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Multi-target identification for emission parameters of building materials by unsteady concentration measurement in airtight micro-cell-type chamber

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ABSTRACT

The purpose of this study is to develop a concurrent determination method that can estimate multiple emission parameters, that is, the emission rate, initial concentration and effective diffusion coefficient *Dc* in building materials, by a single unsteady concentration measurement. This study focused on the time history of VOC concentration in the gas phase that occurred when the target building material was covered with an airtight micro-cell. The VOC concentration in the micro-cell gradually increased and finally reached an equilibrium concentration. Under the condition of uniform distribution of initial concentration, the profile of VOC concentration in the micro-cell was determined by the order of the *Dc* value. A chart of the time history of VOC concentration as a function of *Dc* and thickness of building materials was prepared in advance by numerical analysis and then *Dc* was estimated by overlapping the measurement result with this chart. A chart of emission rate as a function of *Dc* and building material thickness was also prepared and the determination procedure of the emission rate taking into account the consistency between the 20 L small chamber method with in- and out-flow and the micro-cell method under an airtight condition was proposed. The estimation results of *Dc* and emission rate by this method were reasonably consistent with the results of the conventional method.

1. Introduction

Indoor air quality is one of the most important factors when designing a healthy indoor climate [1]. It has been reported that many building materials emit volatile organic compounds (VOCs), which cause sick building syndrome, for example, nose, eye or throat irritation, asthma and other chemical sensitivities [2]. In order to prevent indoor air pollution by VOC emitted from building materials, it is necessary to select suitable building materials with low VOC emissions, and to predict the VOC concentration level in rooms at the design stage. From this point of view, information on physical/chemical properties of building materials, such as VOC emission rate, effective diffusion coefficient and chemical content (initial concentration in building materials), is important for healthy indoor environmental design.

Assuming one-dimensional diffusion along the direction of material thickness, VOC emission rate E at steady state is denoted as shown in equation (1) using representative VOC concentration in building material C_m (mg/m^3) and gas phase concentration of VOC in chamber C_a (mg/m^3).

$$E = \frac{C_m - C_a}{R_m + R_a} \tag{1}$$

Here, R_m (s/m) indicates the resistance of mass transfer defined by both effective diffusion coefficient Dc and diffusion length scale, and R_a (s/m) is the resistance of convective mass transfer defined by flow characteristics over the surface of the building material. On the other hand, in a case of representative VOC concentration in chamber C_a as a perfect mixing concentration, C_a is defined as follows if the concentration in supply air is assumed to be zero.

$$C_a = \frac{EA}{Q} \tag{2}$$

Here, Q (m^3/s) is supply airflow rate to the chamber and A (m^2) represents the surface of the building material. Substitute equation (2) into equation (1) and the following result is obtained.

$$E = \frac{C_m}{R_m + R_a + \frac{A}{Q}} \tag{3}$$

In the case of large R_m and small R_a ($R_m >> R_a$), the flow and turbulent structures over the surface of the building material do not

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