Application study of self-made standard dust in atmospheric particulate monitor calibration device

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Abstract. The ISO12103-1 A2 test dust was used as the reference in the calibration device of the atmospheric particle monitor to investigate the performance of the self-made standard dust in this study. The result indicated that when the aerosol concentration of the calibration device was 500μg/m^3, 400μg/m^3, 200μg/m^3, 100μg/m^3 and 50μg/m^3, the stability of self-made standard dust was close to the ISO12103-1 A2 test dust. In addition, when the aerosol with high concentration of 500μg/m^3, medium concentration of 200μg/m^3 and low concentration of 50μg/m^3, the homogeneity and obtained concentration of the self-made standard dust and the ISO12103-1 A2 test dust evaluated by filter membrane sampling were not much differed. Therefore, the self-made standard dust can replace ISO12103-1 A2 test dust to be used in the calibration device of particle monitor.

1. Introduction
In recent years, PM pollution has became a major air problem in China. The PM pollution, especially the fine particles(PM_{2.5}) causes serious adverse effect on human health and atmospheric radiation. In the past few years, China has experienced serious haze events in different regions[1-2]. The regional outbreak of haze have became important event of air pollution in China both for public and regulatory agencies[3-4]. During the haze events, the daily concentration of PM_{2.5} is rapidly increased up to (500-800)μg/m^3[5-6], reducing visibility and even causing potential health problems. The pollution problems of haze have attracted more and more public and regulatory attentions.

In order to prevent the further deterioration of air quality and to protect human health and the ecosystem, the Chinese government had implemented a series of national control policies since 2005, such as 《Calibration Specification for PM_{2.5} Mass Concentration Measurement Instruments》 (JJF 1659-2017),which pointed out clearly that standard test dust must be used in the calibration process of PM_{2.5} mass concentration monitor. At present, most commonly used of the standard test dust at home and abroad is ISO12103-1 test dust, which is prepared by making use of the desert sand of Arizona in USA. However, the ISO12103-1 test dust we used was mainly depend on foreign import, its price was high and its supply cycle was very long. In order to solve this situation, a new type of test dust was prepared by comparing with the ISO12103-1 A2 test dust, which its characteristic value was D_{50}=(10.28\pm0.24)μm and D_{90}=(30.67\pm1.33)μm. Therefore, the ISO12103-1 A2 test dust was used as the...
reference in the calibration device of the atmospheric particle monitor to investigate the performance of the new test dust in this study.

2. The experiment design

The working principle of the calibration device of the mass concentration monitor was that the three-channel jet aerosol generator sent out aerosol, which was diluted by the clean gas, and then mixed, diffused and settled, and the calibration process was completed by comparing the concentration indication error of the standard monitor and the measured monitor. The standard monitor was β-ray PM$_{2.5}$ monitor (Thermo Scientific, MP101M, USA), which was located in the center of the equipment room, and the measured monitor (LPM1000, zhangjiagang langyi electromechanical equipment co., LTD.) was located in the equipment room, which was 15cm away from the standard monitor. In this study, the BGI PM$_{2.5}$ cutting head of the calibration device was 16.7L/min, and the aerosol concentration was 2g/L, 1g/L and 0.5g/L respectively, which was prepared by ISO12103-1 A1 powder and ultra-pure water. According to the previous experiment, the repeatability and homogeneity of the calibration device are less than 5% and 7% respectively[7].

Because of the calibrated aerosol concentration of the device was divided into (25-75)μg/m$^3$, (75-250)μg/m$^3$ and (250-600)μg/m$^3$, the aerosol concentration of 500μg/m$^3$, 400μg/m$^3$, 200μg/m$^3$, 100μg/m$^3$ and 50μg/m$^3$ were selected to investigate the performance difference between self-made standard dust and ISO12103-1 A2 powder.

3. Results and discussion

First of all, the stability of self-made standard dust as the aerosol source and its difference with A2 powder were investigated. It can be seen from Fig.1 when the aerosol concentration of the calibration device was 500μg/m$^3$, the average aerosol concentration of A2 powder was (494-507) μg/m$^3$ every 5 minutes, and the average concentration within 30 minutes was 501 μg/m$^3$. The detected concentration of the device was (493-517) μg/m$^3$ every 5 minutes, and the average concentration within 30 minutes was 506μg/m$^3$. The difference between the aerosol concentration and the detected concentration was only 5μg/m$^3$, about 1% of the actual aerosol concentration. The mean concentration of the aerosol solution which was made up of the self-made standard dust was (502-512) μg/m$^3$ every 5 minutes, and the average concentration within 30 minutes was 507μg/m$^3$. The mean detected concentration of the device was (486-497)μg/m$^3$, and the average concentration within 30 minutes was 491μg/m$^3$. The difference between the aerosol concentration and the detected concentration was 16μg/m$^3$, which was about 3.1% of the actual aerosol concentration.

![Figure 1](image-url)

**Figure 1** Comparison diagram of A2 powder and self-made standard dust at the concentration of 500μg/m$^3$ (Left diagram:A2 powder; Right diagram:self-made standard dust).
As shown in Fig.2, when the aerosol concentration of the device was 400μg/m³, the mean concentration of A2 powder was (400-425)μg/m³ every 5 minutes, and the average concentration within 30 minutes was 412μg/m³. The mean detected concentration of the device was (400-435)μg/m³ every 5 minutes, and the average concentration within 30 minutes was 417μg/m³. The difference between the concentration and the detected concentration was only 5μg/m³, which was about 1.2% of the actual aerosol concentration. The mean concentration every 5min which was made up of the self-made standard dust was (396-405)μg/m³, and the average concentration within 30min was 402μg/m³. The mean detected concentration of the device was (386-392)μg/m³, and the average concentration within 30 minutes was 388μg/m³. The difference between the concentration and the detected concentration was 14μg/m³, which was about 3.5% of the actual aerosol concentration.

Figure 2 Comparison diagram of A2 powder and self-made standard dust at the concentration of 400μg/m³ (Left diagram:A2 powder; Right diagram:self-made standard dust).

As shown in Fig.3, when the aerosol concentration of the calibration device was 200 μg/m³, the average concentration of A2 powder was (197-207) μg/m³ every 5 minutes, and the average concentration within 30 minutes was 202μg/m³. The mean detected concentration of the device was (202-212)μg/m³ for every 5 minutes, and the average concentration within 30 minutes was 208μg/m³. The difference between the concentration and the detected concentration was 6μg/m³, which was about 3.0% of the actual aerosol concentration. The mean concentration every 5min which was made up of the self-made standard dust was (204-219)μg/m³, and the average concentration within 30min was 211μg/m³. The mean detected concentration of the device was (202-216)μg/m³, and the average concentration within 30 minutes was 208μg/m³. The difference between the concentration and the detected concentration was 3μg/m³, which was about 1.4% of the actual aerosol concentration.

Likewise, as shown in Fig.4, when the concentration of the calibration device was 100μg/m³, the difference between the concentration and the detected concentration of A2 powder within 30 minutes was only 6μg/m³. The difference between the concentration and the detected concentration of the self-made standard dust within 30 minutes was 4μg/m³, when the concentration of the calibration device was 50μg/m³, the difference between the concentration and the detected concentration of A2 powder within 30 minutes was only 5μg/m³. The difference between the concentration and the detected concentration of the self-made standard dust within 30 minutes 6μg/m³(As shown in Fig.5).

When the aerosol with high concentration of 500μg/m³, medium concentration of 200μg/m³ and low concentration of 50μg/m³, filter membrane sampling was used to evaluate the performance difference between the self-made standard dust and A2 powder. The sampling head 1 and 2 of the calibration device were selected as the investigated target. The result was shown in Fig.6, when the concentration of the calibration device was 500μg/m³, the average concentration of A2 powder was (486-511)μg/m³ every 30 minutes, and the average concentration within 180 minutes was 501μg/m³, and the aerosol concentration of the sampling head 1 and 2 were 407μg/m³ and 410μg/m³ respectively, the homogeneity
of the two sampling head was 0.72%, which was calculated by the previous formula [7]. Meanwhile, the mean concentration of the self-made standard dust every 30 minutes was (500-503)μg/m$^3$, and the average concentration within 180 minutes was 502μg/m$^3$. The concentration of the sampling head 1 and 2 were 363μg/m$^3$ and 357μg/m$^3$ respectively, and the homogeneity of the two sampling heads was 1.64%.

**Figure 3.** Comparison diagram of A2 powder and self-made standard dust at the concentration of 200μg/m$^3$ (Left diagram:A2 powder; Right diagram:self-made standard dust).

**Figure 4.** Comparison diagram of A2 powder and self-made standard dust at the concentration of 100μg/m$^3$ (Left diagram:A2 powder; Right diagram:self-made standard dust).

**Figure 5.** Comparison diagram of A2 powder and self-made standard dust at the concentration of 50μg/m$^3$ (Left diagram:A2 powder; Right diagram:self-made standard dust).
As shown in Fig.7, when the concentration of the calibration device was 200μg/m$^3$, the average concentration of A2 powder was (200-201)μg/m$^3$ every 60 minutes, and the average concentration within 300 minutes was 200μg/m$^3$. The aerosol concentration of the sampling head 1 and 2 were 184μg/m$^3$ and 174μg/m$^3$, respectively, the homogeneity of the two sampling head was 4.94%. Meanwhile, the average concentration of the self-made standard dust every 60 minutes was (200-201)μg/m$^3$, and the average concentration within 300 minutes was 201μg/m$^3$. The concentration of the sampling head 1 and 2 were 174μg/m$^3$ and 166μg/m$^3$ respectively, and the homogeneity of the two sampling heads was 4.16%.

As shown in Fig.8, when the concentration of the calibration device was 50μg/m$^3$, the average concentration of A2 powder was (46-51)μg/m$^3$ every 60 minutes, and the average concentration within 360 minutes was 50μg/m$^3$. The concentration of the sampling head 1 and 2 were 35.57μg/m$^3$ and 37.19μg/m$^3$, respectively. The homogeneity of the two sampling heads was 3.93%. Meanwhile, the average concentration of the self-made standard dust every 60 minutes was (50-51)μg/m$^3$, and the average concentration within 360 minutes was 50μg/m$^3$. The concentration of the sampling head 1 and 2 were 33.33μg/m$^3$ and 31.67μg/m$^3$ respectively, and the homogeneity of the two sampling heads was 4.54%.

![Figure 6](image-url1)

**Figure 6.** Membrane sampling diagram of A2 powder and self-made standard dust at the concentration of 500μg/m$^3$ (Left:A2 powder; Right:self-made standard dust).

![Figure 7](image-url2)

**Figure 7** Membrane sampling diagram of A2 powder and self-made standard dust at the concentration of 200μg/m$^3$ (Left:A2 powder; Right:self-made standard dust).
4. Conclusion

To sum up, the stability of self-made standard dust was close to the ISO12103-1 A2 test dust, and the homogeneity and obtained concentration of the self-made standard dust and the ISO12103-1 A2 test dust evaluated by filter membrane sampling were not much different. Therefore, the self-made standard dust can replace ISO12103-1 A2 test dust to be used in the particle monitor calibration device.

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