

Review

# A Comprehensive Guide to Textile Process Laboratories: Risks, Hazards, Preservation Care, and Safety Protocol

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**Abstract:** Textile chemistry and textile processing laboratories are essential environments for textile product research and development, but they also pose hazards that require rigorous precautions. Among the most common risks is handling chemicals used in the textile industry, such as dyes, solvents, and finishing chemicals, which can be contaminants, corrosive, and flammable, presenting risks of poisoning and fire. Textile processing laboratories also require proper ventilation, as a lack of appropriate ventilation in these environments can accumulate toxic vapors in the air. The most relevant risks and hazards of using textile chemistry laboratories include using equipment such as dyeing autoclaves under pressure and high temperature; drying ovens like furnaces/lab stenters; cylinders of squeezing, calenders, and others, capable of causing severe accidents. These laboratories also generate or handle solid waste and effluents containing, heavy metals to pathogens (e.g., from industrial sludge). It is essential to adopt rigorous safety measures in textile chemistry laboratories, including using personal protective equipment (PPE), proper training of workers, effective ventilation systems, and safe waste disposal protocols. Good laboratory work practices not only reduce risk but also promote better research; more accurate results; and better data. Therefore, this study aimed to map the risks and hazards of textile processing laboratories with a view to accident prevention and formalizing a protocol for good practices.

**Keywords:** laboratory safety; textile laboratories; textile chemistry; accidents prevention; risks and hazards



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## 1. Introduction

Textile laboratories play a fundamental role in the fashion industry and in developing innovative materials. These spaces are dedicated to research, development, and quality testing of textile products, ranging from fiber analysis and chemical inputs to clothing items, and others. Despite their great importance and functionality, textile laboratories also present a series of issues that must be properly managed to guarantee the safety of workers, the quality of products, and the preservation of the environment through the correct disposal of waste [1]. Textile laboratories present a series of risks and hazards inherent to the activities carried out in these spaces. Some of the main risks include chemicals, accidents with equipment, fires, explosions, and particles suspended in the air. Textile laboratories often work with a variety of chemicals, which include dyes, solvents, auxiliary chemicals, and other reagents [2]. Inadequate exposure to these substances can result in health consequences for workers.

Risks and hazards in textile laboratories can be categorized into several key areas, including chemical risks, physical risks, biological risks, and ergonomic risks. Chemical risks refer to exposure to toxic, irritating, and flammable chemicals used [3]. Physical risks include fires, explosions, electromagnetic radiation, and noise. Biological risks are related to exposure to microorganisms, such as bacteria and fungi, present in effluent and activated sludge samples and can grow in moist substrates. Ergonomic risks are related to working conditions that can lead to musculoskeletal injuries due to inadequate postures and repetitive movements. Preservation care in textile laboratories is also essential to maintain the integrity of samples and equipment [4]. Textile samples can be sensitive to moisture, light, heat, and atmospheric pollutants. Inadequate preservation can lead to sample degradation and unreliable results [5]. Furthermore, laboratory equipment, much of which is expensive and delicate, needs to be regularly maintained and calibrated to ensure its proper functioning [4].

Implementing effective safety protocols is essential to minimize risks and hazards in textile laboratories. It involves appropriately educating and training employees, using personal protective equipment (PPE), creating standard operating procedures (SOPs), and maintaining a clean and organized work environment [6]. Chemical and biological waste management also plays a critical role in reducing laboratory risks. ISO 45001 is the international standard that deals with occupational health and safety management systems and is an essential reference for creating safety protocols in laboratories, as well as in other work environments [6,7]. It provides guidelines and requirements for establishing, implementing, and maintaining effective occupational health and safety management systems.

Although not exclusively aimed at laboratories, ISO 45001 is a relevant standard for safety management in all work environments, including laboratories [6,7]. Organizations seeking to improve occupational safety can implement the principles of ISO 45001 to establish effective safety protocols. Adopting ISO 45001 helps ensure that textile laboratories comply with local and international occupational health and safety regulations [6]. It not only maintains the legality of operations but also demonstrates a commitment to the safety and health of workers.

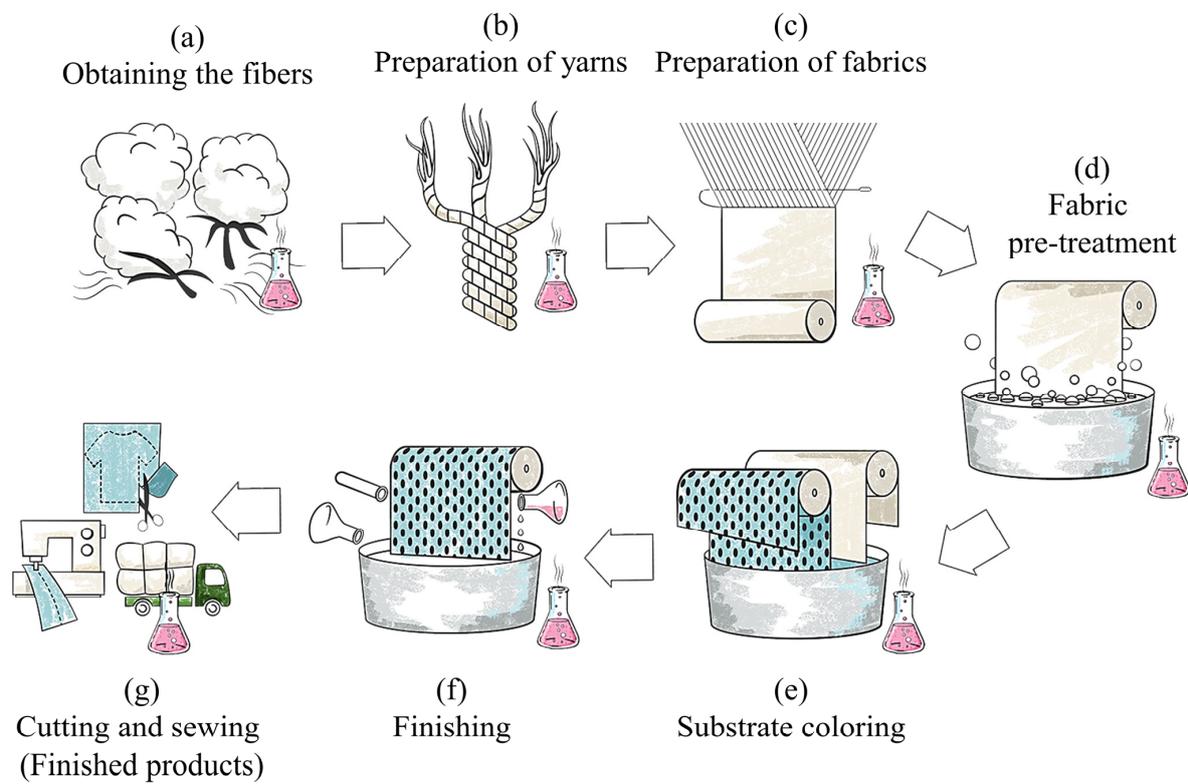
In this context, the present work sought to explore the risks and dangers associated with textile chemistry laboratories, as well as the preservation precautions and safety protocols necessary to mitigate these risks.

## 2. Textile Laboratories

Every product considered textile has textile fibers as its fundamental raw material, which, during industrial processes, are transformed into yarns and fabrics, which ultimately produce finished products for the most diverse applications [8]. The textile industry is a very complex manufacturing segment comprising many production stages [3]. Figure 1 shows a simplified illustrative scheme of the conventional textile manufacturing chain. All stages of textile production, from fiber extraction/manufacturing to product manufacturing, have quality and process control mechanisms [3,8]. Some of these mechanisms are the investigation of the quality of the raw material that feeds the production and the characteristics of the manufactured product, intending to ensure that they fulfill their functionality and meet customer requirements in terms of quality, aesthetics, and comfort [9].

Throughout its evolution, the textile industry has understood the need to establish analysis standards to certify the quality of its products, with many of these standards being converted into international standards. As a result, each segment of the textile chain organized places to carry out specific tests and analyses, intending to ensure the quality of their outputs [2]. In this way, the following process, upon receiving its raw material, which is the product of the previous process, jointly receives a report that assures the customer and supplier the guarantee that the material supplied does not cause quality problems in subsequent processes [2,3]. A simple example is a spinning mill that produces yarn and supplies these yarns as raw material to a weaving factory. In this case, the spinning mill

must provide a report with the physical characteristics and mechanical properties of the batch of yarn received by the weaving factory.



**Figure 1.** Simplified illustrative diagram of the main production stages of a conventional textile manufacturing chain. (a) Fibers are obtained according to their origin, i.e., natural, or manufactured fibers (regenerated or synthetic). Unlike cotton, wool fibers require mechanical and chemical cleaning before making yarn. (b) Yarn preparation occurs in staple fiber spinning processes or continuous spinning processes (manufactured fibers). (c) The preparation of knitted and woven fabrics occurs in the knitting and weaving processes. (d) Cleaning of substrates includes mechanical cleaning and chemical pre-treatment processes for yarns and fabrics for coloring processes. (e) Coloring processes include the different types of dyeing and printing processes with dyes and pigments through dry and wet chemical processes. (f) The finishing process includes finishing steps to make fabrics softer, more comfortable, functional, and suitable for cutting and sewing. (g) The sewing processes can be followed by laundry processes and finishing of the manufactured item, which will depend on the type of product, before shipping.

The analyses of different raw materials and textile products are carried out in textile laboratories. Textile laboratories have specific equipment that follows specific standards and requires specialized technical labor. Textile laboratories form a large group of laboratories that perform destructive and non-destructive techniques on textile samples based on physical, chemical, physicochemical, and mechanical tests [10]. Most analyses carried out in textile laboratories provide qualitative and quantitative results, almost always aimed at determining the quality of the finished product. Some textile laboratories are focused on research, and in these cases, the analyses are almost always aimed at developing and investigating the characteristics and properties of new materials [10]. Most of the different types of textile laboratories are found within the industries themselves, especially those considered large [2]. There are also private textile analysis laboratories that outsource reports to smaller industries, which do not have their own laboratory because some equipment is costly, which makes its acquisition unfeasible for small production volumes.

### 3. Types of Laboratories: Risks, Hazards, Preservation, and Safety Precautions

This work focuses on a generic approach to risks, dangers, preservation care, and safety in textile laboratory environments. As previously explained, there are many types of textile laboratories. For this reason, this work presents a quick discussion on most of them, emphasizing textile chemistry laboratories, considered the highest risk due to high temperatures, high pressure, and chemical products for carrying out textile tests.

#### 3.1. Laboratory for the Analysis and Classification of Cotton Fibers

Around 80% of the natural fibers still used by humans are cotton, making it a fiber widely produced and sold worldwide. After harvesting, cotton fibers undergo a cleaning and preparation process for spinning. The fiber preparation process consists of removing plant materials, such as leaf and twig residues, and extracting the seeds through the ginning process [9]. Once the fibers are clean and ready to be baled and sold to spinning companies, they are subjected to analysis and classification [2]. Fiber classification includes several quality parameters, such as micronaire, fineness, maturity, color, resistance, length, and sugar index, among others. Based on these parameters, the fiber is classified and can be priced for trade. The analyses mentioned above take place on equipment specially designed for cotton classification [8]. At this stage, the tests are exclusively physical and mechanical, occurring with minimal interference from the laboratory technician, guaranteeing a high degree of comfort and operational safety. Therefore, this type of laboratory and its analysis are not the focus of this work.

#### 3.2. Laboratory for Quality Control of Raw Yarn

During the spinning process, as batches of yarn are produced, a series of quality analyses of the produced yarn are conducted by the spinning. Parameters such as elongation, mechanical strength, number of twists per unit of measurement, yarn count (yarn thickness), and pilling index, among others, are assessed [2,9]. The report with the analysis results is used for pricing the yarn and facilitating its trade. At this stage, the tests are exclusively physical and mechanical, occurring with minimal interference from the laboratory technician, ensuring a high degree of comfort and operational safety. Therefore, this type of laboratory and its analyses are not the focus of this work.

#### 3.3. Laboratory for Quality Control of Raw Fabric

In the weaving processes, fabrics are manufactured using yarns purchased from spinning. Depending on their type, pattern, weight, and yarn type, fabrics can exhibit particular characteristics and properties [9]. These characteristics are verified during the weaving/knitting process to ensure that the fabric in production meets the specifications of the final product. Some quality parameters are also necessary at this stage of textile manufacturing, such as shrinkage percentages, twist, mechanical strength, weight, stitch opening, and density, among others [2,9]. Once the fabrics meet the prerequisites of the technical sheet, they can be priced and marketed or proceed to the next production stages, which include cleaning, dyeing, and finishing. At this stage, the tests are exclusively physical and mechanical, occurring with minimal interference from the laboratory technician, ensuring a high degree of comfort and operational safety. Therefore, this type of laboratory and its analyses are not the focus of this work.

#### 3.4. Laboratory for Quality Control of Finished Yarns and Fabrics

After the finishing process, which includes preparation, dyeing and/or printing, and finishing, the fabrics are ready for the cutting and sewing stages [5,11]. However, the finished fabric needs to meet quite strict quality requirements, such as colorfastness tests (to light, heat, washing, chlorine, and others), validation tests for functional finishing, mechanical strength, elongation, weight, shrinkage, twist, and others [2]. Some of these tests are quite simple physical and mechanical tests, while others are relatively simple

chemical tests that do not involve the use of hazardous substances [5]. Therefore, this type of laboratory and its analyses are not the focus of this work.

### 3.5. Textile Chemistry Laboratories

The handling of chemical products is inherent to textile chemistry laboratories, where they are applied, from developing recipes for dyeing yarns and fabrics to new finishes capable of improving the fiber properties or giving them new functionalities [12]. However, exposure to certain chemicals can pose significant health risks to laboratory workers if adequate precautions are not taken. These risks include skin irritation, respiratory problems, and even exposure to potentially carcinogenic substances [13]. Due to the presence of solvents and other flammable chemicals in textile chemistry laboratories, the risk of fire and explosions is also a constant concern. Furthermore, the combustion of textile materials can be rapid and highly hazardous, requiring specific safety protocols [9]. Due to the above reasons, textile chemistry laboratories can be considered those with the most significant risk and hazard concerning the others.

#### 3.5.1. Laboratory for Developing Colors and Textile Finishes

Textile ennoblement laboratories are generally installed in manufacturing units where cleaning, dyeing, and finishing operations of fibers, yarns, and fabrics are carried out. The inputs and equipment used in these locations are particular for processing these materials. Each type of fiber, depending on its origin (plant, animal, regenerated polymer, or synthetic) and chemical composition, needs to be treated with different inputs and temperatures [8]. Inadequate choice of inputs and process parameters can result in ineffective cleaning or dyeing or even, in more severe cases, in partial or complete degradation of the fibers. The structures of textile substrates also affect the choice of processing machinery. That is, the processing of loose fibers, yarns, and fabrics must occur in equipment suitable for these materials [8]. The use of inadequate equipment results in process errors, such as quality defects or loss of the substrate. On all occasions, to prepare process recipes, which are later delivered to the production environment, laboratory workers need to test and develop the process on a laboratory scale, carrying out preliminary tests that ensure reproducibility and the expected result [9]. Therefore, the same inputs, generally fed directly into production machines by automated systems, are handled daily in small quantities by laboratory workers who develop process recipes, which exposes them to daily and constant risks of poisoning [5].

During the textile ennoblement process, the substrates first go through the pre-treatment stage. In this phase, the substrates are cleaned of natural dirt and dirt added in previous processes, which can harm the subsequent coloring and finishing phases [3]. Pre-treatment processes include desizing, scouring, and bleaching. In some cases, to improve the visual appearance of some fabrics and make them more absorbent and resistant, an optional mercerization process can be carried out [3]. In these cases, for each type of substrate and fibrous composition, the laboratory technician develops a recipe containing the inputs and process parameters (concentrations, temperature, time, and pressure) [5]. Table 1 summarizes the main inputs commonly used in pre-treatment processes, the risks and dangers of their use, safety precautions, and recommended PPE.

After the pre-treatment processes, the textile substrates become suitable for the coloring processes, such as dyeing and printing [3]. Dyeing processes impart color to substrates by reacting fibers with coloring organic compounds, such as dyes. Each fiber, according to its origin and chemical composition, has particular characteristics that require specific process conditions [8]. Furthermore, each type of fiber or fibrous mixture has a class of dyes capable of chemically reacting with them under particular conditions.

**Table 1.** Chemical inputs most used in the pre-treatment processes of textile substrates, their risks, hazards, and prevention measures.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Surfactants <sup>a,b,d,f,g,h</sup> (commercial product)	-		Direct contact with hands and eyes due to non-use of PPE.		
Wetting agent <sup>c,d,e,h,i</sup> (commercial product)	-	Due to its hidden commercial formulation, it is not possible to define the specific hazards of this substance.	Direct contact through splashes, transport, and leaks due to inattention.		[14,15]
Enzymes <sup>c,e</sup> (commercial product)	-		Contamination due to lack of training.	Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat.	
			Contact with moisture or water may generate sufficient heat to ignite combustible materials.	Always transport the container closed.	
			Fire and explosion on contact with incompatible substances.	Always carry out collections in a fume hood with exhaustion.	
			Fire and spread of flames due to incorrect storage.	Close containers immediately after use.	
			It reacts violently with acid and is corrosive to metals such as aluminum, tin, lead, and zinc.	Read the product safety information sheets before use.	
Sodium hydroxide <sup>a,b,d,f,g,h</sup> (Caustic Soda)	1310-73-2	Direct contact can cause burns, and deep ulceration can destroy tissue. Inhalation of dust may seriously affect the lungs. Ingestion causes severe tissue damage. Redness, pain, blurred vision, severe burns, blisters, cough, shortness of breath, nausea, vomiting, shock, or collapse.	Contact with moisture and water generates heat. Reacts with ammonium salts, releasing ammonia. Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging. Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Exposure to toxic vapors due to inadequate mixing with other incompatible substances. Contamination due to lack of training and alert regarding the toxic potential of the substance.	Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols. In case of leakage, consult the safety data sheet, avoid direct contact, and use appropriate collection and cleaning tools and PPE. Maintain maximum attention when using and handling the product. Maintain appropriate storage conditions, such as position, temperature, and light. Maintain control of expiration dates and avoid cross-contamination between products due to the use of contaminated glassware.	[14–18]

Table 1. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Sodium carbonate a,b,d,f,g,h	497-19-8	Concentrated solutions tend to produce local necrosis of mucous membranes. Ingestion of large quantities may produce corrosion of the gastrointestinal tract, vomiting, diarrhea, circulatory collapse, and even death. Exposure to dusts of sodium and potassium carbonate may cause dermal necrosis, corneal opacity, and irritation of the mucous membranes with subsequent coughing and shortness of breath.	Contact with moisture and water generates heat. Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Exposure to toxic vapors due to inadequate mixing with other incompatible substances.	Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat. Always transport the container closed. Close containers immediately after use. Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols. Maintain maximum attention when using and handling the product.	[14,17,18]
Magnesium sulfate <sup>b</sup>	7487-88-9	If inhaled, it can cause severe coughing. Redness and irritation of the eyes. If ingested, it can cause severe abdominal pain, diarrhea, and vomiting.	Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention.		[18]
Hydrogen peroxide b,f,i	7722-84-1	Hydrogen peroxide has moderate acute toxicity from oral exposure, which can cause lethargy, immobility, irregular respiration, hunched posture, gross changes in the tongue, esophagus, stomach, and duodenum, and adhesions in the peritoneal cavity. Moderate toxicity from inhalation exposure, and low acute toxicity from dermal exposure. The chemical can be corrosive to the skin and eyes depending on the concentration and contact time and is a respiratory irritant.	It may react violently with acids and is corrosive to some metals. Reacts with ammonium salts, releasing ammonia. Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Exposure to toxic vapors due to inadequate mixing with other incompatible substances. Exposure to volatile toxicants due to handling chemicals in an unventilated location.	Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat. Always transport the container closed. Close containers immediately after use. Read the product safety information sheets before use. Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols. In case of leakage, consult the safety data sheet, avoid direct contact, and use appropriate collection and cleaning tools and PPE. Maintain maximum attention when using and handling the product.	[15,16,18]
Sodium persulfate <sup>b</sup>	7775-27-1	The persulfate salts can cause combustible materials to ignite, increasing the intensity of a fire. They are incompatible with acids, alkalis, and halides. Explosion hazard when mixed with finely powdered organic matter, metal powder (particularly aluminum plus water), sodium peroxide, or reducing agents. It is classified as harmful via the oral route. It is irritating to the eyes, to the respiratory system, and the skin.		Maintain appropriate storage conditions, such as position, temperature, and light. Maintain control of expiration dates and avoid cross-contamination between products due to the use of contaminated glassware.	[17,18]

Table 1. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Sodium silicate <sup>b,i</sup>	1344-09-8	Harmful if swallowed. It causes severe skin burns and serious eye damage.			[18]
Sodium sulfite <sup>b,d</sup>	7757-83-7	Harmful if swallowed. It may cause allergy or asthma symptoms or breathing difficulties if inhaled, such as cough, and sore throat. It may cause an allergic skin reaction. Harmful to aquatic life.		Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat. Always transport the container closed. Close containers immediately after use. Read the product safety information sheets before use.	[18]
Acetic acid <sup>a,b,c,e,f,h</sup>	64-19-7	Corrosive to the eyes, the skin, and the respiratory tract. Inhalation of vapor and/or fumes may cause shortness of breath (lung edema). Severe toxic effects occur with prolonged exposure (~ 60 min) to concentrations above 200 ppm. Severe cases can be fatal.	Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Contamination due to lack of training. Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging.	Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols. In case of leakage, consult the safety data sheet, avoid direct contact, and use appropriate collection and cleaning tools and PPE. Maintain maximum attention when using and handling the product.	[14,15,18]
Formic acid <sup>f</sup>	64-18-6	Corrosive on ingestion, which can cause sore throat, cough, burning sensation, shortness of breath, labored breathing, abdominal cramps, vomiting, diarrhea, blurred vision, and unconsciousness. The substance can be absorbed into the body by inhalation of its vapor, through the skin, and by ingestion. It is very corrosive to the eyes, skin, and respiratory tract. Inhalation of the vapor may cause lung edema, and severe deep burns.		Maintain appropriate storage conditions, such as position, temperature, and light. Maintain control of expiration dates and avoid cross-contamination between products due to the use of contaminated glassware.	[17,18]

Table 1. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Ammonium hydroxide <sup>h</sup>	1336-21-6	The substance can be absorbed into the body by inhalation of its aerosol or vapor and by ingestion. It is corrosive to the eyes, skin, and respiratory tract. Corrosive on ingestion. Inhalation of high vapor concentrations may cause laryngeal edema, inflammation of the respiratory tract and pneumonia. Exposure could cause asphyxiation due to swelling in the throat. Harmful air contamination can be reached very quickly on evaporation of this substance at 20 °C. Effects of long-term or repeated exposure. Repeated or prolonged inhalation may cause lung sequelae.	<p>Fire and explosion on contact with incompatible substances.</p> <p>It is corrosive to some metals.</p> <p>Reacts with some acids, releasing ammonia.</p> <p>Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging.</p> <p>Direct contact with hands and eyes due to non-use of PPE.</p> <p>Direct contact through splashes, transport, and leaks due to inattention.</p> <p>Exposure to toxic vapors due to inadequate mixing with other incompatible substances.</p> <p>Contamination due to lack of training and alert regarding the toxic potential of the substance.</p>	<p>Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat.</p> <p>Always transport the container closed.</p> <p>Always carry out collections in a fume hood with exhaustion.</p> <p>Close containers immediately after use.</p> <p>Read the product safety information sheets before use.</p> <p>Do not make direct contact with the chemical product.</p> <p>Follow laboratory safety and emergency protocols.</p> <p>In case of leakage, consult the safety data sheet, avoid direct contact, and use appropriate collection and cleaning tools and PPE.</p> <p>Maintain maximum attention when using and handling the product.</p> <p>Maintain appropriate storage conditions, such as position, temperature, and light.</p> <p>Maintain control of expiration dates and avoid cross-contamination between products due to using contaminated glassware.</p>	[15,16,18]

Table 1. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Sulfuric acid <sup>a</sup>	7664-93-9	Extremely irritative, corrosive, and toxic to tissues. Repeated contact with dilute solutions can cause dermatitis. Repeated or prolonged inhalation can cause inflammation of the upper respiratory tract, leading to chronic bronchitis. Workers gradually lose their sensitivity to low concentrations. Eye, nose, and throat irritation; anuria; bronchitis; conjunctivitis; corneal necrosis; dental erosion, and discoloration; dermatitis; emphysema; hemoptysis; nausea and vomiting; pneumonitis; pulmonary edema; stomatitis; skin and eye burns. As little as 1 oz may cause death.	Contact with moisture or water may generate sufficient heat to ignite combustible materials. Fire and explosion on contact with incompatible substances. Fire and spread of flames due to incorrect storage. It may react violently with some acids and is corrosive to metals such as aluminum, iron, tin, lead, and zinc. Sudden contact with moisture or water can generate instant heat, explosion, boiling and splashing.	Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat. Always transport the container closed. Always carry out collections in a fume hood with exhaustion. Close containers immediately after use. Read the product safety information sheets before use. Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols.	[14–17]
Hydrochloric acid <sup>a</sup>	7647-01-0	Serious local effects by all routes of exposure. The substance can be absorbed into the body by inhalation. Rapid evaporation of the liquid may cause frostbite. The substance is corrosive to the eyes, skin, and respiratory tract. Inhalation of this gas may cause asthma-like reactions. Exposure could cause asphyxiation due to swelling in the throat. Inhalation of high concentrations may cause lung edema, pneumonitis, chronic inflammation of the respiratory tract and reduced lung function. Repeated or prolonged inhalation may cause effects on the teeth, which may result in tooth erosion. Mists of this acid are carcinogenic to humans.	Reacts with ammonium salts, releasing ammonia. Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging. Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Exposure to toxic vapors due to inadequate mixing with other incompatible substances. Contamination due to lack of training and alert regarding the toxic potential of the substance.	In case of leakage, consult the safety data sheet, avoid direct contact, and use appropriate collection and cleaning tools and PPE. Maintain maximum attention when using and handling the product. Maintain appropriate storage conditions, such as position, temperature, and light. Maintain control of expiration dates and avoid cross-contamination between products due to using contaminated glassware.	[14,16,18]

Table 1. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Sodium hypochlorite <sup>b</sup>	7681-52-9	Serious local effects by all routes of exposure. The substance is corrosive to the eyes, skin, respiratory tract, and digestive tract. Inhalation may cause lung edema, but only after initial corrosive effects on eyes and/or airways have become manifest. Repeated or prolonged contact with skin may cause dermatitis.		Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat. Always carry out collections in a fume hood with exhaustion. Always transport the container closed. Close containers immediately after use. Do not make direct contact with the chemical product.	[16–18]
Sodium chlorite <sup>b</sup>	7758-19-2	The substance can be absorbed into the body by inhalation of its aerosol and by ingestion. The substance is irritating to the eyes, skin, and respiratory tract. Evaporation at 20 °C is negligible; a harmful concentration of airborne particles can, however, be reached quickly when dispersed, especially if powdered. When ingested or inhaled it causes cough, sore throat, abdominal pain, and vomiting.	Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Contamination due to lack of training. Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging.	Follow laboratory safety and emergency protocols. Maintain maximum attention when using and handling the product. Maintain control of expiration dates and avoid cross-contamination between products due to the use of contaminated glassware.	[15,17,18]
Sodium bromide <sup>b</sup>	7647-15-6	It may cause drowsiness or dizziness. Suspected of damaging fertility. It may cause damage to organs (central nervous system) through prolonged or repeated exposure.			[18]

Table 1. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Sodium bisulfite <sup>b,f,g</sup>	7631-90-5	The substance can be absorbed into the body by ingestion. It irritates the skin, eyes, respiratory tract, and gastrointestinal tract. Repeated or prolonged inhalation may cause asthma-like symptoms. The substance may have effects on the skin and cause headaches.	Direct contact with hands and eyes due to non-use of PPE.		[18]
Sodium hydrosulfite <sup>b,f,g</sup>	7775-14-6	The substance can be absorbed into the body by ingestion. It irritates the eyes and respiratory tract, causing redness, cough, and sore throat. A harmful concentration of airborne particles can be reached quickly when dispersed, especially if powdered, causing abdominal pain, nausea, and vomiting.	Direct contact through splashes, transport, and leaks due to inattention.		[14,18]
Sequestering agents <sup>a,b,c,d,e,f,g,h</sup> (commercial product)	-	Due to its hidden commercial formulation, it is not possible to define the specific hazards of this substance.	Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Contamination due to lack of training.	Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat. Always transport the container closed. Close containers immediately after use. Do not make direct contact with the chemical product.	[14,15]
Magnesium silicate <sup>i</sup>	1343-88-0	Toxic by inhalation, use in foods restricted to 2%.		Follow laboratory safety and emergency protocols. Maintain maximum attention when using and handling the product.	[18]
Sodium nitrate <sup>f</sup>	7631-99-4	The substance can be absorbed into the body by inhalation of its aerosol and by ingestion. The substance is irritating to the eyes, skin, and respiratory tract. Ingestion could cause effects on the blood (by the formation of methemoglobin), abdominal pain, convulsions, diarrhea, headache, labored breathing, confusion, nausea, blue lips, fingernails, and skin. Evaporation at 20 °C is negligible; a harmful concentration of airborne particles can, however, be reached quickly when dispersed.	Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Inhalation of toxic dust due to open packaging.		[17,18]
Sodium phosphate <sup>f</sup>	7558-80-7	Not a hazardous substance.			[18]

Notes: <sup>a</sup> hydrolytic desizing; <sup>b</sup> oxidative desizing; <sup>c</sup> enzymatic desizing; <sup>d</sup> scouring; <sup>e</sup> bioscouring; <sup>f</sup> oxidative bleaching; <sup>g</sup> reductive bleaching; <sup>h</sup> mercerization, <sup>i</sup> scouring-bleaching combined.

Most synthetic textile dyes pollute the environment. Numerous studies with dyes have elucidated the mechanism of contamination of aquatic and terrestrial ecosystems by industrial dyes. Research has also revealed damage to living organisms and indirect contamination of human beings through food [19]. Among the various classes of existing dyes, azo dyes are the most used and are also the most harmful to health. Research indicates that in exhaust dyeing processes, 15% to 50% of the azo dye does not bind to the fibers and is lost in the wastewater [13]. One of the mechanisms of damage to the body after contamination with azo dyes is not caused directly by absorbed dye molecules but rather by the degradation products of these molecules in the body, such as the breakdown of azo groups and the formation of nitrosamines, which present a high carcinogenic and mutagenic potential in humans [19,20].

In practice, periodically, when factories create their collections, they bring together a series of types of yarns, fabrics, fibrous compositions, colors, and finishes that generate challenging demands for production technicians. For dyeing textile substrates, requirements include the exact color pattern, that is, its intensity, chromatic hue, and saturation [5]. In these cases, laboratory experts, technicians, and process analysts test and develop colors in the laboratory to formulate recipes that are passed on to the production environment to obtain the expected color results [3,21]. To do this, laboratory workers need to handle different types of dyes and their dyeing aids. This task keeps these professionals at risk of contamination daily. However, each process and each class of dye requires different auxiliary chemicals, as well as temperature and process time [3]. Any skipped step, measurement errors, or inadequate parameters can result in color results that differ from the standard, staining, mechanical weakening of the fibers, and dimensional deformations of the substrate [4].

It is estimated that more than 10,000 types of dye molecules for textiles are currently sold worldwide. The large number of types and classes of dyes, their derivations, and color diversity make it unfeasible to specifically list the dyes most used in the industry, as this depends on many factors [13]. Among the types most used in the textile industry are reactive dyes, direct dyes, acid dyes, vat dyes, disperse dyes, cationic dyes, sulfur dyes, and azoic dyes. Users who daily handle dyes such as those mentioned above put themselves at risk of contamination [20]. Direct contact of these dyes with the body regularly can lead to severe illnesses. The complexed metal dyes are widely used in the textile industry. These dyes contain heavy metals, such as nickel, copper, cobalt, and mainly chromium [20,22]. Heavy metals are bioaccumulative in human organs such as the liver and heart and can cause severe damage to DNA and a series of pathologies [23]. According to Gregory ([19]), frequent contact with textile dyes based on 2-naphthylamine and benzidine can generate a high incidence of bladder cancer.

In general, diseases caused by textile dyes can range from superficial dermatitis to disorders of the central nervous system, including changes in enzymatic activities [23,24]. The most acute forms of contamination occur through accidental ingestion and inhalation of dust, but absorption through injured skin on fingers and hands is quite common [19]. The greatest danger of dyes to human health in the long term is their genotoxicity [20,25]. Dyes such as Disperse Orange 1 and Azure-B have been shown to be highly mutagenic [20], and mutagenic factors are among the steps that favor carcinogenesis in human organisms. More than 4000 indexed dyes have already been investigated and cataloged for their toxicity. Despite this, more than 100 types with high poisoning potential and the formation of carcinogenic amines are freely commercialized [14,19,20]. Table 2 presents the leading equipment used in dyeing and finishing laboratories.

**Table 2.** Laboratory equipment for dyeing and finishing textile substrates used for quality testing and development of production recipes: functions, hazards, risks, and PPE.

Dyeing and Finishing Equipment	Prevention Measures
	<p><b>Equipment:</b> Beaker dyeing machine.</p> <p><b>Function:</b> Used for batch exhaust dyeing of textile substrates. The system uses inox beakers (batch reactors) into which all chemical inputs and the textile material to be dyed are inserted. It can also be used for chemical modification and pretreatment of substrate samples. The equipment heats the beakers using infrared, reaching temperatures of 140 °C, depending on the process.</p> <p><b>Hazards:</b> Burns, explosion, leakage, overheating.</p> <p><b>Risks:</b> Burning your hands on the hot beakers. Direct contact of chemicals with the skin in case of leaks if the lid is not well sealed. Explosion of poorly sealed beakers if the internal pressure and temperature are too high. Contact with chemical splashes when opening very hot beakers.</p> <p><b>PPE:</b> Gloves and protective glasses.</p>
	<p><b>Equipment:</b> Jigger machine.</p> <p><b>Function:</b> Used for batch exhaust dyeing. The system is recommended for woven fabrics and larger quantities. The fabric has its beginning and end attached to two rotating rollers, which, when rotating, alternately accumulate the fabric on one side. Between winding inversions, the fabric passes through a dye bath containing chemicals. It can also be used for pretreatment of substrate samples. Its maximum operating temperature is 95 °C.</p> <p><b>Hazards:</b> Burns, release of toxic vapors.</p> <p><b>Risks:</b> Burning hands when removing the fabric. Direct contact of chemicals with the skin in case of tank leaks. Breathe toxic vapors when opening the lid.</p> <p><b>PPE:</b> Protective glasses, gloves, and mask.</p>
	<p><b>Equipment:</b> Drum dyeing and washing machine.</p> <p><b>Function:</b> Used for the dyeing and pretreatment of textile substrates by batch exhaust. The system is recommended for knitted fabrics in larger quantities. The fabric is processed into rope inside a rotating drum with alternating inversion. The equipment can reach 140 °C. The chemicals are added manually through two feed tanks at the top.</p> <p><b>Hazards:</b> Burns, leaks, and release of toxic vapors.</p> <p><b>Risks:</b> Burning hands when removing the fabric. Direct contact of chemicals with the skin in case of leaks from the front door. Breathe toxic fumes when opening the door. Chemical spillage while feeding the machine.</p> <p><b>PPE:</b> Waterproof apron, gloves, protective glasses, and mask.</p>
	<p><b>Equipment:</b> Lab stenter.</p> <p><b>Function:</b> Used to dry polymerize resins applied by coating, thermoset synthetic fabrics, and fix prints. The equipment works like an oven and can reach temperatures up to 300 °C. The support on which the fabrics are fixed has movable perforating tips, which allow the adjustment of the desired width.</p> <p><b>Hazards:</b> Burns, cuts, and punctures of hands and fingers.</p> <p><b>Risks:</b> Puncture of hands and fingers when fixing samples to the support. Burns during removing fabrics from the hot support. Hands stuck in oven inlet when rack is powered automatically.</p> <p><b>PPE:</b> Thermal glove.</p>

Table 2. Cont.

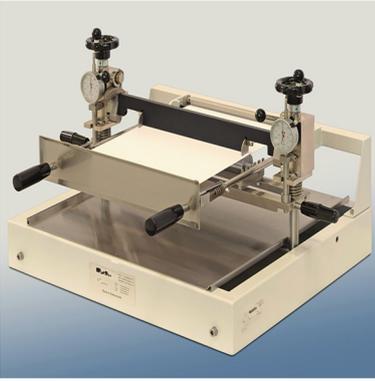
Dyeing and Finishing Equipment	Prevention Measures
	<p><b>Equipment:</b> Lab calender.</p> <p><b>Function:</b> Used for finishing woven and knitted fabrics. It consists of two pressure rollers compressed against each other through which the fabric passes. The compression between the cylinders is adjustable and promotes fabric compaction while subjecting the material to vaporization. The calender acts like a large iron and adds shine and touch to the fabrics, as well as eliminating wrinkling.</p> <p><b>Hazards:</b> Burns, crushing/amputation of hands and fingers.</p> <p><b>Risks:</b> Steam burn. Compression of fingers and hands between the compaction cylinders. Burns on the surface of metal cylinders.</p> <p><b>PPE:</b> Thermal gloves, mask, and protective glasses.</p>
	<p><b>Equipment:</b> Horizontal/vertical padder (Foulard).</p> <p><b>Function:</b> Used as a hydroextractor to remove excess water and/or chemicals applied to the fabric and to standardize the treatment. It can be used for knitted or woven fabrics. It consists of two pressure rollers compressed against each other through which the fabric passes. The compression and speed of the cylinders are adjustable.</p> <p><b>Hazards:</b> Crushing/amputation of hands and fingers.</p> <p><b>Risks:</b> Compression of fingers and hands between the compaction cylinders.</p> <p><b>PPE:</b> Gloves and protective glasses.</p>
	<p><b>Equipment:</b> Coating table.</p> <p><b>Function:</b> Used to coat knitted or flat fabrics by the controlled and uniform application of viscous substances for technical or functional purposes. The coating is carried out with a floating knife, roller, or rubber blanket.</p> <p><b>Hazards:</b> Release of volatile compounds from applied products.</p> <p><b>Risks:</b> Inhalation of volatile chemicals during the application process.</p> <p><b>PPE:</b> Gloves, mask, and protective glasses.</p>
	<p><b>Equipment:</b> Air compressor.</p> <p><b>Function:</b> Compress atmospheric air for use in pneumatic equipment.</p> <p><b>Hazards:</b> Explosion, injury to mucous membranes, retinal displacement, rupture of veins (hemorrhage).</p> <p><b>Risks:</b> In case of explosion or improper use, it can cause everything from burst eardrums, heart attack, stroke, hemorrhage, eye disorders, to death.</p> <p><b>PPE:</b> Hearing protection, protective glasses, and gloves. Regular inspection according to safety standards.</p>

Table 2. Cont.

Dyeing and Finishing Equipment	Prevention Measures
	<p><b>Equipment:</b> Lab oven  <b>Function:</b> Used to dry treated samples. Some equipment can reach 300 °C.  <b>Hazards:</b> Burn, inhalation of toxic gases/vapors.  <b>Risks:</b> Direct burns to fingers, hands, and arms when touching the internal parts of the heated stove without gloves. Burning the eyes and mucous membranes of the face with heated air when opening the stove door at high temperatures. Inhale toxic vapors from sample drying when opening the door.  <b>PPE:</b> Thermal gloves, glasses, and protective mask.</p>
	<p><b>Equipment:</b> Ultra-Turrax disperser  <b>Function:</b> Used to carry out the mixing and homogenization of chemical solutions, dispersion of pigments, and dissolution of dyes.  <b>Hazards:</b> Injuries to hands and fingers.  <b>Risks:</b> Touching the rod with your hands during operation can cause serious injuries.  <b>PPE:</b> Gloves and protective glasses.</p>

Notes: All images are free images from the internet. The brands have been hidden to avoid any attribution of responsibility or advertising to the manufacturer. All equipment shown has safety features and meets strict safety standards.

After dyeing processes, some textile substrates, especially fabrics, are subjected to textile finishing processes. One of the objectives of finishing is to make the substrate more pleasant to use, giving it a better touch, better fit, and greater dimensional stability [12]. Finishing processes also improve the appearance of fabrics, making them shinier and less wrinkled. Many types of finishes can also provide additional functionalities to the substrate, such as greater hydrophilicity, hydrophobicity, insect repellency, antimicrobial activities [26], antifungal, antiviral, and anti-mite, quick-drying, easy cleaning, and self-cleaning activity, among others [12,13].

Finishing processes can be physical, chemical, and mechanical. Chemical finishes can significantly improve the usability, appearance, and functionality of some textile products. Chemical finishes can be durable or non-durable, as the chemicals applied interact differently with each type of fiber [8]. However, many finishes use chemical compounds that are highly polluting and toxic to health. Some functional chemical compounds can even cause illnesses or sequelae to the end user due to the slow release of chemical species harmful to human health. Many studies have questioned the safety of the application and use of some finishing products [9]. Other research seeks alternatives to the use of some finishing products known to be hazardous, such as flame retardants based on antimony trioxide, formaldehyde, and halogenated compounds, which are carcinogenic, neurotoxic, bioaccumulative, mutagenic, and pose a high risk of poisoning.

Some textile finishes are based on coating fabrics with functional polymers/resins. Some treatments based on polyfluoroalkyl (PFAS) to obtain effects such as hydrophobicity resistance to oily stains and heat are very common in household textiles, such as tablecloths and rugs, as in raincoats, shoes, mattress protectors, and fabric backpacks [27]. However, these compounds are known to be hazardous; their effects on living organisms include liver diseases, hormonal changes, and sterility in humans, among others [28]. Differentiated sporting goods often have features that facilitate the use and conservation of clothing or help the user's performance. Some of the finishes for this segment include antimicrobial

function, sometimes, these finishes use silver ions. Although silver is not considered a dangerous metal, its use as ions and nanometric particles can cause bioaccumulation and intoxication of the user, in addition to being extremely harmful to the environment as it acts as a sterilizer of soil microbiota and aquatic biomes.

### 3.5.2. Laboratory of Textile Printing

The printing laboratory is an environment used to develop screen printing pastes. Various printing effects are performed nowadays in the textile industries, and each type of printing directly depends on the formulation of the prepared paste [11]. Like color development and textile finishing laboratories, printing laboratories handle hazardous chemical reagents and dyes [5,29]. Many of the chemical auxiliaries and dyes used in pretreatment and dyeing are also used in printing, in addition to other specific chemical auxiliaries [10,29]. Table 3 presents the leading equipment used in printing laboratories. Table 4 summarizes the main inputs used in the printing processes, the risks and dangers of their use, safety precautions, and recommended PPE. In addition to chemical products, printing laboratories also use equipment with a certain degree of hazard which requires the use of PPE.

**Table 3.** Laboratory printing equipment used for product development and production recipes: functions, hazards, risks, and PPE.

Printing Equipment	Prevention Measures
Padder-foulard Lab stenter Lab oven 	See Table 2  <b>Equipment:</b> Chemical mixer. <b>Function:</b> Used for the preparation and homogenization of the screen-printing paste. <b>Hazards:</b> Injuries to hands and fingers. Direct contact with chemicals on the skin and eyes. It releases toxic gases. <b>Risks:</b> Cutting and amputation of limbs that come into contact with the moving rod propeller. Contamination and skin irritation due to product splashes during shaking. Direct contact of chemicals with the skin due to possible leaks from the tank. Ergonomic problems due to the lack of suitable tools for moving large quantities of screen-printing paste. <b>PPE:</b> Waterproof apron, protective glasses, and gloves.
	<b>Equipment:</b> Transfer stamping heating plate. <b>Function:</b> Used to apply prints to t-shirts and other manufactured items. It consists of a base and a heated plate between which the substrate is pressed together with art printed on special paper. Due to the high contact temperature between the heated plate and the substrate, the art is transferred to the fabric. The plate can be heated to approximately 200 °C. <b>Hazards:</b> Burns and hand pressing. <b>Risks:</b> Burning fingers and hands due to direct contact with the heated plate. Accidental pressing of hands and fingers. <b>PPE:</b> Thermal glove.
	<b>Equipment:</b> Viscometer. <b>Function:</b> Used to measure and adjust the viscosity of screen-printing paste. Without this analysis, unwanted quality defects may occur, such as loss of design definition, smudging, change in drying time, color migration, staining, and low solidity of the print, among others. <b>Hazards:</b> No data available. <b>Risks:</b> No data available. <b>PPE:</b> Gloves.

Notes: All images are free images from the internet. The brands have been hidden to avoid any attribution of responsibility or advertising to the manufacturer. All equipment shown has safety features and meets strict safety standards.

**Table 4.** Chemical inputs most used in textile substrate printing processes, their risks, hazards, and prevention measures.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Starches (e.g., corn, manioc, rice)	-				
Modified cellulose and starches (e.g. carboxymethyl cellulose and carboxymethyl starch)	-	Not a hazardous substance	-	-	[30]
Gums (e.g., guar, arabica, agar, and carob)	-				
Sodium alginate	-				
Sodium bicarbonate	144-55-8	The substance can be absorbed into the body through ingestion. It is mildly irritating to the eyes. Evaporation at 20 °C is negligible; however, a nuisance-causing concentration of airborne particles can be reached quickly when dispersed, especially if it is in a powdered form.	No data available	Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat. Always transport the container closed. Close containers immediately after use. Read the product safety information sheets before use.	[15,18]
Sodium m-nitrobenzenesulfonate	127-68-4	Causes serious eye irritation. It may cause an allergic skin reaction.		Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols.	[17,18]
Ammonium sulfate	7783-20-2	No significant effects or critical hazards. Prolonged contact with dust may cause skin irritation. Ingestion may cause gastrointestinal irritation with sore throat, abdominal pain, nausea, diarrhea, and vomiting. Systemic ammonia poisoning is possible if sufficient absorption occurs.	Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Contamination due to lack of training and alert regarding the toxic potential of the substance.	Maintain maximum attention when using and handling the product. Maintain appropriate storage conditions, such as position, temperature, and light. Maintain control of expiration dates and avoid cross-contamination between products due to the use of contaminated glassware.	[16,18]

Table 4. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Sodium dichromate	10588-01-9	The substance can be absorbed into the body by inhalation of its aerosol, through the skin and by ingestion. It is corrosive to the eyes, skin, respiratory tract, and on ingestion. The substance may cause effects on the kidneys and liver and may result in tissue lesions. A harmful concentration of airborne particles can be reached quickly when dispersed. Repeated or prolonged contact may cause skin sensitization. Repeated or prolonged inhalation may cause asthma and nasal ulceration (this may result in perforation of the nasal septum). The substance may have effects on the kidneys (this may result in kidney impairment). The substance is carcinogenic to humans. Animal tests show that this substance possibly causes toxicity to human reproduction or development.	Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging. Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Exposure to toxic vapors due to inadequate mixing with other incompatible substances. Contamination due to lack of training and alert regarding the toxic potential of the substance.	Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat. Always transport the container closed. Close containers immediately after use. Read the product safety information sheets before use. Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols. Maintain maximum attention when using and handling the product. Maintain appropriate storage conditions, such as position, temperature, and light. Maintain control of expiration dates and avoid cross-contamination between products due to the use of contaminated glassware.	[17,18]
Sodium Hydroxymethane Sulfonate	870-72-4	No data available	-		[18]

Table 4. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Dihydroxybutanedioic acid	133-37-9	The substance can be absorbed into the body by inhalation and by ingestion. It is corrosive to the eyes. The substance is irritating to the skin and upper respiratory tract. A harmful concentration of airborne particles can be reached quickly when dispersed, especially if powdered. If ingested, it can cause burning sensation, cough, sore throat, nausea, vomiting. The solution in water is a medium-strong acid. Reacts with fluorine, strong oxidants, hydrogen peroxide, alkaline compounds, and silver. This produces toxic fumes.	Fire and/or explosion on contact with incompatible substances. It can react violently with some alkalis, metals, salts, and oxidizing agents. It is corrosive to some metals. Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging. Direct contact with hands and eyes due to non-use of PPE.	Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat. Always transport the container closed. Always carry out collections in a fume hood with exhaustion. Close containers immediately after use. Read the product safety information sheets before use. Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols. In case of leakage, consult the safety data sheet, avoid direct contact, and use appropriate collection and cleaning tools and PPE. Maintain maximum attention when using and handling the product. Maintain appropriate storage conditions, such as position, temperature, and light. Maintain control of expiration dates and avoid cross-contamination between products due to the use of contaminated glassware.	[17,18]
Tin chloride	7772-99-8	The substance can be absorbed into the body by inhalation of its aerosol and by ingestion. The substance is irritating to the eyes and respiratory tract. A harmful concentration of airborne particles can be reached quickly when dispersed. If ingested it can cause abdominal pain, diarrhea, nausea, and vomiting. Decomposes on heating. This produces toxic and corrosive gases. The substance is a strong reducing agent. It reacts with oxidants such as nitrates and peroxides and bases.	Direct contact through splashes, transport, and leaks due to inattention. Exposure to toxic vapors due to inadequate mixing with other incompatible substances. Contamination due to lack of training and alert regarding the toxic potential of the substance.		[16,18]

Table 4. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Urea	57-13-6	The substance can be absorbed into the body by inhalation of its aerosol and by ingestion. The substance is irritating to the eyes, skin, and respiratory tract. Repeated or prolonged contact with skin may cause dermatitis. Decomposes on heating above the melting point. This produces toxic gases. Reacts with strong oxidants, nitrites, inorganic chlorides, chlorites, and perchlorates. This generates fire and explosion hazard.	Fire and explosion on contact with incompatible substances. Fire and spread of flames due to incorrect storage. It may react violently with some oxidizing agents and salts. Exposure to toxic vapors due to inadequate mixing with other incompatible substances. Contamination due to lack of training and alert regarding the toxic potential of the substance.	Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat. Always transport the container closed. Close containers immediately after use. Read the product safety information sheets before use.	[16–18]
Thiourea	62-56-6	The substance can be absorbed into the body by inhalation of its aerosol and by ingestion. The substance is irritating to the eyes. Repeated or prolonged contact may cause skin sensitization. The substance may have effects on the thyroid. This substance is possibly carcinogenic to humans. Decomposes on heating (this produces toxic fumes of nitrogen oxides and sulfur oxides). Reacts violently with acrolein, strong acids and strong oxidants.	Fire and/or explosion on contact with incompatible substances. It may react violently with some acids and oxidizing agents. It is corrosive to some metals. Exposure to heat and consequent release of toxic gases. Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging. Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Exposure to toxic vapors due to inadequate mixing with other incompatible substances. Contamination due to lack of training and alert regarding the toxic potential of the substance.	Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols. Maintain appropriate storage conditions, such as position, temperature, and light. Maintain control of expiration dates and avoid cross-contamination between products due to the use of contaminated glassware.	[17,18]

Table 4. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Sodium formaldehydesulfoxylate	6035-47-8	It is suspected of causing genetic defects. It is suspected of harming the fetus. Mutagenicity in germ cells. Possibility of formation of dangerous combustion gases or vapors in case of fire. Contact with acids releases very toxic gases. It is chemically stable under standard environmental conditions (room temperature).	It may react violently with some acids and oxidizing agents. It is corrosive to some metals. Exposure to heat and consequent release of toxic gases. Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging. Direct contact with hands and eyes due to non-use of PPE. Exposure to toxic vapors due to inadequate mixing with other incompatible substances.	Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat. Always transport the container closed. Always carry out collections in a fume hood with exhaustion. Close containers immediately after use. Read the product safety information sheets before use. Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols. In case of leakage, consult the safety data sheet, avoid direct contact, and use appropriate collection and cleaning tools and PPE. Maintain maximum attention when using and handling the product. Maintain appropriate storage conditions, such as position, temperature, and light. Maintain control of expiration dates and avoid cross-contamination between products due to the use of contaminated glassware.	[31]

Table 4. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Formaldehyde	50-00-0	<p>The substance can be absorbed into the body by inhalation. The substance is severely irritating to the eyes and respiratory tract. Inhalation of high concentrations may cause lung edema, but only after initial corrosive effects on the eyes and the upper respiratory tract have become manifest. Repeated or chronic inhalation of the vapor may cause chronic inflammation of the upper respiratory tract. Repeated or prolonged contact may cause skin sensitization. This substance is carcinogenic to humans. The substance polymerizes in contact with alkalis and if dissolved in water. Upon heating, toxic fumes are formed. Reacts violently with strong oxidants, strong acids and strong bases (this generates explosion hazard). The gas mixes well with air, and explosive mixtures are easily formed.</p>	<p>Contact with moisture or water may generate sufficient heat to ignite combustible materials.</p> <p>Fire and explosion on contact with incompatible substances.</p> <p>Fire and spread of flames due to incorrect storage.</p> <p>It may react violently with some acids and it is corrosive to metals such as aluminum, iron, tin, lead, and zinc.</p> <p>Sudden contact with moisture or water can generate instant heat, explosion, boiling and splashing.</p> <p>Reacts with ammonium salts, releasing ammonia.</p> <p>Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging.</p> <p>Direct contact with hands and eyes due to non-use of PPE.</p> <p>Direct contact through splashes, transport, and leaks due to inattention.</p> <p>Exposure to toxic vapors due to inadequate mixing with other incompatible substances.</p> <p>Contamination due to lack of training and alert regarding the toxic potential of the substance.</p>	<p>Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat.</p> <p>Always transport the container closed.</p> <p>Always carry out collections in a fume hood with exhaustion.</p> <p>Close containers immediately after use.</p> <p>Read the product safety information sheets before use.</p> <p>Do not make direct contact with the chemical product.</p> <p>Follow laboratory safety and emergency protocols.</p> <p>In case of leakage, consult the safety data sheet, avoid direct contact, and use appropriate collection and cleaning tools and PPE.</p> <p>Maintain maximum attention when using and handling the product.</p> <p>Maintain appropriate storage conditions, such as position, temperature, and light.</p> <p>Maintain control of expiration dates and avoid cross-contamination between products due to the use of contaminated glassware.</p>	[17,18]
Dyes (commercial product)	-		See topic 2.5.1 of this work [22,32]		

Table 4. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Pigments (commercial product)	-	No data available			[15,30]
Synthetic gums (e.g., polyacrylates) (commercial product)	-	Due to its hidden commercial formulation, it is not possible to define the specific hazards of this substance.	No data available	No data available	
Softeners (commercial product)	-			Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat.	
Antifoamer agents (commercial product)	-			Always transport the container closed. Close containers immediately after use. Read the product safety information sheets before use.	
Dispersing agents (commercial product)	-	Due to its hidden commercial formulation, it is not possible to define the specific hazards of this substance.	Direct contact with hands and eyes due to non-use of PPE.	Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols.	[15,30]
Binding agents (commercial product)	-		Direct contact through splashes, transport, and leaks due to inattention. Contamination due to lack of training.	In case of leakage, consult the safety data sheet, avoid direct contact, and use appropriate collection and cleaning tools and PPE.	
Emulsifying agents (commercial product)	-			Maintain maximum attention when using and handling the product. Maintain appropriate storage conditions, such as position, temperature, and light.	
Surfactants agents (commercial product)	-			Maintain control of expiration dates and avoid cross-contamination between products due to the use of contaminated glassware.	

Table 4. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Plastisol (Vinyl chloride / Chloroethylene)	-	Due to its hidden commercial formulation, it is not possible to define the specific hazards of this substance.	Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging. Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Contamination due to lack of training and alert regarding the toxic potential of the substance.	Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat. Always transport the container closed. Close containers immediately after use. Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols. Maintain maximum attention when using and handling the product.	[29]
Solvents such as toluene/benzene, ethylbenzene, nitrobenzene/xylene/n-hexane/n-alkanes/hexamethylene, diisocyanate/cyclohexane, acetone/cyclohexanone/butanone, butan.1.ol/propan.2.ol/isobutanol/2-methylpropan.1.ol/methanol/benzyl alcohol. Used as diluents for ready-to-use inks, purchased as matt ink, acrylic ink, white spirit, glue, cellulose thinner, plastisol thinner, and plastisol remover, among others.	-	Respiratory infection, sore throat, rhinitis, cough, asthma, shortness of breath, dry skin, scaling, itching, rash, skin irritation, ocular disturbances, itching, headache, dizziness, fatigue, dizziness, neck pain, back pain, knee pain, shoulder pain, abdominal pain, vomiting, and nausea. Serious injuries and respiratory disorders. Carcinogenic potential (especially leukemia). Other common disorders include hypertension, depression, work fatigue, and vision disorders.	Fire and/or explosion on contact with flame and incompatible substances. Fire and spread of flames due to incorrect storage. Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging. Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Exposure to toxic vapors due to inadequate mixing with other incompatible substances. Contamination due to lack of training and alert regarding the toxic potential of the substance.	Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat. Always transport the container closed. Close containers immediately after use. Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols. Maintain maximum attention when using and handling the product.	[16–18,29]
Sodium carbonate	497-19-8				
Sodium hydroxide	1310-73-2				
Sodium silicate	1344-09-8				
Sulfuric acid	7664-93-9				

See Table 1

### 3.5.3. Laboratory for Garment Laundry and Finishing

Laundry processes for ready-made garments are widely used to add value and beauty, generally in jeans and similar products. Stone washing processes and intentional wear promote effects that never go out of fashion. On the contrary, they have generated a growing demand, especially from younger audiences. Most laundry finishes are based on chemical treatments of the manufactured items. Chemical wear is based on strongly oxidizing products used in high concentrations, such as chlorite, hypochlorite, hydrogen peroxide, and potassium permanganate [33]. To inactivate the oxidants, high concentrations of reducing agents such as metabisulfite, bisulfite, and sodium hydrosulfite are used. Such compounds, in addition to being toxic, can cause irreversible consequences if frequently inhaled, ingested, or absorbed into the skin. Table 5 summarizes the main inputs commonly used in laundry processes, the risks and hazards of their use, safety precautions, and recommended PPE.

**Table 5.** Chemical inputs most used in laundry finishing, their risks, hazards, and prevention measures.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Softeners (commercial product)	-			Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat.	
Polymer resins (commercial product)	-			Always transport the container closed. Close containers immediately after use.	
Surfactant agents (commercial product)	-			Read the product safety information sheets before use.	
Essences (commercial product)	-	Due to its hidden commercial formulation, it is not possible to define the specific hazards of this substance.	Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Contamination due to lack of training.	Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols. In case of leakage, consult the safety data sheet, avoid direct contact, and use appropriate collection and cleaning tools and PPE.	[15,32,33]
Optical brightener (commercial product)	-			Maintain maximum attention when using and handling the product. Maintain appropriate storage conditions, such as position, temperature, and light.	
Dispersing agent (commercial product)	-			Maintain control of expiration dates and avoid cross-contamination between products due to the use of contaminated glassware.	
Sequestering agent (commercial product)	-				

Table 5. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Potassium permanganate	7722-64-7	Serious local effects by all routes of exposure. The substance is corrosive to the eyes, skin, and respiratory tract. Corrosive on ingestion. Inhalation of dust may cause lung edema. A harmful concentration of airborne particles can be reached quickly when dispersed, especially if powdered. The substance may have effects on the lungs (this may result in bronchitis and pneumonia). Animal tests show that this substance possibly causes toxicity to human reproduction or development. Decomposes on heating (this produces toxic gases and irritating fumes). If inhaled, it can cause a burning sensation, cough, sore throat, shortness of breath, labored breathing (symptoms may be delayed). In contact with the skin, it causes redness, skin burns, severe burns, and a burning sensation. If ingested, it causes abdominal pain, diarrhea, nausea, vomiting, shock, or collapse. The substance is a strong oxidant. It reacts with combustible and reducing materials (this generates fire and explosion hazards). Reacts violently with powdered metals (this causes fire hazard).	Fire and explosion on contact with incompatible substances. Fire and spread of flames due to incorrect storage. It may react violently with some metals. Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging. Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Exposure to toxic vapors due to inadequate mixing with other incompatible substances. Contamination due to lack of training and alert regarding the toxic potential of the substance.	Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat. Always transport the container closed. Close containers immediately after use. Read the product safety information sheets before use. Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols. In case of leakage, consult the safety data sheet, avoid direct contact, and use appropriate collection and cleaning tools and PPE. Maintain maximum attention when using and handling the product. Maintain appropriate storage conditions, such as position, temperature, and light. Maintain control of expiration dates and avoid cross-contamination between products due to the use of contaminated glassware.	[14,18,33]
Sodium metabisulfite	7681-57-4	The substance can be absorbed into the body by ingestion. The substance is severely irritating to the eyes. The substance irritates the skin, respiratory tract, and gastrointestinal tract. Exposure could cause asthma-like reactions or urticaria in sensitive persons. Repeated or prolonged inhalation may cause asthma-like symptoms. The substance may have effects on the skin. Decomposes on heating and contact with acids (this produces sulfur oxides). The substance is a potent reducing agent, and it reacts violently with oxidants (this generates a fire hazard). It reacts violently with a concentrated solution of sodium nitrite.	Fire and/or explosion on contact with incompatible substances. It may react violently with some oxidizing agents and metallic salts. Rapid decomposition in the presence of heat or heating. Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging. Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Exposure to toxic vapors due to inadequate mixing with other incompatible substances. Contamination due to lack of training and alert regarding the toxic potential of the substance.		[18,33]

Table 5. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Hydroxylamine sulfate	10039-54-0	The substance can be absorbed into the body by inhalation of its aerosol, through the skin, and by ingestion. The substance is irritating to the eyes and skin. Repeated or prolonged contact may cause skin sensitization. The substance may affect the blood (this may result in anemia). It has high absorption by the eyes. If ingested, it can cause blue lips, fingernails, skin, confusion, convulsions, dizziness, headache, nausea, and unconsciousness. It decomposes in contact with hot surfaces or flames (this produces corrosive fumes of sulfur oxides). The solution in water is a medium-strong acid. The substance is a potent reducing agent. It reacts violently with oxidants, powdered metals, nitrates, nitrites, and heavy metal salts.	Fire and/or explosion on contact with incompatible substances. It may react violently with some oxidizing agents and metallic salts. Rapid decomposition in the presence of heat or heating. Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging. Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Exposure to toxic vapors due to inadequate mixing with other incompatible substances. Contamination due to lack of training and alert regarding the toxic potential of the substance.	Use personal protective equipment (PPE), e.g., protective glasses, gloves, respiratory mask, protective clothing, or lab coat. Always transport the container closed. Close containers immediately after use. Read the product safety information sheets before use. Do not make direct contact with the chemical product. Follow laboratory safety and emergency protocols. In case of leakage, consult the safety data sheet, avoid direct contact, and use appropriate collection and cleaning tools and PPE. Maintain maximum attention when using and handling the product. Maintain appropriate storage conditions, such as position, temperature, and light. Maintain control of expiration dates and avoid cross-contamination between products due to the use of contaminated glassware.	[18]
Oxalic acid	144-62-7	The substance can be absorbed into the body by inhalation of its aerosol and by ingestion. The substance is corrosive to the eyes, skin, and respiratory tract. Corrosive on ingestion. The substance may cause effects on the calcium balance after ingestion. Exposure to high levels could cause death. Repeated or prolonged contact with the skin may cause dermatitis. Exposure may result in kidney stones, slow-healing ulcers, and black fingernails. Decomposes on contact with hot surfaces or flames (this produces formic acid and carbon monoxide). The solution in water is a medium-strong acid. Reacts violently with strong oxidants (this generates fire and explosion hazards). Reacts with some silver compounds (this produces explosive silver oxalate). It attacks some forms of plastic.	Contact with moisture or water may generate sufficient heat to ignite combustible materials. Fire and explosion on contact with incompatible substances. Fire and spread of flames due to incorrect storage. It may react violently with some acids and it is corrosive to metals such as aluminum, iron, tin, lead, and zinc. Sudden contact with moisture or water can generate instant heat, explosion, boiling and splashing. Reacts with ammonium salts, releasing ammonia. Inhalation of odorless toxic vapors due to leakage or volatilization from opened packaging. Direct contact with hands and eyes due to non-use of PPE. Direct contact through splashes, transport, and leaks due to inattention. Exposure to toxic vapors due to inadequate mixing with other incompatible substances. Contamination due to lack of training and alert regarding the toxic potential of the substance.		[14,18,34]
Sodium chloride	7647-14-5	Not a hazardous substance	No data available	-	[14,18]
Stones (e.g., cinnasite, pumice)	-	Not a hazardous substance	No data available	-	[33]

Table 5. Cont.

Chemical Substance	CAS-Number	Hazards	Risks	Prevention Measures	References
Dyes	-				
Pigments	-		See Table 4		
Enzymes (e.g., amylase, cellulase, peroxidase)	-				
Sodium hypochlorite	7681-52-9				
Sodium chlorite	7758-19-2				
Hydrogen peroxide	7722-84-1				
Sodium bisulfite	7631-90-5		See Table 1		
Sodium hydrosulfite	7775-14-6				
Acetic acid	64-19-7				
Formic acid	64-18-6				
Sodium hydroxide	1310-73-2				
Sodium carbonate	497-19-8				

The products and machinery used in jeanswear laundry are hazardous. In addition to chemical products, many laundry processes also use abrasive equipment and elements, such as sandpaper, stones, bottle caps, grinders, polishers, among others, which create many accident risks [33]. Some widely used equipment, such as horizontal washers and centrifuges, are the biggest causes of severe accidents in production, such as open fractures, limb amputation, and even death. This same production equipment is sometimes used for recipe development by laboratory workers and development technicians. Some laboratories have industrial or similar equipment but are smaller in size. However, the risks of accidents are the same, and laboratory workers must also use the same precautions and PPE used in production. Table 6 shows some images of laundry equipment.

**Table 6.** Laundry equipment used for laboratory testing, product development, and production, and its functions, hazards, risks, and PPE.

Laundry Equipment	Prevention Measures
	<p><b>Equipment:</b> Lab washer machine (Side loading).  <b>Function:</b> Used to carry out finishing washes on manufactured items, especially jeanswear. The main chemical wear processes, such as stone washing, acid washing, delavée, destroyed, and others, are performed in this machine. The equipment consists of a rotating perforated drum that beats the clothes against other abrasive elements and strongly oxidizing chemicals.  <b>Hazards:</b> Leak, release of toxic vapors, burns, injuries to hands and arms.  <b>Risks:</b> Direct contact with chemical products when removing clothes from the machine without gloves or due to leaks and splashes of wet fabric. Inhalation of oxidizing vapors. The machine lid may fall off onto upper limbs, causing severe injuries. Amputation of limbs due to accidental activation of the machine.  <b>PPE:</b> Gloves, mask, and protective glasses.</p>

Table 6. Cont.

Laundry Equipment	Prevention Measures
	<p><b>Equipment:</b> Lab washer machine (Front loading).</p> <p><b>Function:</b> Used to carry out finishing washes on manufactured items, especially jeanswear. Some chemical wear processes are performed on this machine. The washer is a rotating perforated drum that beats the clothes against other abrasive or finishing elements (e.g., fabric softeners and silicones).</p> <p><b>Hazards:</b> Leaks, release of toxic vapors, burns, and injuries to hands and arms.</p> <p><b>Risks:</b> Direct contact with chemicals when removing clothes from the machine without gloves or due to leaks and splashes of wet fabric. Inhalation of oxidizing vapors. Amputation of limbs due to accidental activation of the machine.</p> <p><b>PPE:</b> Gloves, mask, and protective glasses.</p>
	<p><b>Equipment:</b> Hydro extractor machine (Lab centrifuge).</p> <p><b>Function:</b> Used to remove excess water from clothes after washing and rinsing. The centrifuge system promotes the homogenization of moisture in the clothes.</p> <p><b>Hazards:</b> Amputation of limbs (hands and arms), injuries.</p> <p><b>Risks:</b> Improper use of the machine and insertion of hands and arms inside the working machine can cause amputations and even death. Working with the equipment covered is dangerous and dramatically increases the chances of serious accidents.</p> <p><b>PPE:</b> Gloves and protective glasses.</p>
	<p><b>Equipment:</b> Lab dryer machine (steam or gas)</p> <p><b>Function:</b> Used to dry clothing items after the laundry and finishing processes. The machine can reach temperatures of up to 150 °C.</p> <p><b>Hazards:</b> Burns and bruises.</p> <p><b>Risks:</b> Directly touching the heated internal parts of the machine can cause burns. Inserting hands and arms into a moving machine can cause severe injuries and injuries.</p> <p><b>PPE:</b> Protective gloves.</p>
	<p><b>Equipment:</b> Grinding machine.</p> <p><b>Function:</b> Used to make physical wear on clothes, especially jeans. Generally, some intentional tear marks, especially pockets and hems of jeans, can be made with this machine.</p> <p><b>Hazards:</b> Cuts, injuries to hands and fingers, scrapes, amputation of limbs.</p> <p><b>Risks:</b> Carelessness can cause cuts, scrapes, and other injuries to operators who are sanding clothing items in a localized manner. Lack of appropriate gloves and lack of attention can result in serious injuries.</p> <p><b>PPE:</b> Steel gloves and protective glasses.</p>

Table 6. Cont.

Laundry Equipment	Prevention Measures
	<p><b>Equipment:</b> Portable grinding machine (Politriz).</p> <p><b>Function:</b> Used to make physical wear on clothes, especially jeans. Generally, some intentional tear marks, especially pockets and hems of jeans, can be made with this device.</p> <p><b>Hazards:</b> Cuts, injuries to hands and fingers and scrapes. Breakage of the sanding disc.</p> <p><b>Risks:</b> Carelessness can cause cuts, scrapes, and other injuries to operators who are sanding clothing items in a localized manner. Lack of appropriate gloves and lack of attention can result in serious injuries. Disc fragments can injure eyes without protective glasses.</p> <p><b>PPE:</b> Gloves and protective glasses.</p>
	<p><b>Equipment:</b> Micro grinder.</p> <p><b>Function:</b> Used to carry out localized small wear on clothing items, especially on jeans.</p> <p><b>Hazards:</b> Injuries to hands and fingers.</p> <p><b>Risks:</b> Due to inattention, passing the grinding tip onto the skin causes scrapes and injuries. Breaking the sanding stones during use can injure eyes without protective glasses.</p> <p><b>PPE:</b> Gloves and protective glasses.</p>
	<p><b>Equipment:</b> Spray gun and dummy.</p> <p><b>Function:</b> Used to spray chemicals (e.g., potassium permanganate) on clothing items to give localized fading or coloring effects.</p> <p><b>Hazards:</b> Poisoning with chemical vapors. Inhalation of particles and droplets of strong oxidizing products. Chemical burn.</p> <p><b>Risks:</b> Eye irritation and burns due to accidental spraying near the face. Respiratory tract disorders due to prolonged contact with inhalation of chemical vapors. Chemical poisoning.</p> <p><b>PPE:</b> Mask with filter, gloves, protective glasses, and waterproof apron.</p>
Chemical mixture machine	See Table 3

Notes: All images are free images from the internet. The brands have been hidden to avoid any attribution of responsibility or advertising to the manufacturer. All equipment shown has safety features and meets strict safety standards.

#### 4. Final Considerations

To mitigate risks and dangers in textile laboratories, implementing conservation measures for facilities and equipment is essential. In this context, all laboratory team members must be aware of and receive adequate training on the risks associated with their tasks to know how to deal with chemicals and equipment in emergencies. Information and education are the first steps towards preventing accidents.

Chemical management is a critical aspect of safety in textile laboratories. This involves safe storage, clear labeling, and careful handling of chemicals. Using personal protective equipment (PPE), such as gloves, aprons, and masks, is essential to minimize exposure to dangerous chemicals. Furthermore, regular maintenance of laboratory equipment is crucial to ensure safe and accurate operation. Such issues include calibrating instruments, checking safety systems, and replacing worn parts. Dust and particle control is another area of attention. The handling of discontinuous textile fibers can generate particles suspended in the air. Inhaling these particles, depending on their nature, can cause respiratory problems, allergies, and even chronic lung diseases. Therefore, it is important to implement

dust control systems, such as exhaust fans and air filters, to reduce exposure to airborne particles. In addition, workers must wear respiratory protection masks when necessary.

The creation and implementation of safety protocols are essential to ensure the protection of everyone involved in textile laboratories. Some common protocols include emergency procedures, waste management, access control, and records/documentation. Regarding emergency procedures, all textile laboratories must have documented protocols that include evacuation plans, properly located fire extinguishers, and training for fire situations, chemical spills, and other critical incidents. Preparing to act in an emergency is essential to minimize human and property damage. Waste management is another vital aspect of safety. The correct management of chemical waste and textile materials is essential to avoid environmental contamination and protect the health of workers. This includes the proper identification, labeling, and storage of waste, as well as its disposal following applicable regulations.

Access control is an important security measure, limiting access to critical areas of the laboratory. Ensuring that only authorized personnel can operate specific equipment or access hazardous chemicals reduces the risk of accidents and unauthorized exposure to hazardous substances. Additionally, keeping detailed records of activities performed, chemicals used, and incidents that occur is crucial for subsequent investigations and to comply with safety regulations. Documenting all operations and events is critical to transparency and accountability in a laboratory environment.

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## References

1. de Oliveira, C.R.S.; da Silva Júnior, A.H.; Mulinari, J.; Ferreira, A.J.S.; da Silva, A. Fibrous Microplastics Released from Textiles: Occurrence, Fate, and Remediation Strategies. *J. Contam. Hydrol.* **2023**, *256*, 104169. [[CrossRef](#)] [[PubMed](#)]
2. Lewin, M.; Sello, S.B. Handbook of Fiber Science and Technology: Chemical Processing of Fibers and Fabrics, Fundamentals and Preparation, Part A. *Text. Res. J.* **1984**, *54*, 418. [[CrossRef](#)]
3. Needles, H.L. *Textile Fibers, Dyes, Finishes, and Processes—A Concise Guide*; Noyes Publications: Saddle River, NJ, USA, 1986; ISBN 0815510764.
4. Chakraborty, J.N. Dyeing Machineries. In *Fundamentals and Practices in Colouration of Textiles*; CRC Press: Boca Raton, FL, USA, 2015; pp. 501–535.
5. Shang, S.M. Process Control in Dyeing of Textiles. In *Process Control in Textile Manufacturing*; Elsevier: Amsterdam, The Netherlands, 2013; pp. 300–338, ISBN 9780857090270.
6. Bathrinath, S.; Bhalaji, R.K.A.; Saravanasankar, S. Risk Analysis in Textile Industries Using AHP-TOPSIS. *Mater. Today Proc.* **2021**, *45*, 1257–1263. [[CrossRef](#)]
7. ISO 45001:2018. Occupational Health and Safety Risk Assessment: A Systematic Literature Review of Models, Methods, and Applications. Available online: <https://www.iso.org/standard/63787.html> (accessed on 30 November 2023). [[CrossRef](#)]
8. Menachem, L.; Pearce, E.M. *Handbook of Fiber Chemistry*, 3rd ed.; Lewin, M., Ed.; CRC Press: New York, NY, USA, 2006; ISBN 9780429116391.
9. Majumdar, A.; Das, A.; Alagirusamy, R.; Kothari, V.K. *Process Control in Textile Manufacturing*; Woodhead Publishing Limited: Cambridge, UK, 2013; ISBN 978-0-85709-027-0.
10. Lopes, T.J.; Rosa, G.R.; da Silva, L.S.; Scheeren, C.W.; Antelo, F.S.; Martins, M.L. Identification, Characterization and Quality Management of Natural Textile Fibres. In *Fundamentals of Natural Fibres and Textiles*; Elsevier: Amsterdam, The Netherlands, 2021; pp. 473–513.

11. Shang, S.M. Process Control in Printing of Textiles. In *Process Control in Textile Manufacturing*; Elsevier: Amsterdam, The Netherlands, 2013; pp. 339–362.
12. Rippon, J.A.; Evans, D.J. Improving the Properties of Natural Fibres by Chemical Treatments. In *Handbook of Natural Fibres*; Elsevier: Amsterdam, The Netherlands, 2020; pp. 245–321, ISBN 9780128187821.
13. de Oliveira, C.R.S.; da Silva Júnior, A.H.; Mulinari, J.; Immich, A.P.S. Textile Re-Engineering: Eco-Responsible Solutions for a More Sustainable Industry. *Sustain. Prod. Consum.* **2021**, *28*, 1232–1248. [[CrossRef](#)]
14. Lacasse, K.; Baumann, W. *Textile Chemicals*; Springer: Berlin/Heidelberg, Germany, 2004; ISBN 978-3-642-62346-2.
15. Clarck, M. *Handbook of Textile and Industrial Dyeing—Part I: General Aspects of Dyeing*; Clarck, M., Ed.; Woodhead Publishing Limited: Cambridge, UK, 2011; ISBN 2042-0811.
16. Sax, I. *Hazardous Chemicals Information Annual*, 1st ed.; Sax, N.I., Ed.; Van Nostrand Reinhold Information Services: New York, NY, USA, 1986; Volume 1, ISBN 0442281358.
17. Sweet, D.V.; Fang, J.; Shiang, D. *Registry of Toxic Effects of Chemical Substances (RTECS)*; National Inst. for Occupational Safety and Health: Cincinnati, OH, USA, 1986.
18. OECD. EChemPortal—The Global Portal to Information on Chemical Substances. Available online: <https://www.chemportal.org/chemportal/substance-search> (accessed on 20 October 2023).
19. Gregory, P. Toxicology of Textile Dyes. In *Environmental Aspects of Textile Dyeing*; Elsevier: Amsterdam, The Netherlands, 2007; pp. 44–73.
20. Lellis, B.; Fávaro-Polonio, C.Z.; Pamphile, J.A.; Polonio, J.C. Effects of Textile Dyes on Health and the Environment and Bioremediation Potential of Living Organisms. *Biotechnol. Res. Innov.* **2019**, *3*, 275–290. [[CrossRef](#)]
21. Hirsch, G. *Dyeing and Chemical Technology of Textile Fibers*; John Wiley & Sons Inc.: Hoboken, NJ, USA, 1985; Volume 36, pp. 456–457.
22. Ayadi, I.; Souissi, Y. Chemical Synonyms, Molecular Structure and Toxicological Risk Assessment of Synthetic Textile Dyes: A Critical Review. *J. Dev. Drugs* **2015**, *5*. [[CrossRef](#)]
23. Khan, S.; Malik, A. Toxicity Evaluation of Textile Effluents and Role of Native Soil Bacterium in Biodegradation of a Textile Dye. *Environ. Sci. Pollut. Res.* **2018**, *25*, 4446–4458. [[CrossRef](#)]
24. Copaciu, F.; Oprea, O.; Coman, V.; Ristoiu, D.; Niinemets, Ü.; Copolovici, L. Diffuse Water Pollution by Anthraquinone and Azo Dyes in Environment Importantly Alters Foliage Volatiles, Carotenoids and Physiology in Wheat (*Triticum aestivum*). *Water Air Soil Pollut.* **2013**, *224*, 1478. [[CrossRef](#)]
25. Tiwari, S.; Tripathi, A.; Gaur, R. Bioremediation of Plant Refuges and Xenobiotics. In *Principles and Applications of Environmental Biotechnology for a Sustainable Future*; Springer: Singapore, 2017; pp. 85–142.
26. de Oliveira, C.R.S.; Mulinari, J.; Batistella, M.A.; Ulson de Souza, A.A.; Ulson de Souza, S.M. de A.G. Antimicrobial Effect of Cotton Fabric Functionalized with a Kaolinite-Titania Nano-Hybrid Composite. *Mater. Chem. Phys.* **2023**, *295*, 127078. [[CrossRef](#)]
27. Shabanian, S.; Lahiri, S.K.; Soltani, M.; Golovin, K. Durable Water- and Oil-Repellent Textiles without Long- or Short-Chain Perfluoroalkylated Substances. *Mater. Today Chem.* **2023**, *34*, 101786. [[CrossRef](#)]
28. Dewapriya, P.; Chadwick, L.; Gorji, S.G.; Schulze, B.; Valsecchi, S.; Samanipour, S.; Thomas, K.V.; Kaserzon, S.L. Per- and Polyfluoroalkyl Substances (PFAS) in Consumer Products: Current Knowledge and Research Gaps. *J. Hazard. Mater. Lett.* **2023**, *4*, 100086. [[CrossRef](#)]
29. Rose, N.M.; Yves, T.; Junie Lauraine, T.; Dieudonné, A.; Charles, F. Evaluation of Toxicological Risks among Screen Printing Workers: The Case of the City of Yaoundé (Cameroon). *Pharm. Pharmacol. Int. J.* **2023**, *11*, 29–34. [[CrossRef](#)]
30. Izdebska, J.; Sabu, T. *Printing on Polymers*; Elsevier: Amsterdam, The Netherlands, 2016; ISBN 9780323374682.
31. Sigma-Aldrich SAFETY DATA SHEET: Hydroxymethanesulfinic Acid Monosodium Salt Dihydrate. Available online: <https://www.sigmaaldrich.com/CA/en/sds/ALDRICH/71530?userType=undefined> (accessed on 20 October 2023).
32. Clarck, M. *Handbook of Textile and Industrial Dyeing—Part II: Dye Types and Processes*; Clarck, M., Ed.; Woodhead Publishing Limited: Cambridge, UK, 2011; Volume 1, ISBN 978-1-84569-695-5.
33. Paul, R. *Denim—Manufacture, Finishing and Applications*; Elsevier: Amsterdam, The Netherlands, 2015; ISBN 9780857098436.
34. Manickam, P.; Vijay, D. Chemical Hazards in Textiles. In *Chemical Management in Textiles and Fashion*; Elsevier: Amsterdam, The Netherlands, 2021; pp. 19–52, ISBN 978-0-12-820494-8.

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