

Exposure to fibres in the Occupational Environment

Matos, Luísa^a; Santos, Paula^b; Barbosa, Fernando^c

^a UCTM – Lab.- LNEG / S. Mamede de Infesta; luisa.matos@lneg.pt; ^b A.Ramalhão – Porto; paulasantos@aramalhao.com; ^c Cinfu – Porto; fernando.barbosa@cinfu.pt

ABSTRACT

Occupational exposure to fibres is a risk both new and with a tendency to increase, which classifies it as an emerging risk. The fibers are used in many sectors of activity, however, knowledge of its health effects are not fully known. Based on a literature research, we intend to contribute to improving our knowledge of fibers, reporting on their classification, characteristics, hazards, uses, means of exposure and preventive measures, giving like practical examples, the asbestos fibers and the fibers of talc, among others.

Keywords: Fibres; Asbestos; Occupational Exposure; Emerging risk.

1. INTRODUCTION

The fibres are used in many sectors of activity, however, knowledge of its health effects are not yet fully known. It appears that the fibres are part of our day to day, although the proportion of chemicals classified as fibres in the Portuguese standard NP 1796:2007 (NP1796, 2007) is minimal (about 0.4%). Fibre is considered, a particle with 5 µm or more in length and a thickness with a length of 3 to 1 or more. Occupational exposure to fibres is a risk both new and with a tendency to increase, which classifies it as an emerging risk. Although the information on the exposure of the workers and their health effects is well known, must be maintained and improved the basic principles of prevention.

The fibres can be classified based on their chemical nature: organic and inorganic. Synthetic and artificial fibres are materials in constantly evolving and with a wide diversity of uses. Among the many examples presented, particular emphasis will be given to fibrous materials that appear naturally or are produced or used in some national industry activities. Talc is a hydrated magnesium silicate, which may contain asbestos fibres and because of its lubricating properties is used as filler in many industrial sectors, such as in ceramic industry, textiles, pharmaceuticals, cosmetics and paper and rubber industry (Dias & Canzian, 2011). Can be found in its pure form or associated with other minerals (Gibbs, Pooley, & Griffiths, 1992), causing different forms of pulmonary disease (Feigin, 1986). It's called asbestos, one group of six fibrous minerals belonging to the group of silicates that are found in natural rock formations. The six different types of mineral fibres have different structure and commercial interests. The carcinogenic effect appears to result from their physical properties and not their chemical structure.

2. OBJECTIVE

The purpose of this article, based on literature research, is contribute to the improvement of knowledge about occupational exposure to fibres, their ways of classification and characteristics, types of use, type of industry, means of exposure in the workplace, exposure risks methodologies, collection and analysis, preventive measures by giving practical examples, among others, the fibres of asbestos and talc. It is also the intention of the authors, throughout this article, alert to this emerging risk, which you can find a variety of activities and for which the Technician of Safety at Work and other professionals should be aware. The assessment and analysis of emerging occupational risks play a crucial role in early identification of effective prevention measures. In order to enable a quick analysis of the researched information is presented at the end of the article, a table that collects this information.

3. METHODOLOGY

3.1. Classification and characteristics

The fibres can be classified based on their chemical nature: organic (carbon and hydrogen) and inorganic (INRS, 2008). These in turn can be of natural, artificial or synthetic origin. Thus, a natural fibre is drawn directly from nature, the artificial fibre is a fibre produced by humans using as raw material products of nature, such as cellulose, the most common is viscose and cellulose acetate, lastly, fibre is a synthetic fibre produced by humans using chemicals (eg polyester, polyamide, polypropylene).

For example, are summarized in Table 1 some activities or uses of fibres.

Table 1 – Classification of fibres, based on their chemical nature and origin.

Fibres organics			Fibres inorganics	
Natural Fibres	Synthetics Fibres	Artificial Fibres	Natural Fibres	Synthetics Fibres
Examples: - Cellulose - Cotton - Wool - etc...	Examples: polyester - polypropylene - Polyethylene - aramids polyamide - etc...	Examples: - viscose - Cellulose acetate - etc...	Examples: - asbestos - etc...	Examples: - glass fibre - mineral wool fibres -Refractory ceramic fibres - etc....

As can be seen by the elements shown in Table 1, the inorganic fibres can be of natural origin, which is the case with the asbestos or synthetic origin, such as fibre glass wool or refractory ceramic fibre. The synthetic inorganic fibres can be grouped into a family called FMA - Artificial Mineral Fibres (INRS, 2008). The FMA can be classified according to their chemical composition, fibres siliceous or not siliceous. The FMA siliceous best known are: refractory ceramic fibres, mineral wool, fibreglass, special use and continuous filament fibres. It should also be noted, even though they are outside the scope of research for the present work, the nanofibres that nanofibres are elongated nano-objects, understood in a section and tens of nm and lengths between 500 and 10 000.

3.2. Routes of Exposure

Exposure to asbestos fibres, talc containing asbestos fibres or synthetic fibres can occur in two perspectives:

- Occupational exposure, which occurs mainly through inhalation of fibres, which can damage the lungs and other organs and digestive tract;
- Environmental exposure through contact with the family clothes and workers contaminated by the fibre, the fact that live near factories, exploitation, or in contaminated areas (soil and air) fibre, because of frequent environments where products fibres and also degraded due to the presence of fibres free in nature or points of deposition of products containing fibre.

3.3. Sectors of activity / uses of fibres

The fibres are used in many sectors of activity. For example are summarized in Table 2 some activities or uses of fibre, (FT145,2009), (FT268, 2007), (FT282,2011).

Table 2 – Activities or uses of fibres

Fibre	Activities/uses
Asbestos	Construction and protection of buildings Heating systems Protection of ships against fire or heat, Slabs, tiles and tiles Strengthening of road surfacing and plastic Brake linings Protective clothing against heat.
Talc (containing asbestos fibers or not)	Ceramic industry Textile industry Pharmaceuticals Cosmetics Paper Industry Manufacture of rubber Paints and coatings
Glass fibres for special use	Tablecloths, carpets, felts and fabrics Material and thermal insulation in the aerospace industry Filters for filtration systems with high efficiency Solar Panels Reinforcement for temporary denture resins
Cotton	Textile industry Fabrics for decoration
Refractory ceramic fibres	Tablecloths, sheets, panels Isolation of high temperature furnaces, castings and tubing Cables Manufacture of seals

	Automotive, aerospace Fire Protection
Mineral Wool: Fibre glass wool, mineral wool fibre and fibre slag	Thermal isolation Sound isolation Fire Protection HVAC - Air conditioning heating and cooling systems (insulation of pipes) Isolation of boilers, furnaces, appliances
Cellulose	Paper Folder Chemical and plastic manufacturing Manufacture of textile fibres
Carbon fibres	Sport and leisure (golf clubs, tennis rackets, fishing rods, etc.) Rolls of printing machine Components for textile machines Wind turbine blades Reservoirs of gas under pressure Aircraft industry
Aramids	Clothing fire-proof and bullet Aircraft industry Sport and leisure (tennis rackets) Personal Protective Equipment Sewing

4. RESULTS

4.1 Health Risks

Exposure to fibres is related to the occurrence of various diseases, malignant and benign. On contact, the fibres with a diameter greater than 4 microns can, based on its chemical composition or due to the presence of additives, cause skin or respiratory allergies (eg fragments of carbon fibres cause skin irritation by physical action, and due to feeling "itchy" rub the skin, they penetrate more deeply and can cause secondary inflammation). Another example is the small glass fibres that penetrate and become embedded in the outer layers of the skin, starting fracturing and releasing one of its constituents, the binder of formaldehyde on the skin. Recently, there's Disease or Morgellons "fibre disease" that is the inclusion of multi-colored fibres in skin texture, attributed to exposure to nanofibres produced by industry 2. For the analysis of safety data sheets it can be seen that most fibres presents the risk phrase R 38 - irritating to the skin, making it by this fact, need a special attention to this risk, present in the workplace and to which the workers are subject, and that is often underestimated. Inhalation of fibres can cause inflammatory reactions in the bronchi (bronchitis) and alveoli (alveolitis). Due to prolonged exposure, pulmonary fibrosis may occur, which is presented as a transformation of lung tissue which eventually leads to respiratory failure. This effect is irreversible and, in the case of certain fibres may still be rolling after the exposure. In the long term, some fibres may cause cancer, especially lung and pleura. cancer. The nomenclature used in the NP 1796:2007 (NP1796, 2007) to apply to asbestos fibres, for inorganic synthetic vitreous fibres and talc when it contains asbestos fibres, corresponding to a rating based on the degree of carcinogenicity that goes from A1 to A4.

Among the major diseases related to asbestos fibre, we find:

- Asbestosis, a disease caused by the deposition of asbestos fibres in lung alveoli, causing an inflammatory reaction of these, followed by fibrosis and therefore causes stiffness, reducing the ability to perform gas exchange, promoting the loss of lung elasticity and respiratory capacity with serious limitations to airflow, which may have the result of an inability to work. In the later stages of the disease this inability can be extended up to perform simple tasks and vital for human survival.
- Lung cancer, which may be associated with other morbid manifestations, such as asbestosis, with or without pleural plaques. The risk of this type of cancer can increase by 90 times if the worker exposed to asbestos is also smoking, because smoking enhances the synergistic effect between the two agents recognized as promoters of lung cancer. It is estimated that 50% of workers who have asbestosis will develop lung cancer.
- Larynx cancer, digestive tract and ovaries cancer.
- Mesothelioma is a rare form of malignant tumor that usually affects the pleura. Do not establish any relationship of smoking with mesothelioma, or dose of exposure. Malignant mesothelioma can metastasize via the lymphatic system in approximately 25% of cases.

4.2. Collection Methodology and Analysis

To determine the concentration of fibres, one can resort to sampling methods for use of personal sampling pumps with filters placed in the breathing zone of the worker, or the placement of static samplers in work areas. Personal methods are more representative of personal exposure of workers, while the remaining methods are most useful in the development of improvements in working practices and prevention measures.

For the sampling and measurement of asbestos and other fibres, can be used NIOSH method 7400 (7400NIOSH, 1994), whose analytical technique is the manual counting of fibres using a phase contrast microscope. Regarding asbestos, you can also apply the NIOSH 7402 method (7402NIOSH, 1994), whose determination is made using the electronic transmission microscope.

According to the Act n.º 266/2007, the counting of asbestos fibres is carried out preferably by the method of phase contrast microscopy (membrane filter method), recommended by the World Health Organization, or other method that assures equivalent results in qualified laboratories. For sampling fibres in contact with the skin are being studied methods that use tape or exposed stickers surfaces in the epidermis, as well as methods of aspiration of the skin to a filter and subsequent counting under a microscope.

Each technique has limitations and may give different answers. Therefore, it is necessary to understand the techniques and how they can be used. Table 3 provides a guide for the main classes of fibres encountered. Even when populations of fibres exhibit certain characteristics, these may not be shown by all individual fibres: thus, unless further information is available at least two characteristic properties of each fibre should be examined to permit discrimination. The analyst should choose the most appropriate technique for the strategy selected. However, if the types of fibre are not known, a decision hierarchy may be adopted. The results and their implications should be evaluated after each analysis.

Table 3 – Guidance in selection of the appropriate method (MDHS87, 1998)

Methods				
	PCM/PLM	PCM/UV Fluorescence	SEM-EDXA	TEM-EDXA-SAED
Primary fibre analysed	Strategies			
Asbestos	Exclude other fibres > 1 µm diameter (limited use if some types of other mineral fibres are present)	Not recommended	Include asbestos fibres > 0,2 µm diameter	Include all fibres
MMMF	Include MMMF fibres > 1 µm diameter which are isotropic	Not recommended	Include MMMF fibres > 0,2 µm diameter, can be useful if source of fibre is known	Can be useful for fibres from known source
Other mineral fibres	Exclude other fibres > 1 µm diameter, eg rutile needles (cannot always be used to discriminate between different types of mineral fibres)	Not recommended	Include fibres > 0,2 µm diameter, if source is known: can be used to discriminate between some types of mineral fibres	Include all fibres; can identify or discriminate between fibre types
Synthetic organic fibres	Not recommended, except for a known source which may have a characteristic property	Include certain types of organic fibre from a known source which fluoresce of specific wavelengths	Exclude inorganic fibres > 0,2 µm diameter	Exclude other inorganic fibres of all widths of all widths give in EDX spectrum

MMMF – Man-made mineral fibres; PCM - Phase contrast light microscopy ; PLM - Polarised Light Microscopy;

TEM - Transmission Electron Microscopy; SAED - Selected Area Electron Diffraction; SEM - Scanning Electron Microscopy; EDXA - Energy Dispersive X-ray Analysis;

This table helps the analyst to select the appropriate method and strategies for different fibre types based on the capabilities and limitations of the methods.

4.3. Prevention Measures

After that some prevention measures are indicated:

- Replacement of toxic products for less toxic products such as asbestos for fibre glass or ceramic material;
- Isolate higher risk processes;
- When handling or applying hazardous materials, use clothing, gloves and protection goggles;
- After handling these products, wash skin with soap and warm water;
- Wash work clothes separately from the rest;

- Adequate general and localized ventilation with conservation and maintenance plan;
- Wet cleaning work surfaces;
- Information and training of workers; Use of standards of hygiene and safety;
- Medical examination to diagnose signs and symptoms that allow early detection of disease;
- Systematic monitoring of the concentration of fibres in the air;
- Protection masks;

Note that, the employer must provide adequate masks and in good condition, and should only be used temporarily as a complementary measure to the collective protection.

5. CONCLUSIONS

It follows, for all these reasons, there is still a long way to go for a perfect and proper knowledge of possible effects and especially in the development of mechanisms that can prevent the occurrence of damage. It is not possible at this stage of knowledge (or ignorance) to evaluate the impact of emerging risk at the society level, productivity and sustainability of the industries themselves responsible for the production of fibres, or whose production process involves the release of fibres.

However, factors such as:

- Risk assessment;
- The adoption of measures to prevent or control risks;
- Information, training and consultation of workers;
- Regular monitoring of the risks and control measures;
- Appropriate monitoring of health;
- The examination for admission before the start of exposure, are very important in preventing the risks of exposure.

To implement the proposed objectives, is in Table 4, a small practical example for refractory ceramic fibres, which allows a quick analysis of researched information.

Table 4 – Definition/Characterization and Health Hazards of Refractory ceramic fibres.

Fibre Type	Definition / Characterization	Diameter	Main health hazards	TLE -TWA
Refractory ceramic fibres	<ul style="list-style-type: none"> • Artificial fibres glassy silicates, with random orientation, where the percentage of alkaline oxides and alkaline earth oxides is less than 18%. • Aluminum silicate fibers used for applications above 1000 ° C. • Above 1000 ° C recrystallize gradually and form the cristobalite (crystalline silica is classified as carcinogenic to humans). • It does not form fibers with smaller diameter, but have transverse orientation. • Classified as a category 2. 	1 -3 µm	<ul style="list-style-type: none"> • Irritating to skin ; • Appearance of pleural plaques and alterations in respiratory function • Slightly soluble in biological fluids – biopersistent; • Fibroses • Carcinogenicity comparable to asbestos 	0,1 fibre/cm ³

6. REFERENCES

- 7400NIOSH. (1994). Asbestos and other fibres by PCM.
- 7402NIOSH. (1994). ASBESTOS by TEM.
- Dias, O., & Canzian, M. (2011). Talc asbestosis and pulmonary tuberculosis in a patient exposed to the talc used in the production of soccer balls. *37, 4*, 563-566. Brasil: J Bras Pneumol. .
- Feigin, D. (1986). Talc: understanding its manifestations in the chest. *146, 2*, 295-301. AJR Am J Roentgenol. .
- FT145. (2009). Amiante. INRS.
- FT268. (2007). Fibres de verre à use spécial. INRS.
- FT282. (2011). Fibres de cellulose. INRS.
- Gibbs, A., Pooley, F., & Griffiths, D. (1992). Talc pneumoconiosis: a pathologic and mineralogic study. *23, 12*, 1344-1354. Hum Pathol.
- INRS. (2008). *Les fibres*.
- MDHS87. (1998). Guidance on the discrimination between fibre types in samples of airborne dust on filters using microscopy.
- NP1796. (2007). Segurança e Saúde no Trabalho. Valores limites de exposição profissional a agentes químicos. IPQ.
- OSHA. (2008). Expert forecast on emerging chemical risks related to occupational safety and health. Bélgica.