Brief Report

Development of Labeled Compound Addition Method for the Prediction of VOC Concentrations Emitted from Vehicle Parts

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1. Introduction

In recent years, health consciousness has become increasingly important in automobile development. Many automobile manufacturers are working to reduce the amount of volatile organic compounds (VOC) in vehicle cabins. In Japan, the Japan Automobile Manufacturers Association, Inc. (JAMA) announced voluntary guidelines for the concentrations of 13 types of vehicle cabin VOCs in 2005.[1] Vehicle cabin VOC concentrations are officially evaluated using a defined method (e.g., the JAMA method), but those in small-sized parts (e.g., test pieces (TP), assembly parts) are often evaluated by other methods (e.g., sampling bag method, chamber method) depending on the type and the size of the sample.[1-3] Therefore, all of the parameters in evaluation including sample size, amount of gas, and ventilation frequency vary according to the method used. Owing to these variable conditions, it is difficult to predict VOC concentrations in vehicle cabins from the evaluated VOC values of component parts. To address this, we have studied the relationship between obtained and predicted values for different methods of evaluation and then tried to estimate the amount of VOC emitted from multiple samples. In this paper, we present the results for measurement of toluene using the sampling bag method.

The sampling bag method is a method to evaluate VOCs emitted from TP samples. A sample TP and nitrogen gas are put in a plastic bag. The bag is set into a thermostat chamber. After a defined time period, the gas in the bag including VOC emitted from TP is condensed in adsorbents and the condensed VOC in the adsorbents are analyzed by GC/MS and HPLC.

2. Relationships Between Toluene Concentration and Conditions of Evaluation

As a first step, we investigated the effect of the evaluation conditions (heating time, sample value, gas volume, and heating temperature) on the toluene concentration. As a result, the following four observations were made:[4]

1) The amount of volatilized toluene reaches a stable level after 4.5 h, which is the heating period for a standard measurement.

2) The amount of volatilized toluene is not proportional to the number of samples in the bag.

3) The amount of volatilized toluene increases with increasing gas volume in the bag.

4) The amount of volatilized toluene increases with increasing heating temperature.

On the basis of these results, we assumed that the VOC emitted from a sample (*RG*) can be described by the VOC contained in the sample (*RA*) and the adsorptive capacity (*K*) when the VOC concentration in the bag reaches equilibrium. We defined *K* as the proportion of VOC remaining in the sample (*RS*) to VOC emitted from the sample (*RG*). *RA* can be expressed as the sum of *RS* and *RG*. It was considered that adsorptive capacity varies in inverse proportion to the amount of gas present and exhibits additivity with respect to sample amount.

Next, we developed a novel method, called the labeled compound addition method, incorporating a labeled compound to estimate *RA* and *K*. In this method, we added a specific amount of a labeled compound (e.g., deuterium-labeled VOC) (*RA'*) to the nitrogen gas in the bag. The labeled compound should behave similarly to the VOC in the bag. The amount of VOC emitted (*RG*) and that of the labeled compound not adsorbed into the sample (*RG'*) were evaluated by

quantitative analysis. The adsorptive capacity of the labeled compound (*K'*) was calculated by total amount of the labeled compound (*RA'*) and amount of the labeled compound in the gas phase of the bag (*RG'*). *K'* and *K* are considered to be of equal value. Thus, *RS* and *RA* can be calculated by estimating the value of adsorptive capacity (*K*) and the emitted amount of VOC from the sample (*RG*).

3. Estimation of the Amount of VOC Emitted from Multiple Samples

We then tried to predict the amount of VOC emitted from multiple samples by using the measured values of individual samples (**Fig. 1**). The *K*, *RA* and *RG* values for sample-A and sample-B were estimated by the labeled compound addition method as follows: sample-A: $K = 7.70$, $RA = 2.77$ μg/TP, $RG = 0.32$ μg/bag; sample-B: $K = 1.24$, $RA = 0.17$ μg/TP, $RG = 0.08$ μg/bag. One piece of sample-A and four pieces of sample-B were used for the estimation. The integrated values of *K* and *RA* were calculated as 12.7 and 3.45 μg, respectively. The value of *RG* predicted using *K* and *RA* was 0.25 μg/bag, and that measured by using the sampling bag method was 0.27 μg/bag. Thus, the predicted and measured values of *RG* were in good agreement with each other (**Fig. 2**). This suggests that the method proposed in this study can be successfully applied for estimating the amount of VOC (*RG*).

4. Summay

We have studied the relationship between obtained and predicted values for different evaluation conditions and then tried to estimate the amount of VOC emitted from multiple samples. We focused on the values measured using the sampling bag method. We assumed that the amount of VOC contained in the parts (*RA*) and the adsorptive capacity of the parts (*K*) can describe the amount of VOC emitted (*RG*) when the VOC concentration in the bag attains equilibrium. We proposed a novel method, called the labeled compound addition method, for estimating the values of *RA* and *K*. The method proposed in this study was considered to be effective for predicting the amount of VOC emitted. We intend to survey the range of materials to which this method can be applied.

References

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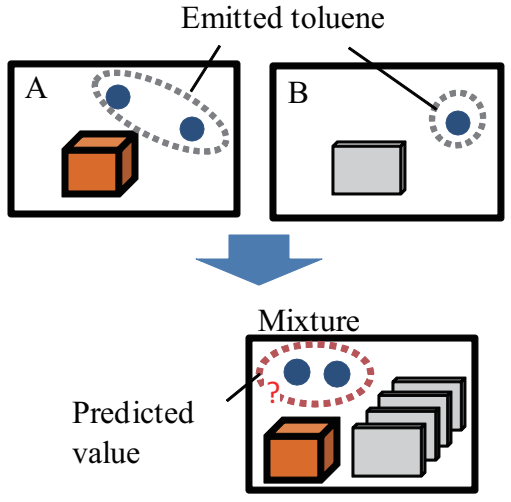

Fig. 1 The prediction of mixture samples.

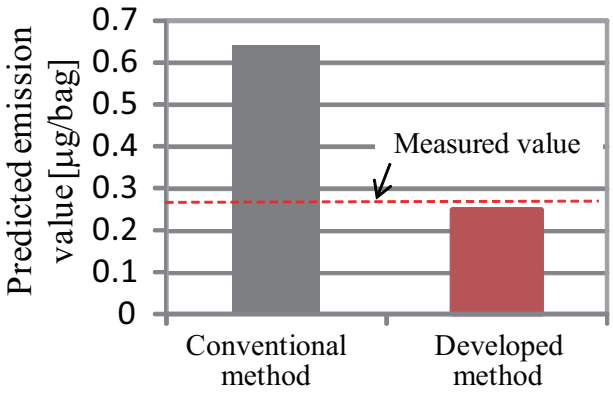

Fig. 2 The result of prediction.

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