Development of a Condensable Particulate Matter Generator

Ting-Yu Lin[1] , Chih-Wei Lin[1] ,Sheng-Hsiu Hung[1], Chih-Chieh Chen[1]

[1]Institute of Environmental and Occupational Health Sciences, National Taiwan University

*Corresponding Author, Tel: +886-2-3366-8086, E-mail: ccchen@ntu.edu.tw

Introduction

There are two EPA methods for sampling condensable particulate matter (CPM) such as dilution and condensation. The condensation method is generally thought to overestimate CPM emissions because dissolved gases. Dilution sampling have more accurately represent particulate concentrations from stack emissions because they better simulate the natural physicochemical processes of particulate formation in the atmosphere. Many research found the measurement was difference between two methods. In order to compared two methods measurement biases we designed a CPM generator to produce condensable particles with known composition, concentration and stability. With this CPM generator to evaluate the factors affecting CPM measurements and to improve the accuracy of the CPM methods.

Materials and Methods

CPM uses IC automatic temperature control tin melting furnace to heat paraffin wax (Fig 1). Paraffin wax is solid at room temperature and begins to melt above approximately 37 °C and its boiling point is above 300 °C. Besides, paraffin wax has low vapor pressure (0.013kPa at 20°C) which can provide stable property of CPM (Table 1). Heating paraffin wax is to produce paraffin vapor after cooling down vapor temperature by passing through a glass serum bottle to formed as paraffin wax particle simulating the CPM in stack. Thermocouples are installed at the bottom of the tin furnace and sampling pipe entrance to represent the heating and sampling temperature, respectively. Control CPM concentration by adjusting IC automatic temperature control tin melting furnace heating temperature (100-130°C) which can control the paraffin wax vapor amount. The instantaneous concentration and particle size of the CPM were analyzed by using an aerodynamic particle sizer, beta gauge, optical particle sizer and haz dust. Also use 37 mm Teflon filters as the reference mass concentration.

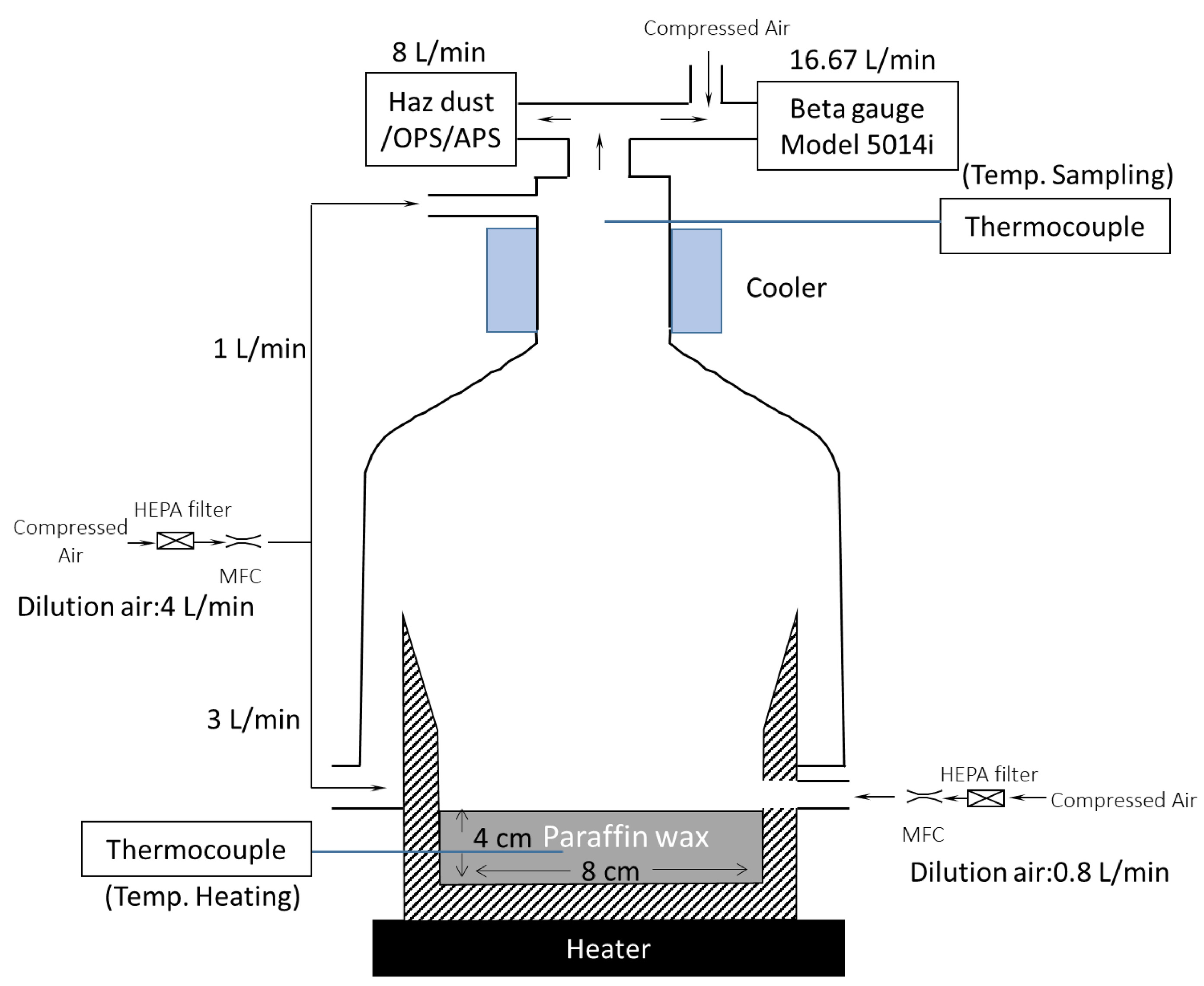

Fig. 1 Schematic diagram of the experimental system set-up.

Table 1. The physicochemical properties of paraffin wax

	Paraffin wax
Molecular Formula	$C_{25}H_{52}$
Molecular Weight (g/mol)	352
Density (g/cm³)	0.90 g/cm³ (20 °C)
Boiling Point (°C)	>300 °C (1013 hPa)
Vapor Pressure (mmHg)	0.013 kpa (20°C)
Saturation mass concentration (C*, μg/m⁻³)	1.88 x 10⁶
Classification (N. M. Donahue et al., 2012)	IVOC

Classification of volatility (N. M. Donahue et al., 2012)

1. Extremely low volatility organic compounds (ELVOC, C* <3×10⁻⁴ μg/m⁻³)
2. Low volatility organic compounds (LVOC, 3×10⁻⁴ < C* <0.3 μg/m⁻³)
3. Semi-volatile organic compounds (SVOC, 0.3< C* <300 μg/m⁻³)
4. Intermediate volatility organic compounds (IVOC, 300 < C* < 3×10⁶ μg/m⁻³)
5. Volatile organic compounds (VOC, C* > 3×10⁶ μg/m⁻³).

Results and Discussion

It takes approximately 20 minutes for the generator to be stabilized (Fig 2). The relationship between heating temperature and mass concentration is a parabola and its mathematical formula is $y=6\times10^{-6}\exp(0.1056x)$ (Fig 3). As the heating temperature increases, both the mass and the number concentration have a high peak in the large particle size (Fig 4). The main reason is that when the heating temperature is increased, the paraffin vapor will increase, too. Compared mass concentration of OPS, beta gauge, haz dust, aerodynamic particle sizer and filters. The result show that mass concentration of OPS, beta gauge, haz dust, aerodynamic particle sizer and filters can be estimated by the relationship of y=0.6231x, y=0.3643x, y=2.2267x, y=1.4747x (Fig 5). Since CPM composition is complex and contains volatile substances which may cause bias when weighing the sampling filters. After sampling the filters will move to weighing chamber to conditioning and every few days weighing the filters to evaluate the variability of paraffin wax weight. The result shows that comparing with blank filter. After 22 days' condition, the CPM and blank filter weight variation is about 2.07, 1.45 μg which in keeping with the standard of constant weight of the filter (<0.5 mg). (Fig 6)

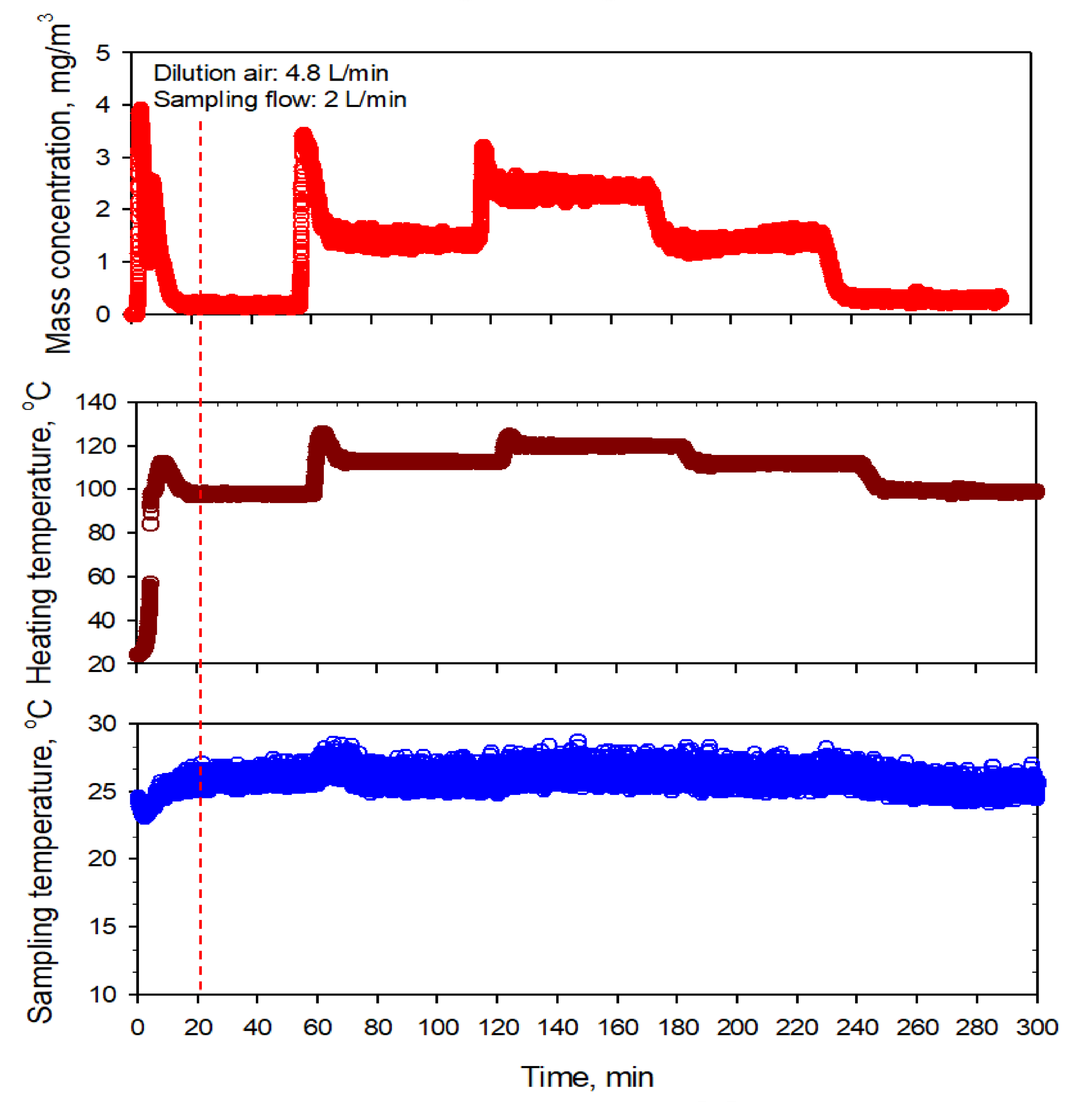

Fig. 2 System stable test

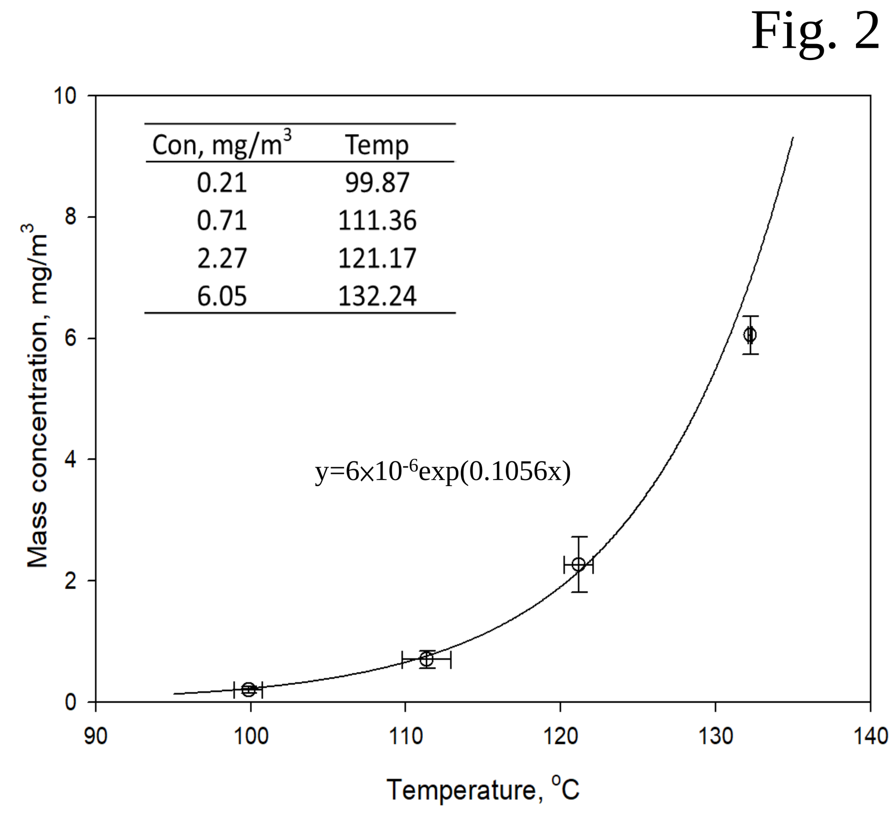

Fig. 3 The relationship between heating temperature and mass concentration

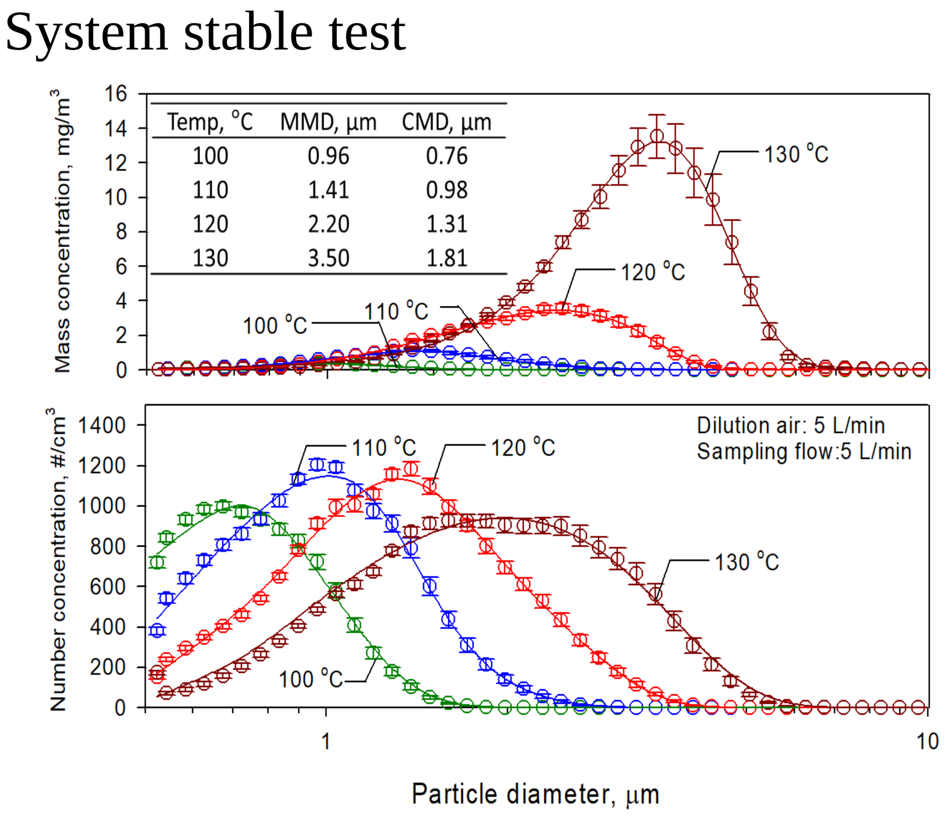

Fig. 4 Particle size distribution

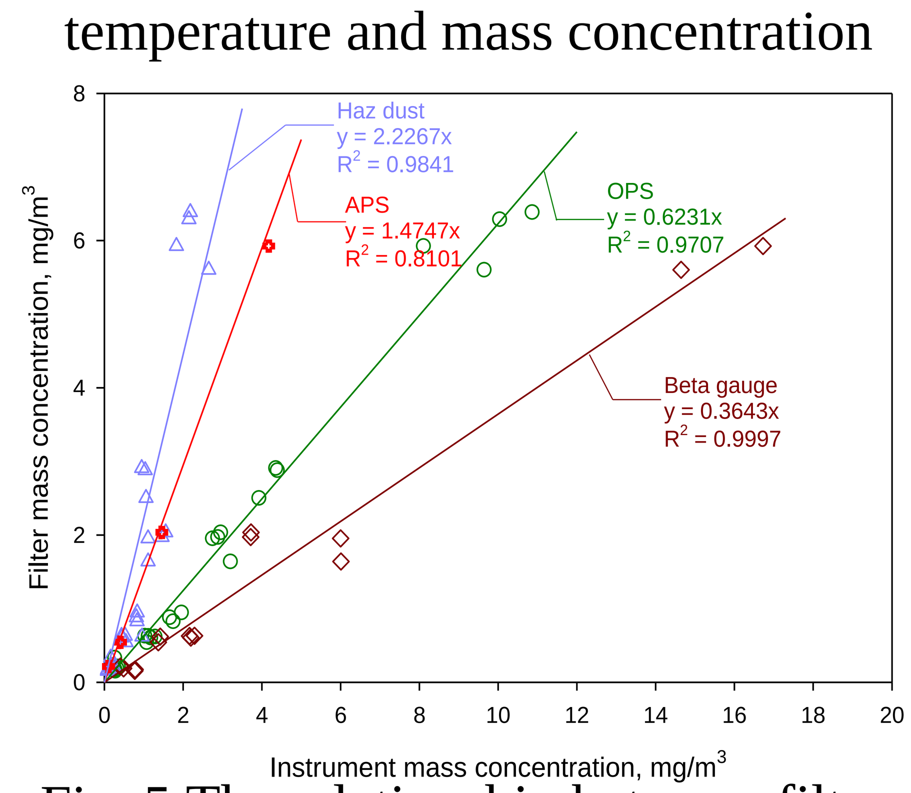

Fig. 5 The relationship between filters and instruments

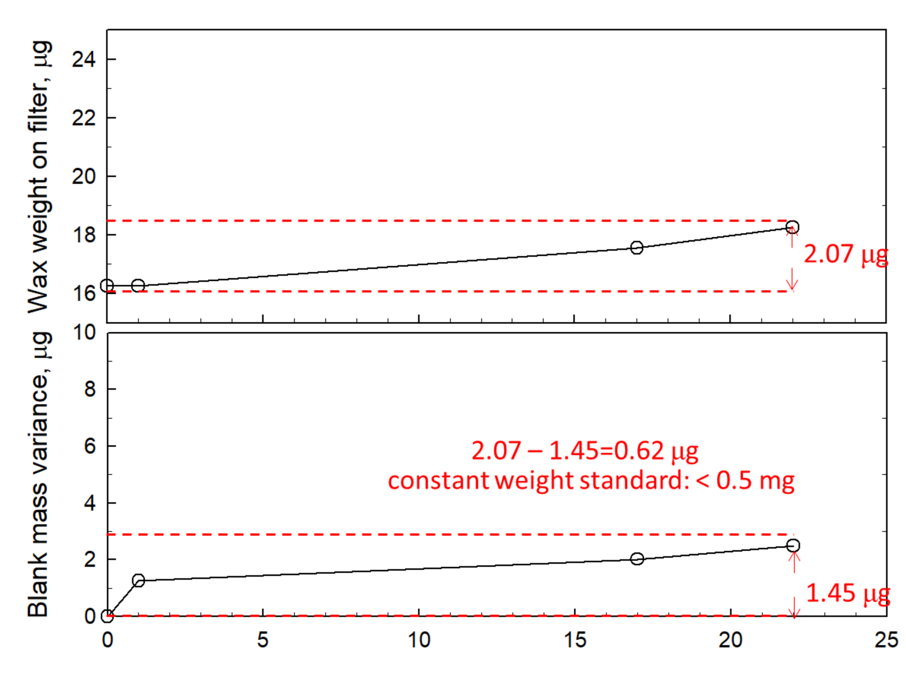

Fig. 6 Filter constant weight test

Conclusions

In conclusions, this generator produces CPM with known composition, concentration and long-term stability.