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Plasma Treatment for Mould Inactivation on Building Materials: Surface Coverage Evaluation with Automated Image Analysis

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Extended Abstract

Moulds are common microorganisms capable of rapid proliferation under favourable conditions. Building materials that are moist or damaged by water are particularly prone to mould colonization, which can have adverse effects on both occupants and buildings. Key factors influencing mould growth include relative humidity, temperature, nutrients, type of mould species, and microstructure of the material. Recent studies have shown that low-temperature atmospheric pressure plasma can effectively inactivate a broad spectrum of microorganisms by generating reactive species that are lethal to cells [1, 2].

In this research, specimens of autoclaved building materials (e.g., plasterboard, fibreboard) were placed on agar plates and artificially inoculated with Aspergillus brasiliensis spores. All samples were conditioned at a constant temperature and relative humidity. During various phases of mould growth, they were exposed to plasma generated by diffuse coplanar surface barrier discharge in ambient air [3].

Photographs taken daily during the incubation period were analyzed using image analysis, providing swift and non-destructive assessment. ImageJ is a widely used software due to its interactive workflow and high extensibility via plugins. However, it faces challenges regarding FAIR (Findability, Accessibility, Interoperability, Reusability) principles and batch processing. Analyzing hundreds or thousands of digital images is time-consuming and error-prone. In our case, for surface coverage evaluation, we utilized the open-source software JIPipe, which incorporates visual programming into the ImageJ ecosystem. This offers a user-friendly approach for creating reproducible and fully automated pipelines [4]. For each type of sample (i.e., based on the colour of the mould and the background material), individual workflows were developed through a flowchart design tailored to their specific requirements. After preprocessing (including file loading, Gaussian blur, channel separation, image annotation), segmentation methods (e.g., edge detection of building materials and moulds using triangle or Otsu's thresholding methods) were carried out and the outcomes were then forwarded to the visualization stages. Furthermore, to expedite data processing, samples were labelled using Tesseract (text recognition used to extract information about the sample type and plasma treatment parameters) and metadata information (e.g., acquisition date/time). Tailored analysis paths for mould type and building material led to a streamlined and objective assessment of surface area.

The results suggest that plasma treatment at the germination phase suppressed mould growth, while treatment during the hyphal phase noticeably slowed mould development. Low-temperature atmospheric pressure plasma treatment emerges as a promising and eco-friendly approach for managing pathogens that commonly infect various materials. Its versatility makes it suitable for numerous potential uses across various industries, ranging from food and agriculture to textiles, electronics, and medicine [1].

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