the specific use to be made of them, and they must be selected according to their suitability and the official standards certificates provided by the supplier.

There is a guideline table showing the chemical resistance of various types of gloves in appendix 2. You can find more information about this from the manufacturers and/or through NTP 517 of the *Ministry of Labour and Social Affairs* (www.mtas.es/insht/ntp/ntp_517.htm).

The most common materials found in disposable gloves for the laboratory are natural latex, nitryl and vinyl.

Natural latex

From the environmental point of view, natural latex is the material with the least impact, as it comes from a renewable resource, the milky sap of the rubber tree *(Heavea braziliens)*, while other gloves are made from plastic petrol by-products. As a result, providing that latex provides the properties being sought in gloves as insulators from external dangers during the handling of the various chemical or biological agents, it is advisable to choose natural latex gloves instead of other materials.

However, between 1 and 6% of the general population, and 8-12% of healthcare staff, are allergic to latex. This allergy is due to the presence of over 200 proteins in natural latex. It is therefore necessary to seek an alternative in this case.

Natural latex gloves dusted on the inside with talcum powder, corn flour, starch, etc. have more pronounced allergic reactions than those that are not. It is therefore advisable to use undusted latex gloves in the event of allergy problems with dusted latex gloves instead of replacing them with gloves made from other materials such as nitryl or vinyl.

Synthetic latex, nitryl and vinyl

Latex or synthetic rubber is based on the polymerisation of petrol and natural gas byproduct compounds such as butadiene or equivalents (isoprene) or byproducts (chloroprene) have the same structure. Unlike natural latex, which comes from a plant, these products come from fossil fuels and therefore from a non-renewable source.

Synthetic latex has the same chemical structure as natural latex, but is synthesised in a laboratory. It does not contain the proteins which natural latex has, and therefore does not cause allergy problems. The same is true of nitryl and vinyl.

In the latex family, and for application in disposable laboratory gloves, there are basically three materials:

- synthetic latex (polyisopropene)
- nitryl (Buta-n)
- vinyl (PVC and/or PVA)

4% of the petrol extracted annually is used in the plastic industry. Petrol is distilled into various fractions, with one of them being naphtha, the basis for the plastic industry. Petroleum undergoes a subsequent process known as cracking (a process for the thermic breakdown of molecules), from which smaller molecules like ethylene, propylene and butadiene are obtained. These molecules are subsequently polymerised or polycondensed to make up the various types of plastics, using specific catalysts.

Table 3: Characteristics of the main synthetic gloves on the market

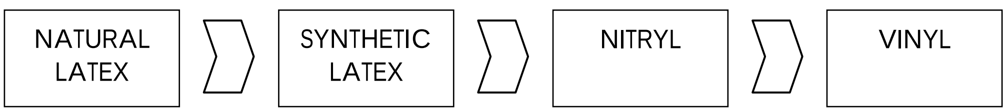
MATERIAL	CHEMICAL COMPOSITION	COMMENTS
Vinyl	Polyvinyl chloride (PVC)	Not advisable for ketones, ether and aromatic solvents or chlorates. No protection against infectious material and less sensitive than latex.
Butyl	A compound of isobutylene and isoprene	Difficult to manufacture and very expensive. Used very often for work with gases because they have very low gas permeability. Low resistance to petrol and its byproducts.
Synthetic latex	Isopropene polymer (polyisopropene)	It has similar characteristics to natural latex. It is very suitable for working with ketones, organic acids and alcohols and not for chlorate solvents.
Neoprene	A chloropropene polymer compound	Excellent protection from chemical products (including alcohols, oils and dyes). Not advisable for use with oxidising agents. It is also a latex substitute, has the same protection level to blood pathogens and is more resistant to punctures.
Nitryl	A butadiene and acronitrile polymer	Very frequently used in cases of allergy to latex. It has the same barrier as latex to blood pathogens and is three times more resistant than it to punctures. Not advisable for use with ketones, strong acids and organic chemical products containing nitrogen.

Source: Own research based on information from [8], [9] and [11].

D.2.2. Green purchase recommendations

As mentioned with the materials, providing latex is suitable as a barrier to the various products used in the laboratory, and there are no allergy problems, it is advisable to use natural latex gloves instead of the other options. If this is not possible, buy synthetic latex, nitryl or vinyl gloves (in that order of preference).

Figure 10: Glove purchasing priorities



To assess the suitability of gloves, apart from the type of plastic - will give it a different level of protection from certain chemical and/or biological agents - it is necessary to look at the product's safety pictograms printed on the box (see Appendix 1).

Always use protective gloves without a dusting (with corn flour, talcum powder, starch, etc.), as they do not make the gloves any more waterproof and use more raw materials than in gloves without a dusting. Furthermore, these agents could aggravate allergy problems.

Choose ambidextrous glove models, so that everyone can use the gloves in the box without having to throw them away unused, and savings will also be made on materials.

D.2.3. Recommendations for use

Because gloves are individual protection equipment for preventing risks in laboratories, checks should be made to make sure that they are in a good condition before using them, the best before date checked, and above all, any faults which may suggest that they are not in perfect condition detected.

In order for them to be effective, rings, watches, bracelets and other items that could damage (pierce or tear) them during the experiment should not be worn.

You can find more information about the minimum health and safety obligations for workers when using PPEs, which are regulated by Royal Decree 773/1997, of 30 May (Official State Bulletin no. 140 of 12 June).

As mentioned above with regard to natural latex, the other raw materials used to manufacture gloves come from non-renewable resources. It is therefore advisable to reuse gloves providing that the safety conditions are ensured and there is no possibility of contaminating samples.

D.2.4. Waste management recommendations

As is the case with glass instruments, management as waste of gloves depends on whether or not they are contaminated with potentially dangerous chemical products. If not, they can be deposited in any refuse container but if there has been an accident or there is the possibility that the glove could be contaminated, they must be deposited in a special waste container for the contaminating agent (see section C.4).

D.3. INDELIBLE MARKER PENS

Indelible marker pens are very common in laboratories and are used for labelling samples, writing on glass, etc. Most marker pens on the market contain volatile organic compounds (VOCs) and heavy metals in their inks, which are harmful to the health and the environment.

D.3.1. Marker pen parts and the environment

VOCs are chemical compounds that easily evaporate at room temperature. As well as being found in marker pens as solvents, they are also present in paints, varnishes, solvents, benzines, cleaning agents and adhesives. Among the most common VOCs are benzine and formaldehyde, which are classified as group 1 (carcinogenic to humans) by the International Agency for Research on Cancer. Prolonged and occasional exposure to this type of compound may have effects on the health, especially in people with respiratory problems or those who are very sensitive to this type of agent, children and the elderly.

Table 5: Effects of exposure to VOCs

Acute effect (temporary exposure)	Chronic effect (permanent exposure)
▪ Eye irritation and tears ▪ Nose irritation ▪ Throat irritation ▪ Headache ▪ Nausea and vomiting ▪ Dizziness ▪ Worsening of asthma	▪ Cancer ▪ Liver damage ▪ Kidney damage ▪ Damage to the central nervous system

Source: Minnesota Department of Health [14]

Because of the effects arising from exposure, regulation of the use of these products is increasingly strict and it is increasingly common to find products on the market such as paints and varnishes which use water instead of VOCs as a solvent. It is also possible to find indelible marker pens that can be used in the laboratory which are free of these compounds.

The Nordic White Swan ecolabel occasionally accepts the use of some VOCs in writing equipment. In specific terms, it allows ethanol and propanol to be used in whiteboard markers, indelible markers and slide markers

The **heavy metals** (antimony, arsenic, barium, cadmium, selenium, mercury, lead and chrome VI) form part of the normal composition of the inks used in marker pens and other writing equipment. The inks are harmful to a greater or lesser extent depending on the colour and the metals used. In general, marker pens with metallic and fluorescent colours should be avoided.

Despite the metallic metals and compounds entering the organism being potentially toxic, some of them, such as zinc, copper, chrome, manganese and nickel are essential for survival [16]. However, chronic exposure and a accumulation of heavy metals in the body may lead to problems in the nervous system and/or vital organs, and cause cancer or other serious diseases.

D.3.2. Purchase recommendations

Indelible marker pens labelled with the White Swan are guaranteed to be free of heavy metals and VOCs (except ethanol and propanol) in their composition.

If no products with this label can be found, there will be others that are VOC-free and/or without heavy metals. In this cases attention must be paid to the information given by the manufacturer and on the product label.

Purchase marker pens which do not have a PVC body or lid and avoid those with metallic or fluorescent inks.

D.3.3. Recommendations for use

Apart from finding products with an ecological label guarantees that they contain no harmful products, we can also find marker pens on the market with or without an ecological label which are refillable. These marker pens are preferable to disposable ones, as they save on manufacturing the plastic body of the marker pen every time they are reused with a new refill.

In order to lengthen the lives of these marker pens, care should be taken to cover them once they have been used, in order to prevent the tips from drying and the marker from being damaged and having to be replaced by a new one. For the same reason, it is also advisable to share this type of material if continued use is not made of it.

D.3.4. Waste management recommendations

The cases of marker pens are usually made of plastic, but their parts (tip, case and lid) are often made of several polymers, which makes their subsequent separation and recycling difficult. Damaged empty cases should be disposed of in the waste paper bin. This waste will be collected by cleaning staff and managed as refuse.

Packages in which marker pens and their cartridges are sold (blister packs, cardboard boxes, etc.) must be selectively separated and deposited in the appropriate container.

D.4. PLASTIC BAGS FOR KEEPING SAMPLES

In laboratories it is normal to use bags to keep samples of solid or liquid material contained in other receptacles. These bags are usually plastic, but in some cases, and when it is not essential to see their contents, paper is also used.

D.4.1. The environmental impact of plastic

The plastics are synthetic polymers combined with colouring agents, plasticisers, and fortifiers which give them a high level of durability. The raw material in their manufacture is petrol, which is a limited and non-renewable raw material.

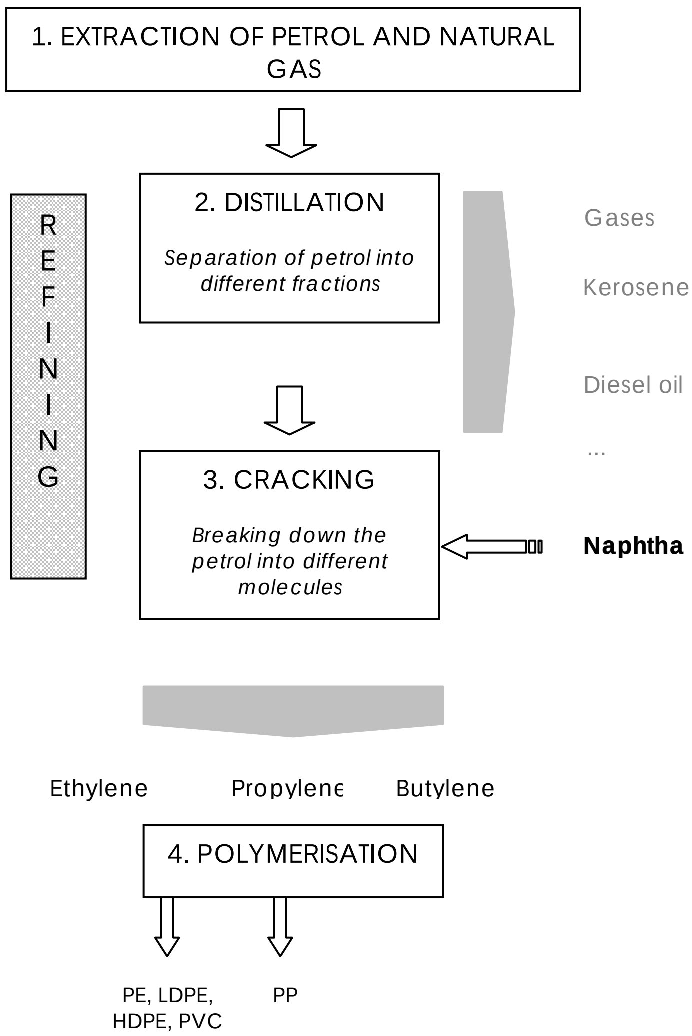
As mentioned above, approximately 4% of the petrol extracted annually is used in the plastic industry. The **extraction** of petrol has direct effects on the areas of supply and also leads to a contamination of the surrounding soil and vegetation because of leaks and spillages. Apart from these effects, large quantities of hydrocarbons and CO_2 and other gases are emitted into the atmosphere in the extraction areas due to the burning of fuel, which contributes to the global warming of the planet.

The **refining and distillation** process for crude oil to make it into raw materials for the plastics industry also leads to emissions into the atmosphere and water of gases, copper oxides and other compounds that pollute the environment. The main processes for transforming petrol into the polymers commonly used for sample placed in laboratories (PEBD, PP and PVC) are shown in Figure 11. The definitions of the processes included follow the figure.

Abbreviations of plastics in the figure:

PE:	Polyethylene
LDPE:	Low Density Polyethylene
HDPE:	High Density Polyethylene
PVC:	Polyvinyl chloride
PP:	Polypropylene

Figure 11: Main phase in the production of plastic polymers



Source: Own research based on data from [15].

Transportation of the crude oil or its byproducts using oil pipelines by sea to areas of refining or consumption also entails a potential risk of environmental impact. Accidents in this type of operations are frequent and cause serious damage to flora, fauna and human health. Examples of these are cases like the Exxon Valdez on the coast of Alaska and the Prestige on the Bay of Biscay coast.

The **treatment as waste** of plastics also has a negative impact when this waste is is deposited in landfills. If their ashes are incinerated, pollutants such as heavy metals accumulate, and these are not volatilised. The incineration of plastics which contain chlorine molecules also leads to the formation of organochlorate compounds such as dioxins and furans, which are classified as carcinogenic by the IARC.

Main processes in the transformation of crude oil into polymers
(Complement to Figure 11)

DEFINITIONS:

Refining: A series of industrial processes used to transform crude oil. The main processes are: distillation, cracking, reforming, isomerisation, alkylation, desulfurisation, viscosity reduction, coking and hydrotreatments.

Distillation: The basic process in a refinery based on the difference in boiling points of the liquids in the mixture to be separated. The lighter products are separated by successive steaming and condensation of the crude oil in a fractioning or distillation tower, leaving a heavier residue.

Naphtha: a light product of petrol refining, with a lower boiling point than kerosene, used as fuel in motor vehicles and as a raw material for the petrochemical industry.

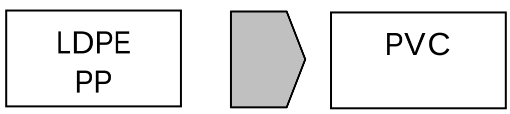
Cracking: A process consisting of breaking down large hydrocarbon molecules into other smaller ones in order to increase the proportion of light and volatile products. When this process takes place only with the application of heat it is called *thermic cracking*. If a catalyst is used it is known as *catalytic cracking*; if carried out in a hydrogen atmosphere it is known as a *hydrocracking process*.

Polymerisation: a chemical process in which the reagents, nonomers, (compounds with a low molecular weight) are grouped together chemically to create a heavy molecule called a polymer, or a linear chain or a three-dimensional macromolecule.

D.4.2. Purchase recommendations

The temporary storage of properly labelled samples makes the use of paper bags possible, although this practice is not widespread. Instead, if plastic bags must be used, priority should be given to those made of LDPE and PP over PVC.

Figure 12: Bag purchasing priorities



Plastics have different permeability or impermeability properties for different substances. As a result, depending on the sample, it will be necessary to choose a certain type of plastic to keep it in perfect condition.

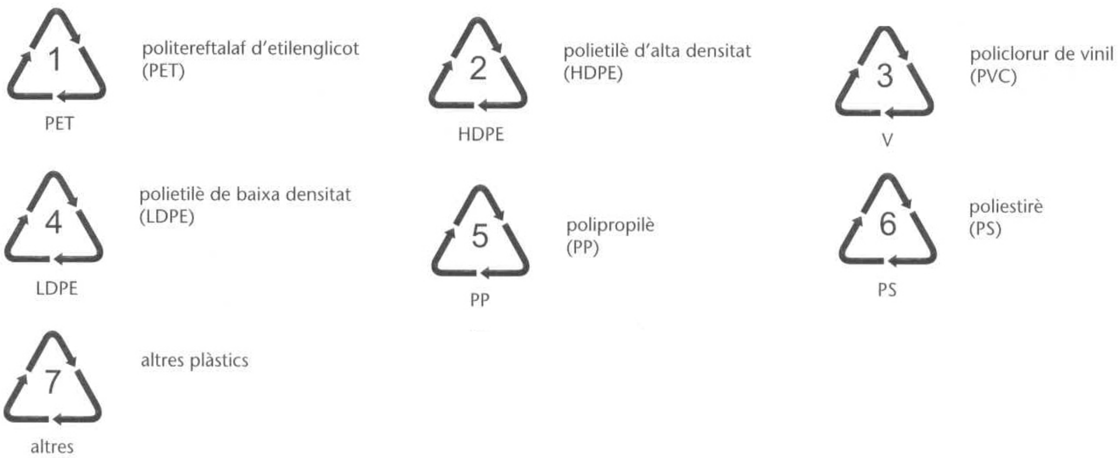
More information can be found in Appendix 3 of this guide.

Despite it not being compulsory, most manufacturers of plastics products use a standard identifying code to distinguish the polymer used (see Figure 13). This makes separation easier in sorting plants and improves the quality of the recycled product.

D.4.3. Recommendations for use

Consumption of both paper and plastic decks should be in moderation. If the experiment permits, it is advisable to reuse them. This will lead to savings on consumption of resources.

Figure 13: Identification of plastics



Source: XTEC, 2006 [23].

D.4.4. Waste management recommendations

Management of sample bags as waste will depend both on the material the bag is made of and the type of sample it contains or has contained. If paper bags have been used to keep samples of non-dangerous solid wastes, they should be deposited in the paper container after emptying.

Plastic bags, if they have not come into contact with dangerous products, should also be deposited in the packages products container. Otherwise, it will be necessary to deposit them in the container for the type of waste they contain, according to the UAB waste classification.

D.5. DETERGENTS OR OTHER CLEANING PRODUCTS

Detergents or other agents with similar properties are used in laboratories to clean glass instruments and leave them in optimum conditions for experimentation.

Detergents are substances with a high cleaning capacity because of two basic chemical properties associated with their composition.

Properties of detergents

- They reduce the surface tension of water, so that water molecules are not attracted to each other, and can penetrate better in the surface to be cleaned (such as a fabric).
- They have a lipophilic pole, which combines well with oils, and a hydrophilic pole, which combines well with water. Dirt - which is attached to fabrics or other materials by means of oily particles - attracts the lipophilic poles, and the hydrophilic poles are positioned towards the outside and circling the dirt, so that the water takes it away.

Source: Options magazine, issue 2 [19]

Generally, when working with aqueous solutions in the laboratory, a conventional dishwasher detergent is used to clean implements, and the process is completed with rinsing in distilled water to remove any possible remains of detergent from the sides. In other cases, however, more aggressive and specific detergents are used, or even prepared solutions to clean the instruments which come into contact with a certain type of product.

D.5.1. The environmental impact of cleaning products

Until the 1930s, detergents were manufactured using natural products, using water, vegetable or animal fats and vegetable ashes or mineral substances such as caustic soda. From the 1930s onwards, detergents derived from petrol began to be synthesised, and later other ingredients were discovered which when added to detergents increased the product's cleaning capacity. Today, when we talk about detergents we refer to them all.

The "active material" or detergent agents in cleaning products may account for between 20 and 35 percent of their volume, according to the level of concentration. Table 6 shows the main ingredients of dishwashing soaps with their function.

Table 6: Main ingredients of dishwashing soaps

INGREDIENT	**FUNCTION**
Anionic surface-active agents	They work mainly on animal and vegetable fats. There are two types: ▪ non-hydrolysable (which irritate the skin). ▪ hydrolysable (with less cleaning capacity than the above, but less irritant).
Non-anionic surface-active agents	These surface-active agents reinforce the action of the anionic agents.
Ampothers	These are the most recent surface-active agents added to the formula and increase the stability of foam in the presence of oils.
Solvents	Increase the fluidity of the dish washing soap and help to eliminate water when rinsing, to prevent calcium deposits. They are usually ethanol or an ethanol-isopropanol mixture.
Colourings and perfumes	These give the detergent smell and colour.

Source: Own research based on information from Consumer magazine [21]

Detergents – both of natural and synthetic origin - affect the behaviour of water in the grammar and therefore have an impact on it. Before the appearance of synthetic detergents, it was found that soap, in very hard water, combined with calcium and left an insoluble film on the surface of the water. In the 1960s, legislation was introduced to limit the amount of foam generated by synthetic detergents.

Today, the most important environmental problems associated with dishwashing detergents are:

The use of surface-active compounds

Because of their ability to reduce the surface tension of water, the presence of surface-active compounds in aquatic environments harms the flora and fauna that live there.

According to current legislation, the word "biodegradable" may appear on a detergent if the surface-active compound no longer has 90 percent of its surface-active properties 28 days after being poured into water.

However, the law says nothing about the other ingredients, which may account for up to 80 percent of the detergent's volume. In conventional detergents, these ingredients are not biodegradable and are toxic to aquatic life (especially petrol by-products). Despite the proliferation of treatment plants, waste is found in sea water.

The use of bactericides

Finally, many detergents and conventional dishwashing liquids contain bactericides, which are of dubious usefulness but which cause problems for aquatic bacterial life. As the manufacturers keep their formulas secret, it is very difficult to know which agents they use.

Apart from these general impacts, there may be others associated with particular substances that are used as additives. Some of these substances are alkylphenoletoxylate (APEO) and its by-products, ethylenediaminetetraacetic acid (EDTA), nitrilotriacetate (NTA), nitromusks and polycyclical musks (used as perfume) and preservatives classified according to the risk phrases R 50/53 of the 67/548/CEE Directive.

D.5.2. Purchase recommendations

When using a conventional detergent to clean instruments, choose a biodegradable one that is phosphate-free. If you cannot find one that is totally phosphate-free, choose one with a maximum content of 2% of the product's weight.

Choose detergents that do not contain EDTA, alkylphenoletoxylate, alkylphenol by-products, nitrilotriacetate or nitromusks . Consult Directive 67/548/CEE and avoid products containing ingredients classified according to the following risk phrases or combinations as additives: R40, R45, R46, R49, R50-53, R51-53, R60, R61, R62, R63, R64, R68.

If you choose a dishwashing liquid with the European ecolabel its compliance with these criteria is guaranteed.

You can find more information about ecological detergents from:

- the EDMA (Association of Ecological Detergent Manufacturers)
- AISE (International Soap, Detergent and Maintenance Products Manufacturers Association) www.aise-net.org
- ADELMA (Association of Detergents and Cleaning, Maintenance and Related Products companies) www.adelma.es

If the instrument is to be cleaned with specific solutions, replace the dangerous cleaning agents with others that give the same result (see the table below).

Table 7: Dangerous cleaning agents and replacement products

Dangerous cleaning agent	Replacement
▪ Chromic-sulphuric acid solutions	▪ Potassium permanganate
▪ Alcoholic potassium hydroxide solutions ▪ Lye (sodium hypochlorite)	▪ Detergents, enzymatic cleaners and acqueous solutions.

Source: GEPL, 2003 (7)

On 8 April 2004, Regulation (CE) no. 648/2004 of the European Parliament and Commission of 31 March 2004 on Detergents was published, aimed at achieving the free circulation of detergents and surface-active agents for detergents in the domestic markets, ensuring a high level of protection for the environment and human health at the same time.

Among the requirements in the Regulation (appendix VII (D)) was the publication of a web page where manufacturers list the ingredients of all the products they sell, ordered from the highest to the lowest concentration. This website must be referred to on the product label and the information must be up to date. While the page is being updated, consumers can ask for the composition by telephone (which must also be specified on the product label).

TABLES SUMMARISING CRITERIA

GLASS INSTRUMENTS (PIPETTES, FLASKS, ETC.)

Curiosities

- The glass mostly used to manufacture laboratory instruments is "brand glass" which has the manufacturer's brand label stamped on it. The most well-known are PYREX™ and DURAN™ (borosilicates).

  These have a low expansion coefficient, are highly resistant to temperature changes and to chemical agents.
- The manufacturers of the most frequently used borosilicates are located in Germany (Schott Duran) and the United States (Corning Pyrex). In Spain, there are blowers who manufacture instruments from glass bars or tubes that these manufacturers provide.
- Glass is a material that does not lose its properties during the recycling process.
- In 2005, 5% of the special chemically contaminated waste collected at the UAB was fragments of contaminated glass.
- Every year, approximately 45,000 Kg of glass are collected selectively at the UAB (this figure includes domestic non-contaminated glassware collected from laboratories).
- Laboratory glass has a clearly defined procedure according to the contamination. If possible, it is preferable to decontaminate the glass and deal with it as normal waste.

How can the environmental impact of using a glass instrument be reduced at UAB?

- Taking care not to damage instruments while using them
- Participating in separate collection and correct management as waste

What to buy?	▪ Glass instruments to meet the laboratory's needs (graduated, resistant to temperature changes, resistant to the action of chemical agents, etc.)

GLASS INSTRUMENTS (PIPETTES, FLASKS, ETC.)	
How should instruments be used correctly?	▪ Following the manufacturer's instructions. For example, do not expose glass instruments to temperatures higher than they can withstand or to chemical agents that they cannot resist. ▪ Handle the instruments with care, in order not to break them. ▪ Asking for the auxiliary parts of the materials (rubber joints for burettes, for example) and not buying the complete appliances. ▪ Others (see the recommendations where more measures are listed)
How should they be managed as waste?	▪ If the glass is contaminated with chemical products and is not broken, place it in the specific container in each laboratory. ▪ If the glass is contaminated with cytostatic products (liquid or solid waste considered carcinogenic, mutagenic or teratogenic), it must be disposed of in a cytostatics container. ▪ If the glass is sharp (pipette points, etc.) or if it is broken and not contaminated, place it in the biorisks container. ▪ Finally, if the glass is intact and not contaminated with chemical products, place it in the conventional glass container (green in separate collection).

Sources of information: own research, [1], [2],[12],[13], ECOCAT (personal communication) and SCHOTT IBERIA (personal communication).

DISPOSABLE GLOVES

Curiosities

- Protective gloves used in the laboratory are manufactured using latex or other materials such as PVC, PVA, nitryl, or neoprene...
- The choice of other material will depend on the agent to be protected against and the sensitivity of the person concerned. You can find information on the chemical resistance of the gloves in appendix 2, from the various manufacturers and/or through the NTP 517 of the Ministry of

How can the environmental impact associated with using disposable gloves be reduced at the UAB?

- Choose the right gloves according to their insulating properties and give priority to materials which have a lower environmental impact.
- Managing them correctly as waste

What to buy?	▪ Select gloves according to their level of insulation from chemical and biological exposure, and give priority to purchasing natural latex gloves, instead of synthetic latex, nitryl and vinyl gloves (in that order of prefernce), if there are no problems with allergy to natural latex. ▪ Gloves without dusting, (talcum powder, corn flour, etc.) ▪ Gloves designed for use on both hands (ambidextrous)
How should they be used correctly?	▪ Before using them, make sure that they are in good condition (holes and other faults). ▪ Before putting them on, your hands should be clean and rings, watches, etc. removed. ▪ If possible, clean them and let them dry so that they can be used again (if this measure does not contradict the laboratory's safety protocols).
How should they be managed as waste?	▪ By placing them in the refuse container (if they are not contaminated with chemical products) or in the special waste container if they are contaminated with a product that is dangerous to health (see section C.4).

Sources of information: Own research, [4],[5, [6], [9],[10] and [11].

INDELIBLE MARKER PENS

Curiosities

- Indelible marker pens contain volatile organic compounds (VOCs) and heavy metals which may cause health problems.
- A single marker pen does not have much of an environmental impact, but as a result of the extensive and continuous use made of them, they should be used rationally.

How can the environmental impact associated with using indelible marker pens can be reduced at the UAB?

- By using marker pens with a lower environmental impact and refillable pens
- Controlling consumption

What to buy?	▪ Ecologically certified marker pens (Cigne Blanc). ▪ Refillable indelible marker pens, and use refills after the ink has run out. ▪ Marker pens that do not contain ink with heavy metals (antimony, arsenic, barium, cadmium, selenium, mercury, lead and chrome VI).
How should marker pens be used correctly?	▪ Share them (leave them somewhere where everyone can find them). That way consumption is minimised and damage to some market pains is prevented (by their tips drying out). ▪ Do not leave the lid off to prevent them from drying out. ▪ Ask for refills when the product has run out instead of asking for new ones.
How should they be managed as waste?	▪ Damaged empty cases should be disposed of in the waste paper bin. This waste will be collected by cleaning staff and managed as refuse. ▪ The packaging (blister packs, cardboard boxes) which the marker pens and refills come with it should be selectively separated and disposed of in the appropriate container.

Sources of information: Own research [3], [4] and [14].

PLASTIC BAGS FOR KEEPING SAMPLES

Curiosities

- Plastic bags are used in many laboratories for keeping samples of solid waste.

How can the environmental impact associated with using bags to keep samples at the UAB be reduced?

- By purchasing more ecological bags
- Reducing consumption
- Managing them correctly as waste

What to buy?	▪ It is best to buy paper, PE or PP bags rather than PVC bags. ▪ Purchase plastic bags with an ecolabel.
How should they be used correctly?	▪ Consumption of bags must be reduced, and they should be used as many times as possible providing that this does not involve possible contamination of samples.
How should they be managed as waste?	▪ Paper bags that have contained non-dangerous solid waste should be disposed of in the paper container. ▪ Plastic bags should be disposed of in the refuse container or packages container (if there is one) if they are not contaminated. ▪ If they are contaminated with a dangerous product, they must be disposed of in the appropriate container (see section C.4).

Sources of information: Own research [4] and [15].

DETERGENTS OR OTHER CLEANING PRODUCTS

Curiosities.

- Detergents are used in the laboratory to clean laboratory instruments and work areas.
- Often, in laboratories that work with acqueous solutions, the detergent used to clean the instruments is a conventional dishwashing detergent.
- In other cases, however, more aggressive and specific detergents are used, or even prepared solutions, depending on the type of chemical products with which the instruments have been in contact.

How can the environmental impact associated with using detergents at the UAB be reduced?

- Purchasing more ecological detergents
- Reducing consumption
- Correct management of the liquid waste generated

What type of detergents or reagents should be used for cleaning an instrument?	▪ If cleaning instruments with chromic-sulphuric acid, replace it with potassium permanganate solutions. ▪ If using alcoholic potassium hydroxide solutions or lye, replace these with detergents, enzymatic cleaners and aqueous solvents. For conventional cleaning, use: ▪ Biodegradable detergents. ▪ Phosphate-free detergents (or with a maximum content of 2% of the product's weight). ▪ Detergents that do not contain EDTA (ethylenediaminetetraacetic acid).
How should they be used?	▪ Both the detergent and the solutions should be used carefully. Buying more ecological detergents does not mean that more of them can be used!
How should the liquid waste generated be managed?	▪ If working with aqueous solutions, the detergent used and the water can be poured straight down the drain. ▪ If using special cleaning solutions, the remains must be disposed of in the appropriate selective collection container for laboratory waste.

Sources of information: Own research, [4], [7],[19],[20],[21] and [22]

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F. FINDING OUT MORE

LABORATORY MANAGEMENT INFORMATION (safety, good environmental practices, waste management, etc.):

- **INSTITUTE OF HEALTH AND SAFETY AT WORK (Ministry of Labour and Social Affairs):** [www.mtas.es/insht/index.htm]
- **SEPMA (UAB):** [www.uab.cat/sepma]

INFORMATION on ECOLABELS (criteria, companies and products):

- **GEN (Global Ecolabelling Network):** [www.gen.gr.jp/]
- **Environmental Quality Guarantee Logo:** [www.gencat.net/mediamb/qamb/distintiu.htm]
- **European Ecolabel:** [www.gencat.net/mediamb/qamb/etiqueta_ue.htm]
- **Blue Angel:**

  [www.blauer-engel.de/englisch/navigation/body_blauer_engel.htm]
- **White Swan:** [www.svanen.nu/Eng/default.asp]
- **Energy Star:** [www.eu-energystar.org/]

APPENDIX 1: STANDADARD SAFETY PICTOGRAMS FOR GLOVES

a b c d

Riesgos mecánicos EN 388

		Niveles de prestación 1	2	3	4	5
a Resistencia a la abrasión	En número de ciclos	100	500	2000	8000	–
b Resistencia al corte por cuchilla	Índice	1,2	2,5	5,0	10,0	20,0
c Resistencia al rasgado	En Newtons	10	25	50	75	–
d Resistencia a la perforación	En Newtons	20	60	100	150	–

Corte por impacto EN 388

Una sola prueba de corte por impacto de una masa de 1050 g lanzada a una altura de 150 mm — Resultado: todo o nada

Electricidad estática EN 388

Reducción del riesgo de generar una descarga de electricidad estática — Resultado: umbral de resistividad volúmina comprendida entre 10^6 y 10^9 Ω cm

a b c

Riesgos por frío EN 511

		1	2	3	4	5
a Resistencia al frío convectivo	Aislamiento térmico (ITR) en m². °C/W	≥0,10	≥0,15	≥0,22	≥0,30	–
b Resistencia al frio de contacto	Resistencia térmica (R) en m². °C/W	≥0,025	≥0,050	≥0,100	≥0,150	–
c Impermeabilidad al agua	Nivel 1: impermeable como mínimo 30 minutos	≥30'	–	–	–	–

abcdef

Calor y/o fuego EN 407

		1	2	3	4	5
a Comportamiento a la llama	Tiempo Post incandescencia (s)	Sin requisito	≤120"	≤25"	≤5"	–
	Tiempo Post inflamación (s)	≤20"	≤10"	≤3"	≤2	–
b Resistencia calor de contacto	≥15 segundos a	100°C	250°C	350°C	500°C	–
c Resistencia al calor convectivo	Tiempo transmisión de calor	≥4"	≥7"	≥10"	≥18"	–
d Resistencia al calor radiante	Tiempo transmisión de calor	≥5"	≥30"	≥90"	≥150"	–
e Resistencia a pequeñas salpicaduras de metal fundido	Número de gotas necesarias para obtener una elevación de tª de 40°C	≥5	≥15	≥25	≥35	–
f Resistencia a grandes masas de metal fundido	Gramos de hierro fundido necesaria para provocar una quemazón superficial	≥30	≥60	≥120	≥200	–

Radiación ionizante y/o contaminación radiactiva EN 421

El guante debe pasar la prueba de estanqueidad y someterse a varios ensayos específicos según su uso.

Riesgos por microorganismos EN 374 -1,2

Índice de penetración (prueba de fuga de aire) — Resultado: Pasa o no pasa.

Riesgos químicos EN 374 -1,2,3

Índice de penetración (prueba de fuga de aire) — Resultado: Pasa o no pasa.

	Clase 1	Clase 2	Clase 3	Clase 4	Clase 5	Clase 6
Índice de permeabilidad (tiempo en minutos que tarda un producto químico en penetrar en el guante)	>10'	>30'	>60'	>120'	>240'	>480'

Source: Scharlab, 2006.

APPENDIX 2. CHEMICAL RESISTANCE OF GLOVES.

CHEMICAL COMPOUND	COMPOSITION OF THE GLOVES					
	Natural rubber or latex	**Neoprene**	**Buta-n (nitrile)**	**Butyl**	**PVC**	**PVA**
Inorganic acids						
Chromic acid	B	F	F	G	G	B
Hydrochloric acid 38%	G	E	G	G	E	B
Fluorhydric acid 48%	G	E	G	G	G	B
Phosphoric acid	G	E	G	G	G	B
Nitric acid 70%	B	G	I	G	F	B
Smoking nitric acid (Red eyes)	NC	I	I	NC	I	B
Smoking nitric acid (Yellow smoke)	NC	I	I	NC	I	B
Sulphuric acid 95%	E	E	F	G	F	B
Organic acids						
Acetic acid	E	E	G	G	G	B
Formic acid	E	E	F	G	E	I
Alcohols						
Butylic alcohol	E	E	G	G	G	F
Ethyl alcohol	E	E	G	G	G	F
Methyl alcohol	E	E	G	G	G	F
Acetaldehyde	G	E	G	G	G	F
Benzaldehyde	F	F	F	G	F	G
Formaldehyde	E	E	G	G	G	I
Caustic agents						
Ammonium hydroxide	E	E	G	G	E	B
50% potassium hydroxide	E	E	G	G	G	B
50% sodium hydroxide	E	E	G	G	G	B
Amines						
Aniline	F	F	G	G	G	F
Diethylamine	F	G	E	NC	F	F
Hydrazine	G	F	G	NC	G	B

CHEMICAL COMPOUND	COMPOSITION OF GLOVES					
	Natural rubber or latex	**Neoprene**	**Buta-n (nitrile)**	**Butyl**	**PVC**	**PVA**
Aromatic solvents						
Benzole	B	L	G	NC	L	E
Soft coal tar distillates	B	F	G	NC	F	E
Styrene	B	F	G	NC	L	E
Toluene	B	B	E	B	G	E
Xylene	B	L	G	F	B	E
Acetone solvents						
Acetone	E	G	L	G	L	F
Methyl ethyl ketone	E	G	F	G	B	E
Methyl isobutyl ketone	E	G	F	G	B	E
Chlorate solvents						
Chloroform	B	G	G	F	B	E
Methyl chloride	F	G	G	NC	B	E
Percloro ethylene	B	B	G	B	B	E
Carbon tetrachloride	B	F	G	B	F	E
Trichloroethylene t.c.e	B	G	G	NC	B	E
Petrol by-product solvents						
Hexane	B	F	E	NC	F	E
Kerosene	B	G	E	B	F	E
Pentane	F	G	E	B	B	E
Various solvents						
Ethyl acetate	L	G	G	G	B	L
Propyl acetate	G	G	G	G	L	G
Acronitrile	G	G	F	G	L	E
Methyl bromide	F	G	G	NC	B	E
Paint solvents	F	G	G	NC	F	E
Freon 11, 12, 21, 22	B	G	L	NC	F	E

CHEMICAL COMPOUND	COMPOSITION OF THE GLOVES					
	Natural rubber or latex	**Neoprene**	**Buta-n (nitrile)**	**Butyl**	**PVC**	**PVA**
Other products						
Cutting oil	I	E	G	B	G	F
Electrolytic baths	E	E	G	I	E	B
Wood varnish (tung oil)	B	G	G	NC	F	E
Paint and varnish strippers	F	G	G	NC	B	G
Toluene disocyanate	G	F	G	NC	B	G
Carbon disulphide	B	F	G	B	F	E
Ethylene glycol	E	E	G	G	G	G
Glycerine	E	G	G	G	E	F
Animal fats	E	G	G	NC	G	E
Hydrogen peroxide 50% (oxygenated water)	G	G	G	G	F	I
Epoxy resins	E	E	G	G	E	E
Printer inks	G	E	E	NC	L	E
Trinitrotoluene	G	G	G	G	E	E
White spirit	B	G	E	B	G	E

E =Excellent L=Low

G=Good B=Bad

F=Fair NC=Not confirmed

Source: NTP 517 of the Ministry of Labour and Social Affairs

APPENDIX 3. PHYSICAL PROPERTIES OF PLASTICS.

Plastic codes:

LDPE: Low density polyethylene

HDPE: High Density Polyethylene

PP: Polypropylene

PPCO: Polypropylene copolymer

PMP: Polymethylpentene

PETG: Terephtalate polyethylene copolyester

FEP: Teflon FEP (ethylene fluoride propylene)

TFE: Teflon TFE (tetrafluoroethylene)

PFA: Teflon PFA (perfluoroalcohoxyl)

ECTFE: Ethylenchlortrifluorethylene copolymer

ETFE: Tefzel ETFE (ethylene-tetraflour-ethylene)

PC: Polycarbonate

PVC: Vinyl polychloride

PSF: Polysulphone

PS: Polystyrene

PVDF: Polyvinyl fluoride

TMX: Thermanox

PMX: Permanox

	Temp. máx. de uso (°C)	Temp. HDT (°C)	Temp. fragilidad (°C)	Transpa-rencia	Capac. microondas	Esterilización					Gravedad espec.	Flexi-bilidad	Permeabilidad			Absorción de agua (%)	Cito-tóxico	Adecuado para uso con alimentos y bebidas Según Reg. Parte 21	
						Auto-clave 121°	Gas OEt	Calor seco 160°	Radia-ción Gamma	Desinfec-tantes			N2	O2	CO2				
ETFE	150	104	-105	Translúcido	Si	Si	Si	Si	Si	Si	1,7	rígida	30	100	250	0,03	No	Si	--
ECTFE	150	115	-105	Translúcido	Si	Si	Si	Si	No	Si	1,69	rígida	10	25	110	0,01	No	Si	--
FEP	205	158	-270	Translúcido	Marginal	Si	Si	Si	No	Si	2,15	Excelente	320	750	2200	<0,01	No	Si	177,1550
HDPE	120	65	-100	Translúcido	No	No	Si	No	Si	Si	0,95	rígida	42	185	580	<0,01	No	Si	177,1520
LDPE	80	45	-100	Translúcido	Si	No	Si	No	Si	Si	0,92	Excelente	180	500	270	<0,01	No	Si	177,1520
PC	135	138	-135	Claro	Marginal	Si	Si	No	Si	Si	1,2	rígida	50	300	1075	0,35	No	Si	177,1580
PEI	170	210	--	Ambar Transp.	Si	Si	Si	--	Si	Si	1,27	rígida	18,6	37	171,3	0,25	--	Si	177,1595
PETG	70	70	-40	Claro	Si	No	Si	No	Si	Si	1,27	Moderada	10	25	80	0,15	No	Si	177,1315
PFA	250	166	-270	Translúcido	Si	Si	Si	Si	No	Si	2,15	rígida	291	881	2260	<0,03	No	No	--
PK	220	218	-40	Opaco	Si	Si	Si	--	Si	Algunos	1,24	rígida	--	0,2	1,6	0,45	--	--	--
PMMA	50	93	20	Claro	No	Si	No	Si	Si	Algunos	1,2	rígida	--	--	20	0,35	No	--	--
PMP	175	85	20	Claro	Si	Si	Si	Si	No	Si	0,83	rígida	1100	4500	--	0,01	No	Si	177,1520
PP	135	107	0	Translúcido	Si	Si	Si	No	No	Si	0,9	rígida	48	240	800	<0,02	No	Si	177,1520
PPCO	121	90	-40	Translúcido	Marginal	Si	Si	No	No	Si	0,9	Moderada	45	200	650	<0,02	No	Si	177,1520
PPO	100	149	-170	Opaco	--	Si	--	No	Si	No	1,06	rígida	--	1000	--	0,06	--	Si	177,2460
PS	90	105	20	Claro	No	No	Si	No	Si	Algunos	1,05	rígida	55	300	1150	0,05	No	Si	177,1640
PSF	165	174	-100	Claro	Si	Si	Si	Si	Si	Si	1,24	rígida	55	300	700	0,3	No	Si	177,1655
PUR	82	<23	-70	Claro	No	No	Si	No	Si	Si	1,2	Excelente	41-119	75-327	450-1650	0,03	No	--	--
PVC (rígido)	70	90	-30	Claro	Si	No	Si	No	No	Si	1,34	rígida	1-10	4-30	4-50	0,15-0,75	No	Si	--
PVC (manguera)	82	-32	-32	Claro	Si	Si	Si	No	No	Si	1,34	Excelente	--	100-1400	20-12000	0,15-0,75	No	Si	--
PVDF	150	139	-62	Translúcido	--	Si	Si	No	No	Si	1,75	rígida	914	14	505	0,05	No	Si	177,2510
SAN	93	104	20	Claro	--	No	Si	No	--	No	1,08	rígida	--	--	--	0,2	-	--	--
Silicona	200	-46	-117	Translúcido	--	Si	Si	--	Si	Si	1,15	Excelente	4300	123000	312000	0,1	No	Si	177,2600
TPE	121	<23	<-50	Opaco	Si	Si	Si	No	--	Algunos	0,9	Excelente	31-145	85-646	900-8634	0,1-0,042	No	--	--
TFE	260	200	-100	Opaco	Si	Si	Si	Si	No	Si	2,20	rígida	--	--	--	<0,01	No	--	--
XLPE	65	59	-118	Translúcido	No	No	Si	No	Si	Si	0,93	rígida	--	--	--	<0,01	No	--	--
Permanox	180	85	-10	Transparente	Si	Si	Si	Si	No	Si	0,84	rígida	--	--	--	<0,01	--	--	--
Thermanox	150	75	-60	Transparente	--	No	Si	No	Si	Algunos	1,30	Moderada	0,7-1,0	3-6	15-25	0,25	--	--	--

Temperatura HDT: Es a la cual una barra del material plástico correspondiente se deforma 0,01 pulgada a 66 PSI (ASTM D648). No obstante el material puede seguir usándose, pero sólo para aplicaciones sin tensión.

Font: Catàleg AFORA, 2006.

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