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Experimental Study on the Formaldehyde Emission under Non-isothermal Conditions

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Abstract

The adverse effects of formaldehyde on the indoor air quality is of serious concern. An experimental apparatus is fabricated to investigate the features of formaldehyde migration from dry porous building materials under non-isothermal conditions. The coupled heat and formaldehyde migration process in an ordinary particle board is investigated in both floor heating system and air circulation system. The instantaneous concentration of formaldehyde in the chamber , the instantaneous temperature of the air, and the instantaneous temperature of the top surface of the board is studied. The temperature of the bottom surface of the board is maintained at 15°C throughout the process. As shown in the experimental process, the equilibrium concentration of formaldehyde increases with an increase in the temperature of air. The equilibrium concentration in an airtight chamber having floor heating system is higher than that in an air circulation heating system. The experimental results validated proposed model. Therefore, it is necessary to improve the ventilation of the rooms using such systems.

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Keywords: Formaldehyde emission; Experimental study

1. Introduction

Porous building materials, including medium density board, particle board and wood based floorboard, are widely used in interior decorations and as construction materials. Exposure to formaldehyde can cause skin irritation,

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allergic reactions, and is a cancer hazard. Patients with long-term exposure to formaldehyde in building material have shown symptoms of sick building syndrome (SBS) [1]. The adverse effects of formaldehyde on the of indoor air quality (IAQ), is therefore of serious concern. The transport of formaldehyde in porous building materials has been an active area of research [2-4]. In order to minimize the emission of formaldehyde from composite materials made from urea-formaldehyde (UF) resins and phenol-formaldehyde (PF), emission norms were established in 1981 [5].

The understanding of various VOCs emission problems of building materials under isothermal conditions [6, 7], have been of particular interest. In the past few years in China, there have been an increasing demand for air circulation systems, and radiant floor heating systems. These systems affect the VOCs migration process a non-isothermal environment. In floor heating systems, the heat is transferred from the floor surface to other surfaces mainly by radiant heat transfer, which is different from air circulation systems that deliver heat from the air to the interior building material by convective heat transfer.

Thus far, the effect of the non-isothermal condition on VOCs migration process has been considered to be almost negligible in most of the proposed studies. Only a few investigators have noticed that the non-isothermal condition is one of the key parameters that influence VOCs migration process from building materials together with the initial conditions [8-11]. An et al. experimentally studied the effect of room temperatures on formaldehyde emission from floor materials, such as laminate and plywood floorings, and furniture materials, such as MDF and particleboard veneered with decorative paper foil, by desiccators method [12]. Kang et al. experimentally investigated the effect of bake-out on reducing indoor VOCs concentrations in a residential building unit with a radiant floor heating system [13]. The effect of an elevated temperature on formaldehyde emissions from a wallpaper assembly, plywood flooring assembly, and particle board (as an example of furniture material) was studied in a small-scale chamber [13]. In Germany and the United States, large-scale test chambers were used for the evaluation of formaldehyde emissions [14]. Although the large-scale chamber method is very reliable, it is also time-consuming and expensive.

Due to a lack of accurate description of the coupled heat and formaldehyde migration process under non-isothermal conditions, the heat and mass transfer in porous building materials have not been fully understood. Therefore, in this study, an experimental apparatus which to investigate the formaldehyde migration in composite board under non-isothermal conditions is fabricated. The coupled heat and formaldehyde migration process in an ordinary particle board is studied under non-isothermal conditions using floor heating and air circulation heating systems.

2. Methods

It is found that formaldehyde is one of the main VOCs emitted from wood-based building materials in China. Since 2001, the Chinese government has set standards for IAQ. The Ministry of Environment prohibits the use of building materials emitting more than 9 mg/100g formaldehyde. The coupled heat and formaldehyde transfer in a particle board commonly used in residential units in China is studied in the present work.

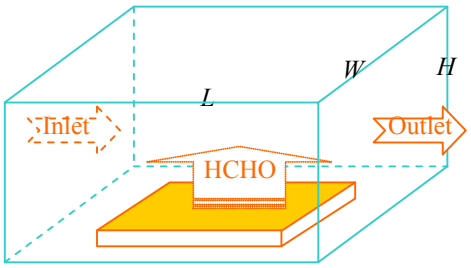

Fig. 1. Schematic of a simplified environmental chamber

In Fig. 1, a schematic of the environmental chamber containing the test slab is shown. In order to study the effect of non-isothermal conditions on the formaldehyde diffusive transport, the temperature of the bottom layer of the