

Merck's Hycon YM 1.44018 slides have been shown to be able to indicate mould contamination early on.

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Early detection of mould

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The various climatic and environmental conditions that are inevitably involved in an often lengthy supply chain can, in some instances, lead to mould being found on the surface of footwear when it is removed from the box at point of sale. While this is clearly not acceptable to either customer or retailer, when during the supply chain did it first appear and how can it be prevented? The most effective solution for preventing the proliferation of mould on any article is to limit initial contamination. This requires preventive action through regular monitoring at production sites as early on as possible

in the supply chain. To help manufacturers detect mould before it becomes visible, CTC has conducted a study on possible monitoring methods.

Tools do in fact already exist for the detection of spores (microscopic particles that cause fungal growth). Although they are currently intended mainly for the pharmaceutical and food-processing industries, they could also be used in regard to footwear. In this instance, these methods would ideally be used to identify high-risk batches and find the sources of contamination.

A study was carried out on all of the methods for monitoring and assessing

the level of fungal contamination in the ambient air and on surfaces such as raw materials or finished footwear. The objective was to determine whether these monitoring methods are sufficiently reliable to be able to use them for footwear products and, if so, to define a model protocol and frame of reference for the extrapolation of results.

AMBIENT MONITORING

Air is the primary vector of fungal spores, so monitoring it makes it possible to detect whether there are any spores present in the ambient environment and, if so, to determine (if

possible) whether there is a risk of these contaminating raw materials or footwear. It can be tested using air biocollectors which draw in air, allowing micro-organisms to be collected on an agar culture medium inserted in the device. After measurements have been taken in the areas under study, the culture media is incubated for three to five days at between 20°C and 30°C. A count per m³ of air can then be performed and further laboratory tests carried out in order to identify the main types of mould present.

Since these measuring devices are not intended for our sector, there is no official scale or risk threshold enabling air quality to be evaluated for the footwear industry. In order to acquire the first sector-specific data, measurements were taken at two production sites in China. The results were similar for both locations:

- Average spore counts of between 300 and 800 CFU/m³ (Colony Forming Unit) at the majority of sampling points and with no visible mould
- Higher spore counts of between 2,000 and 3,000 CFU/m³ in some critical areas and with visible mould
- There were three principal types of mould present: large quantities of *Cladosporium* sp., followed by *Penicillium* sp. and *Aspergillus* sp.

For the present, it would be unwise to establish a risk scale. Indeed, measurements were taken from only two sites, both very similar and not representative of all of the possible environments encountered in the footwear industry. However, based on these initial results and related industries, we may consider that a maximum concentration of 1,000 CFU/m³ of air is a reasonable objective to limit fungal pressure on raw materials and footwear.

Even if the field results obtained do not allow a precise scale to be defined, this study does provide data for the first time on the fungal flora of ambient environments specific to the footwear industry. An estimated maximum concentration of 1,000 CFU/m³ was aimed for in order to limit potential contamination by spores settling on raw materials or footwear.

ANTICIPATORY MONITORING

In the first instance, an analysis was carried out of the behaviour of raw materials and footwear towards mould. Understanding fungal development is indeed important, as it can provide relevant information regarding the selection of raw materials or even the possible application of targeted preventive solutions.

Edibility tests were carried out and different media inoculated with various levels of contamination of a mixture representing as closely as possible the potential strains encountered. The study first of all confirmed that fungal development is possible from the moment contamination occurs and that it follows an exponential growth curve. It also revealed additional important data.

Mould growth varies greatly according to the type of medium, i.e. according to the nature and quality of the materials involved. More specifically, leathers turned out to be less sensitive than the more porous and absorbent inner parts of the shoe such as reinforcing materials, counters, toe puffs, insoles and insocks. These critical components must be subjected to specific checks in order to avoid mould spreading to the rest of the shoe.

A selection of species develops depending on the medium. Generally speaking, *Aspergillus* sp. followed by *Penicillium* sp. are the most critical as regards footwear, while *Cladosporium* sp. would not appear to be a risk. These first two genera, in particular, must be detected as early on as possible in the supply chain. *Cladosporium* sp. failed to develop even when applied to both materials and finished footwear although the possibility of it developing under other conditions or on other materials cannot be totally excluded.

MONITORING BY SURFACE SAMPLING

The reference method used to check whether a material or shoe is contaminated and will develop mould is the ageing test. However, the major drawback with this method is its duration. The 21 days needed renders this test inconvenient for manufacturers as they often have very short manufacturing deadlines. It was therefore decided to focus this study on the search for rapid monitoring tests

that might, if possible, be used on site.

Different methods exist for environmental monitoring in the food-processing and pharmaceutical industries, including surface sampling. Recovery tools include contact plates, contact slides, wipes and swabs. These allow results to be obtained within five days and, depending on the method used, with or without the need for laboratory processing.

A comparative study of these various rapid monitoring tests was carried out in the laboratory and under factory conditions. The objective was to determine whether these sampling systems are applicable to raw materials and footwear with regard to the species identified and the adaptability of the recovery processes to our media and, if so, determine their levels of reliability and then create a frame of reference that, if possible, specifies the risk threshold. In the laboratory, comparative studies of the various recovery methods were carried out on different media, using a range of contamination levels. Test specimens were subjected to ageing tests to allow a comparison of the results.

It was found that the method of recovery by direct contact using Merck Hycon YM 1.44018 contact slides distinguished itself from the other methods tested. Indeed, it offered better results, with relatively even, visible growth on all media at low concentrations and consistent with the fungal growth observed with the samples subjected to ageing tests. This allowed the method to be validated for monitoring both materials and footwear. At the same time, samples were collected from a variety of raw materials at two production sites in China again using the same type of slide. The results confirmed the laboratory data and that sampling using Hycon YM slides is the best and most relevant test method.

According to this study into rapid monitoring tests using surface sampling, Merck Hycon YM contact slides appear to be of potential interest. This easy-to-use system, which can be used on site without the need for laboratory processing, would give an indication as to the degree of contamination of a raw material or complete shoe, within the space of five days.

CONCLUSION

It is definitely possible to detect mould before it becomes visible. Ambient monitoring and surface sampling of raw materials and finished products can be carried out and are also recommended. The purpose of air monitoring is to detect whether any spores are present and, if so, whether they present a risk of surface contamination. Even though there is currently no risk scale or threshold for the footwear industry, in the light of the results of this study it may be considered reasonable to aim for a maximum concentration of 1,000 CFU/m³ of air in order to limit fungal pressure on raw materials and finished footwear.

The purpose of surface sampling is to detect any contamination and thus anticipate the proliferation of mould to the rest of the shoe. Following a study to characterise rapid monitoring tests, one method stands out in particular: Merck's Hycon YM 1.44018 contact slide. This control test could provide manufacturers with an interesting solution as it is able to provide early indications concerning initial contamination directly on site, without the need for laboratory processing and within the relatively short timespan of five days. However, it should be used with caution as a more thorough analysis needs to be carried out in an industrial environment in order to gain further insight and to validate the method.

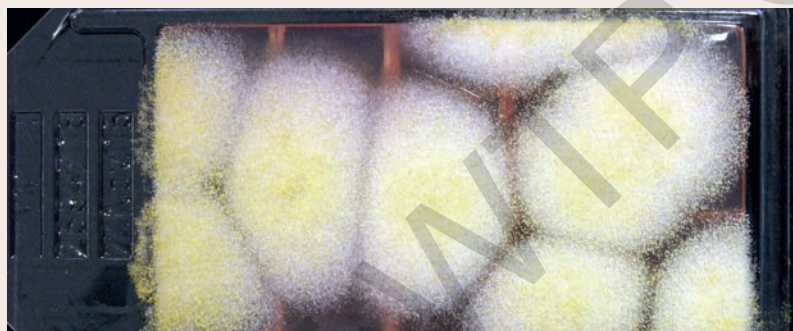
Currently, the ageing test remains the most reliable method for confirming whether a material or shoe will develop mould. Intermediate observations are possible after 10 days, which allows time to be saved if, and only if, mould is visible as well as the origin of the contamination to be identified (i.e. the contaminated materials and contaminants for the entire shoe). This test should therefore be used in addition to the Hycon YM slide.

For the first time, a study has been carried out that provides data relating to the fungal flora present in the ambient environments of the footwear industry and characterises rapid monitoring methods that have not yet been used in it. These tools, which enable the early detection of mould, may help manufacturers improve their preventive action. The additional data acquired will be particularly relevant for the strategic selection of subcontractors and suppliers of raw materials. 🍄

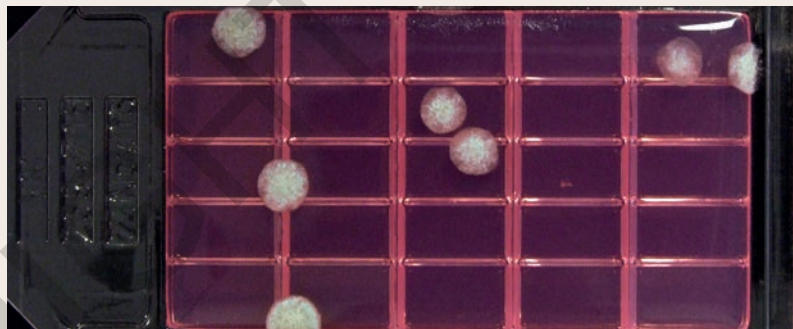
IDENTIFICATION OF MOULDS ON MERCK HYCON YM 1.44018 CONTACT SLIDES



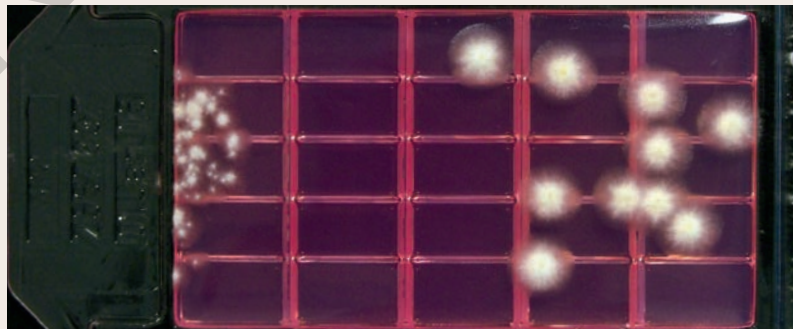
Aspergillus niger.



Aspergillus flavus.



Aspergillus vitis.



Penicillium funiculosum.



Cladosporium cladosporioides.

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