Monitoring beacon for early or hidden fungal development detection dedicated to heritage conservation

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Fungi are common biocontaminants of indoor environments, and numerous studies have demonstrated how they can degrade the materials they colonise (e.g. wood, textiles, paper, pigments, varnishes, etc.), which can even result in total destruction of these substrates. Today, fungal contamination is an increasing problem not only in houses and working places. Objects of art in museums and their depots are seriously threatened by fungal contamination (Sterflinger 2010).
At present, heritage conservation organisations can implement corrective measures (Bousta et al., 2008) in order to restore damaged materials, but no efficient preventive strategies are available, nor are any systems that would trigger a warning so that contamination can be halted before any major damage is observed. This situation results notably from problems inherent to the metrology of biocontaminants (Madelin, 1994 and Flannigan, 1996).

Current techniques are unable to detect mould at an early stage in their development or hidden contaminants. Moularat et al., in 2008 has established chemical fingerprints of mouldy development from Volatile Organic Compounds (VOCs) arising specifically from fungal metabolism. This approach has the advantage of detecting fungal development both reliably and rapidly before any visible signs of contamination could be detected. Since the development of this Fungal Contamination Index (FCI), other specific indexes have been developed to monitor works of art in terms of mould development risks. Their applications constitute a new approach for diagnosis (Moularat 2007; Moularat and Robine 2011; Moularat and Robine 2011).

However, even if the FCI has been widely tested (Joblin, Moularat et al. 2010; Moularat, Hulin et al. 2011; Hulin, Moularat et al. 2013), VOCs'analysis by GC/MS, which is required for index calculation, is incompatible for indoor environment real-time monitoring strategy. So having such a device, which could be set up in buildings and able to provide almost instantaneous information on prospective fungal development, constitutes a breakthrough. In this context, researches around FCI exploitation have been followed up in order to provide a monitoring device widely deployable. This device is the result of the miniaturization of an analytical chain for portable, reliable and low-cost applications (Anton, Moularat et al. 2015).
The proposed system is based on one hand on the selection and concentration of chemical compounds from the sample of interest and on the other hand on the development of an array of different sensors in order to obtain a specific footprint. Thus, the developed device has three modules validated individually: one for preconcentration of samples, one for

separation and one for detection. This innovative microsystem involving the collection, analysis, and interpretation of data replaces all these indispensable index calculation steps. This fungal contamination detection device was the subject of patent applications by the CSTB (Moularat, Joblin et al. 2010; Moularat, Joblin et al. 2011).