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Sedimentation behavior of indoor airborne microparticles

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Abstract: Experiments on the behavior of airborne microparticle sediments and their adhesion on glass slides were conducted in a laboratory located on the first floor of a teaching building. Clean tiles and glass slides were placed at different angles (0°, 45° and 90°) with respect to the horizontal plane in the laboratory. The sedimentation of microparticles was investigated at certain time intervals (1 d, 3 d, 10 d and 30 d). The results of testing, at day 30, show that the diameters of particles on the horizontal tiles varied from 20 to 80 μm; few particles with diameter less than 0.5 μm or greater than 100 μm were found. The amount of particle sediment on all the slides increased along over time, while the average diameter of particles was not correlated with time, nor with the angle of placement. The maximum particle size, the total particle surface area, the total perimeter of all particles and the cover ratio of light (the proportion of total area of particles to the observed area of the slides surfaces) did not change significantly within the first 10 days. Inspection of all the samples for the last 20 days, however, showed that these variables increased substantially with the passage of time and were in reverse proportion to the placement angles, which indicates a concentration of particles, as well as physical and chemical changes.
Key words: particle; sedimentation; size distribution; surface; indoor air

1 Introduction

China is one of the countries in the world with serious atmospheric pollution, especially in some metropolitan areas. Frequently, the average concentration of dust in some cities is beyond the second level of the Ambient Air Quality Standard (GB3095-1996). In mining areas, particles in the air mainly consist of aerosols in the atmosphere, which have complex mineral and chemical components. During the past few years, numerous studies have been conducted on airborne particles and associated problems regarding the quality of the atmospheric environment, the ecology, human health, etc[1–7]. Up to now, atmospheric particle depositions and characteristics have been investigated through experiments[8–13]. However, few investigations on indoor particle sedimentation and adhesion behavior are available, which focus on particle concentration and deposition characterization under different ventilated conditions[14]. These include indoor and outside dust effects on indoor air quality, the effect of wall texture on particle deposition and characteristics of particle deposition on smooth and rough indoor vertical surfaces[15–18]. Therefore, we present some experiments conducted on the factors affecting particle sedimentation and adhesion behavior on object surfaces of indoor air. It is expected to be beneficial to particle governance, surface cleaning and helping to make the indoors dustproof.

2 Test discription

A laboratory in a teaching building at Central South University was selected for our experiment. The laboratory has four windows in one wall. The left and right windows were kept one-third open during the test. Clean tiles were placed on top of an experimental table, with height of 1.1 m, in the middle of the room. Fig. 1 displays the ichnography of the laboratory disposal. The collection and analysis of particles sediments on the tiles under natural ventilation for 30 days will be used to come to a better understanding of the basic physical characteristics of the particles. The results will be used for subsequent research.

For the purpose of comparison, a set of clean glass slides (76.2 mm×25.4 mm×1.0 mm) were placed on top of the same table. The response variables in our particle sampling scheme were four time intervals (1 d, 3 d, 10 d and 30 d) and three placement angles from the horizontal plane (0°, 45° and 90°).

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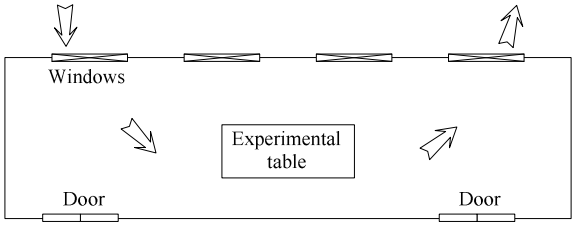

Fig. 1 Ichnography of laboratory disposal

The experimental equipment involved was a programmable high temperature chamber (Chongqing Hanba, HT302E), a laser particle size analyzer (Zhuhai OMEC, LS-800) and an analytical micrograph system (Beijing TEC, SA3300).

3 Experimental results and analysis

3.1 Particles on the tile surfaces

Given the experimental requirements, the tiles and glass slides were placed in the room at the start of the test. The weather conditions under which particles were recorded and analyzed at different days are listed in Table 1.

Table 1 Outdoor weather conditions during experiment

Time	Temperature (°C)	Relative humidity (%)	Outdoor weather
Day 1	4~6	50~60	Cloudy to small amount of rain
Day 3	7~8	64	Small amount of rain
Day 10	7~8	78	Middling snow to cloudy
Day 30	13~14	67	Cloudy to fine

The laser particle size analyzer was used to investigate the diameter of the particles. Particles were saturated in clean water and oscillated by using an ultrasonic cleaning machine for 2 min. Particles with diameters ranging from 0.05 to 300 μm were analyzed. Fig. 2 displays the diameter distribution of particles collected on day 30 from the slide placed at 0°. Results are also listed in Table 2.

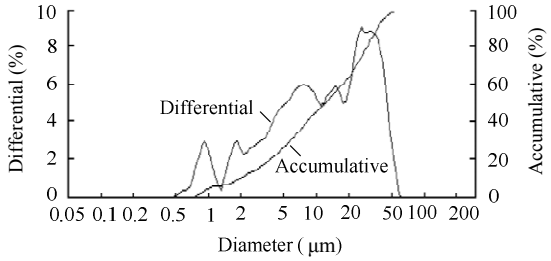

Fig. 2 Size distribution of particles

Table 2 shows that the diameters of most particles were between 20 and 80 μm. Few particles had diameters less than 0.5 μm or greater than 100 μm. The percentage changes from one size to the next was minimal in the range of 0–0.5 μm. There were some changes between sizes from 0.5–20 μm, while significant changes were seen in the range of 20–100 μm and almost no change occurred in sizes >100 μm. Indoor particles came largely from the outdoors and the concentration of particles depended on the outdoor concentration. The ventilation ratio significantly affected the size and distribution of indoor particles[15]. It is suspected that the particles were mainly from the outdoor atmosphere since there was no source of particles in the laboratory where this experiment was conducted. The behavior of particles sedimentation was affected by outdoor atmospheric conditions as well as weather conditions.

Table 2 Size distribution of particles on tile surfaces

Size (μm)	Percent (%)	Total (%)	Size (μm)	Percent (%)	Total (%)	Size (μm)	Percent (%)	Total (%)
0.42	0.04	0.04	3.48	1.64	9.26	29.1	6.32	41.20
0.52	0.21	0.25	4.31	2.12	11.38	35.9	7.78	48.98
0.64	0.38	0.64	5.32	2.30	13.68	44.4	10.99	59.97
0.79	0.87	1.51	6.58	2.48	16.16	54.9	13.91	73.89
0.98	1.21	2.72	8.14	2.65	18.81	67.9	13.65	87.54
1.21	0.52	3.24	10.06	2.83	21.64	84.0	7.96	95.50
1.49	0.58	3.82	12.44	2.76	24.40	103.8	3.42	98.92
1.84	1.46	5.28	15.38	2.63	27.30	158.7	0.06	100.00
2.28	1.20	6.48	19.0	3.11	30.14			
2.82	1.14	7.62	23.5	4.74	34.88			

3.2 Particles on slide surfaces

The slides were numbered and particle samples at three areas (740 μm×530 μm) along the middle line of the surface of each slide were analyzed by using our analytical micrograph system. The system measured diameter, area and perimeter etc of each particle as shown in Fig. 3. The parameters and curves of the distribution were also provided by the system. Representative data are listed in Tables 3, 4 and 5. The

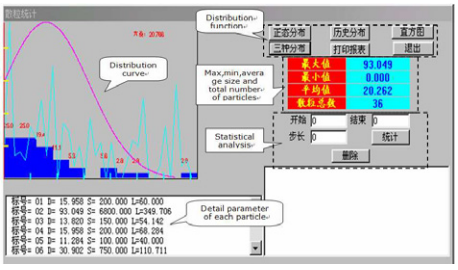

Fig. 3 Analytical results of particles