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Evaluation of the influence of hygric properties of wallpapers on mould growth rates using hygrothermal simulation

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ABSTRACT

Mould growth on building materials is a complex phenomenon involving various causes environmental conditions including temperature and relative humidity, nutrients, exposure time. Environmental conditions and nutrient are closely related to physical properties of building materials. Thus, the appropriate selection of building materials is very important for prevention of adverse health effects due to mould growth. The aim of this study is to determine the influence of the hygric properties of interior finishing materials on the mould growth.

This paper presents the results of mould growth risk evaluation with variation of hygric properties of interior finishing materials using hygrothermal and bio-hygrothermal simulation approaches. An experimental study was conducted to characterize the hygric properties of wallpapers which are used mainly as interior finishing material in residential buildings. Six types of wallpapers and two type of hygric properties (water vapour transmission property and moisture storage function) were selected for the study. WUFI Plus was selected for a whole building hygrothermal simulation. The results from the hygrothermal simulation were used for the assessment of mould growth risk using a biohygrothermal calculation model, WUFI-Bio. The simulation results show the clear correlation between the mould growth rates and the hygric properties of wallpapers.

1. Introduction

Mould growth in buildings is recognized as one of the main causes of Indoor Air Quality (IAQ) problems. Mould growth in buildings could increase the risk of adverse health problems, such as symptoms of asthma, coughing, wheezing, and upper respiratory tract infections [1]. Moreover some indoor fungi species produce mycotoxins that are considered toxic to occupants [2]. Some of fungi species can also cause discoloration and deterioration of building materials [3]. Especially, in recent years, mould problems in apartment houses have increased due to changes in the built environment such as higher air-tightness, removal of balcony space, and energy-saving design, and so on.

Mould infestation problems in building are a complex phenomenon due to various causes such as environmental conditions including temperature and relative humidity, substrates, exposure time, and so on. Earlier studies showed the interrelationship among humidity, substrates, exposure time and temperature conditions and mould growth [4–6]. Sedlbauer [7] has developed the isopleth systems that represent the requirements for mould germination and growth as a function of temperature and relative humidity in different species. He has also divided building construction materials into four classes according to the type of substrate with respect to the nourishment that the material is able to provide for the fungi. Clarke et al. [8] have also proposed the limit curves of mould growth. In this approach, the principal mould species affecting the U.K. dwellings were identified and their minimum growth requirements, in terms of temperature and relative humidity, were established. Ayerst [9] has conducted experiment in order to characterize the ideal conditions and the minimum values of humidity and temperature required in the substrate for spore germination and mycelia growth of various mould species.

Although temperature, humidity, nutrients and exposure time are known as key parameters that can increase or decrease the rate of mould growth on surface of building materials, there may be other valuable parameters, including surface structure, hygric properties, PH and so on. However, a few researches have revealed the effect of the above-mentioned parameters of a material on mould growth [10,11]. Lugauskas et al. [12] have reported that surface with cracks or rough surfaces may concentrate nutrients and

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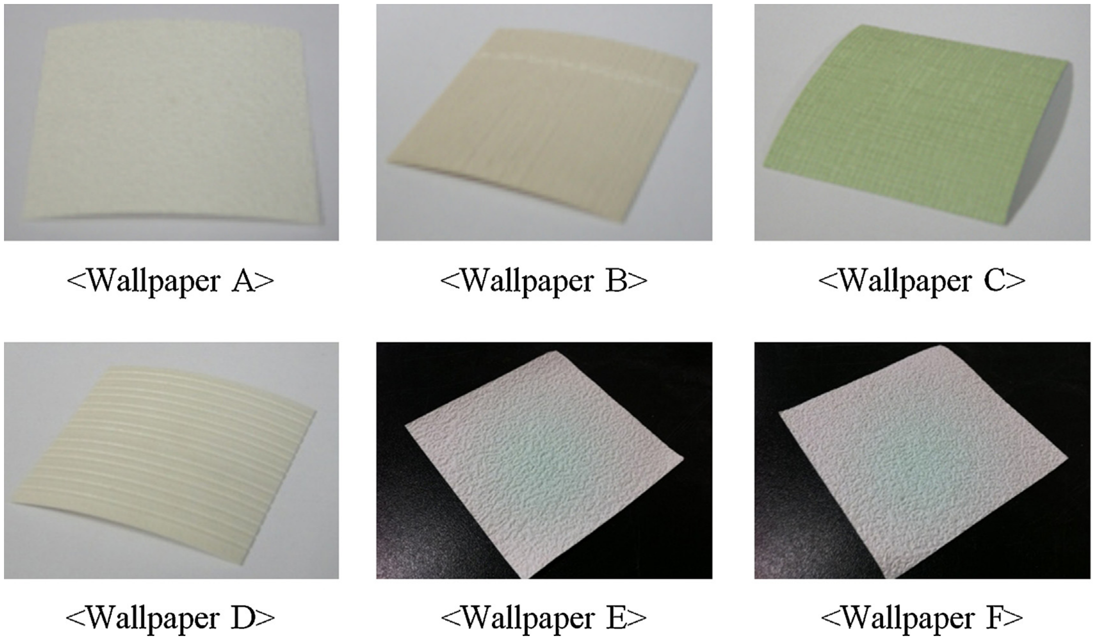

Fig. 1. The selected wallpapers.

moisture more easily and provide favourable conditions for fungal attachment and growth. D'Orazio et al. [13] conducted experimental study to establish a correlation between the hygrometric properties and organic substances of building materials (plasters, finish and paints) and the rate of mould growth. The results showed a correlation between the organic substances in building materials and the growth rate of the mould.

The aim of this study is to determine the influence of the hygric properties of interior finishing materials, i.e. wallpapers on the mould growth in built environment. In this study, we conducted an experimental study for measurement of hygric properties of wallpapers. A case study was also conducted to investigate the influence of hygric properties of wallpapers on mould growth risk. For this, mould growth risks at the specific trouble spot in a residential building with variation of hygric properties of wallpapers were evaluated using hygrothermal and bio-hygrothermal simulation approaches.

2. Measurement of hygric properties of interior finishing materials

2.1. Materials

In our mould risk analysis study, we focused on the wallpapers among the interior building materials, since it is one of the most frequently used interior finishing materials. Six types of wallpapers on the market were selected for the study (Fig. 1). Main materials of the selected wallpapers are shown in Table 1.

Table 1
Main materials of the selected wallpapers.

Wallpaper	Main material
A	PVC
B	PVC
C	Acrylic
D	PVC
E	Natural substance (porous mineral)
F	Natural substance (porous mineral)

2.2. Water vapour transmission properties

The water vapour transmission properties characterize the ability of a material to transfer moisture under a vapour pressure gradient once the steady state is reached.

In this study, water vapour transmission properties were measured using a method described in ISO 12572:2001 [14]. This standard specifies a method based on cup tests in climatic chamber for determining the water vapour permeance of building products and the water vapour permeability of building materials under isothermal conditions.

In this study, five specimens of each wallpaper were tested in the climatic chamber which was maintained within ±2% relative humidity around the 50% of relative humidity and ±0.3 °C around the 23 °C of temperature over the whole test area. In order to ensure uniform conditions throughout the chamber, air velocity in the chamber was also maintained between 0.01 and 0.06 m/s. The test specimens were periodically weighted at 24 h intervals. The specimen was embedded at the top of the cup (Fig. 2).

The relative humidity in the cup is controlled by silica gel while the relative humidity around the cup is controlled by the climatic chamber. The difference of water vapour pressures leads to a flux. For measuring water vapour transmission, a water vapour resistance factor, μ, was calculated as being the ratio of the vapour permeability of air to the vapour permeability of the material. The determined water vapour resistance factor of the selected wallpapers is shown in Fig. 3. According to the results, the ability to transmit moisture of Wallpaper E and F are better than of other wallpapers.

2.3. Moisture storage isotherm

The moisture storage isotherm relates the amount of equilibrium moisture content to the ambient relative humidity for a given temperature. In this study, the moisture storage isotherms were measured using the climatic chamber method described in ISO 12571:2000 [15]. The climatic chamber method consists of measuring the amount absorbed by the specimen at successive stages of increasing and decreasing relative humidity. The specimens were placed in the climatic chamber which regulates temperature and