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To cite this article: J H Wang *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **504** 012100

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A novel fog-haze aerosol collector and its application

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Abstract. According to the problem that collector available consumes a lot of power, and is less efficient, using the theory of heat release charge, a novel fog-haze collecting device was designed and produced, and the new collectors were applied to collection and measurement of haze aerosol in urban areas, the results showed that this new collector could save energy to a great extent, and collected samples could reflect the characteristics of local environment, and was representative.

1. Introduction

Recently, disastrous weather occurred frequently, for example the fog haze. Haze or fog-haze can cause visibility decline, and also could corrode the equipment, it brings a lot of troubles to people's life and production[1-3]. Which make people pay more and more attention to it, many related research activities were asked to carry out[4-5]. However, before you start to study the effect of the fog-haze, you must be able to obtain the haze samples in the right way. From this point of view, how to efficiently collect the smog aerosol particles become very important.

Nowadays, the commonly used method is to collect the haze particles on the filter by using an air suction device. This method requires a lot of power, and it is not efficient.

In this paper, a novel fog-haze collecting device was designed and produced, and the collector was used to collect haze samples in six different cities, which was subsequently analyzed by a variety of characterization method.

2. Design of the fog-haze aerosol collector

The collection of aerosol particles is based on the principle of heat release charge, which is that some wafer made of certain material could release charge to surface when heated, so as to absorb the particulate matter rapidly. The principle and the configuration of the collector are shown in Figure1, Figure2 and Figure3.

The collector is composed of two parts, the core adsorption part and subsidiary support part. The wafer was the core of adsorption part, the silicone rubber pad was used to heat the wafer. The advantage of the device was simple operation, low energy consumption, and environmentally friendly. And it is adapt to various weather conditions outdoor.



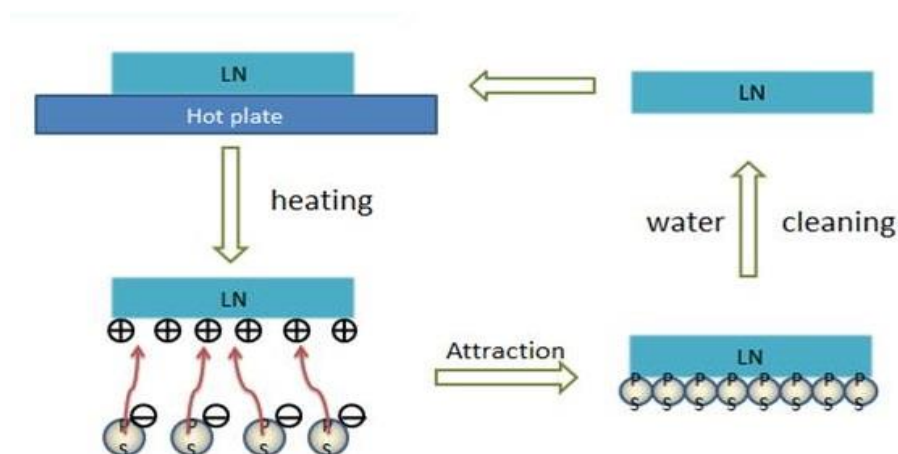


Figure 1. The principle of the collector.

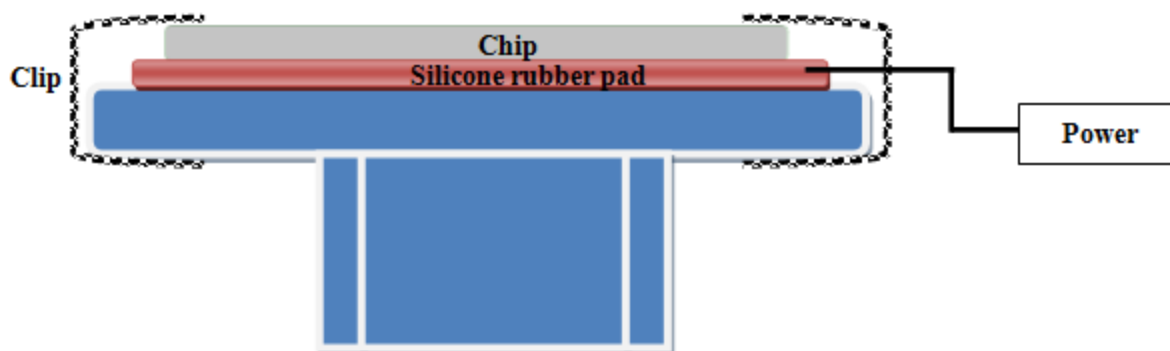


Figure 2. the configuration of adsorption part.

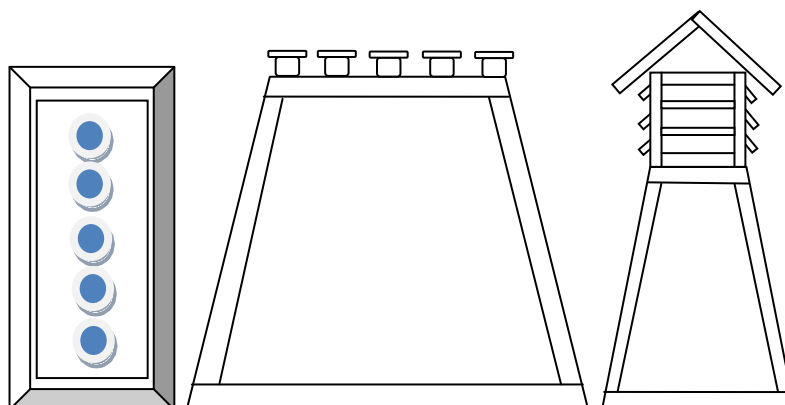


Figure 3. the subsidiary support part.

When we use the device to collect the particles, we need to place the collector on the right terrace with a certain height to the ground, in order to prevent interference of the filthy from the ground. Then, make power on, the silicone rubber start to heat the wafer, the wafer after heated became charged, and start to capture particles in air.

Its advantages was reflected in the comparative experiment, one is using new collector, the other one is using ordinary collector with sampling membrane, as shown in Figure4. Compared with

ordinary sampling device, the new one is more efficient, obviously.

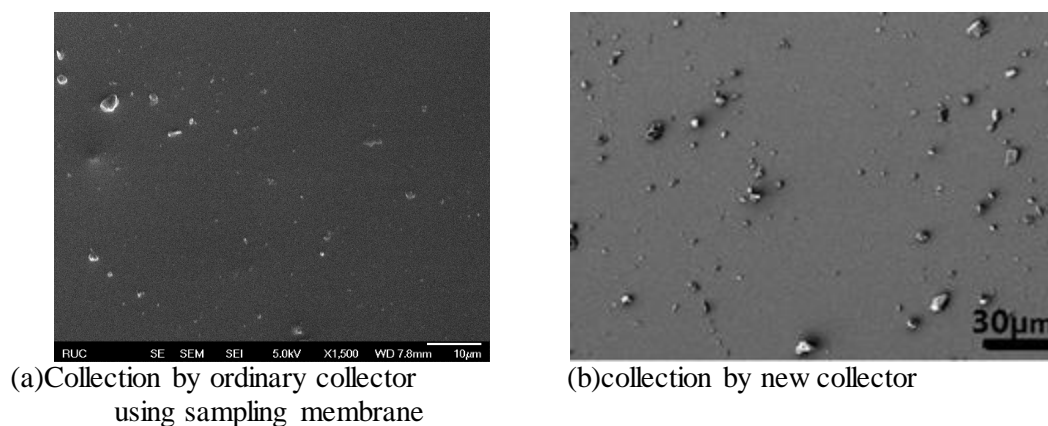


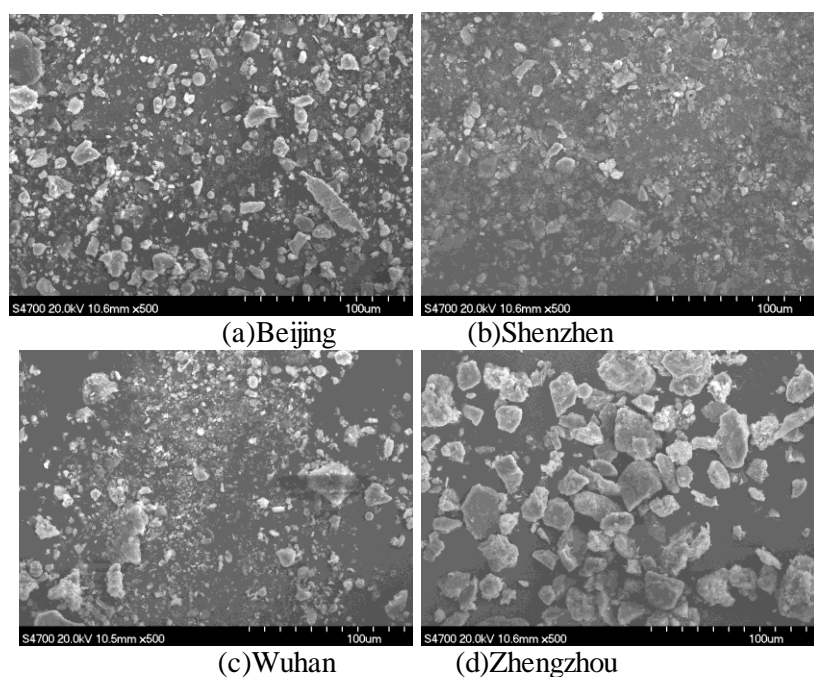
Figure 4. Comparison of two kinds of collectors.

3. Application test

We delivered the haze aerosol collector to six typical urban areas, that is Beijing, Zhengzhou, Shanxi, Wuhan, Shenzhen, Chongqing, respectively, and conducted a sampling test for three month in winter, from December 1, 2016 to February 29, 2016. All samples were asked to be placed to ten meters high from the ground, and the residential area was selected as testing environment.

3.1. Micro-characterization of particle samples

Samples collected from six regions were observed by scanning electron microscopy. It can be seen from SEM pictures (Figure 5), there was great difference between regions, particle size of the sample from northern region, such as Beijing and Zhengzhou, was mainly large particles with one hundred of microns particle size, the particles from the central and western area, such as xi'an and Chongqing, large, medium and small particles all have a certain content. While the particles of Shenzhen and Wuhan, representatives of southern region, were mostly smaller ones, the particle size was about a few microns below.



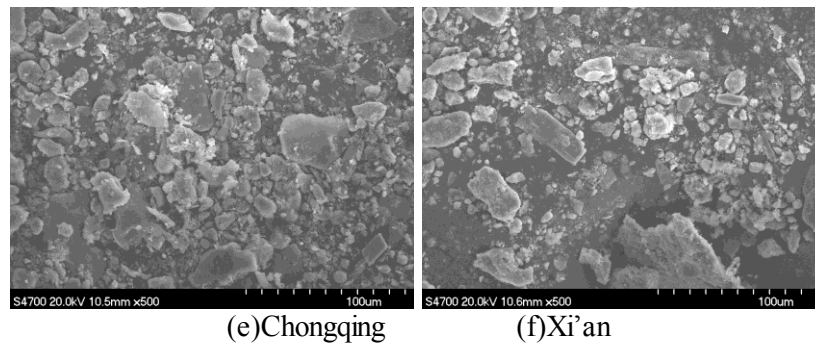


Figure 5. SEM pictures of samples from six cities .((a)Beijing(b)Shenzhen(c)Wuhan(d)Zhengzhou(e)Chongqing(f)Xi'an).

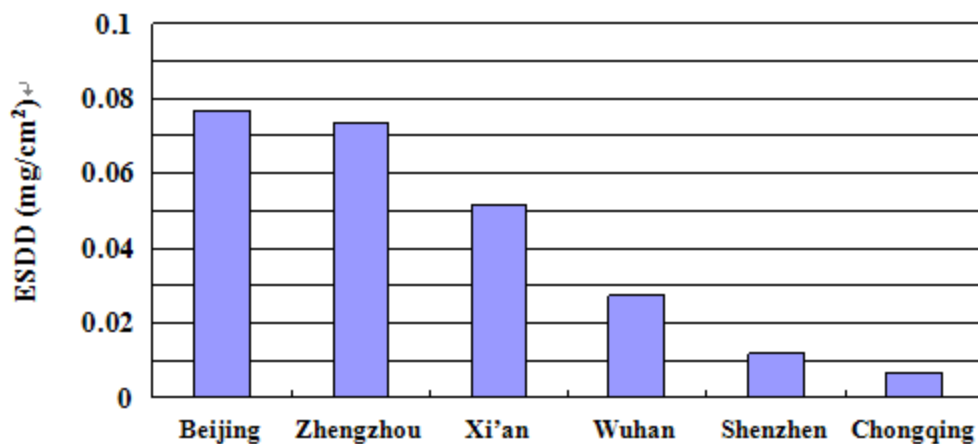
3.2. Equivalent salt deposit density(ESDD) and non-soluble deposit density(NSDD) test

The wafer with haze particles was washed with deionized water, the resulting contamination solution mixture was measured for conductivity, then the insoluble matter was filtered, dried and weighed. The result was listed in Table 1 and Figure 6.

The salt density was decreased in turn from the north to south, Beijing and Zhengzhou, as the representatives of northern area, had the highest concentration. Xian and Wuhan followed, Chongqing and Shenzhen had the lowest. and the salt density in northern region was about eight times that in southern region. The non-soluble deposit density can be clearly divided into two cases, the density is more than 0.5 mg/cm^2 , and less than 0.1 mg/cm^2 , the city with higher deposit density were Beijing, Zhengzhou and xi'an, the order from high to low was, Zhengzhou>Beijing>Xi'an.

Table 1. The equivalent salt and non-soluble deposit density test result of six cities.

Region	Conductivity (us/cm)	Ash content (mg)	ESDD (mg/cm^2)	NSDD (mg/cm^2)
Beijing	121.8	168.8	0.07707	0.7407
Shenzhen	15.86	20.08	0.01180	0.1621
Wuhan	44.6	21.21	0.02738	0.09307
Zhengzhou	116.4	203.62	0.07355	0.8935
Chongqing	11.52	13.26	0.00679	0.05818
Xi'an	83	120.99	0.05192	0.5309



(a) ESDD

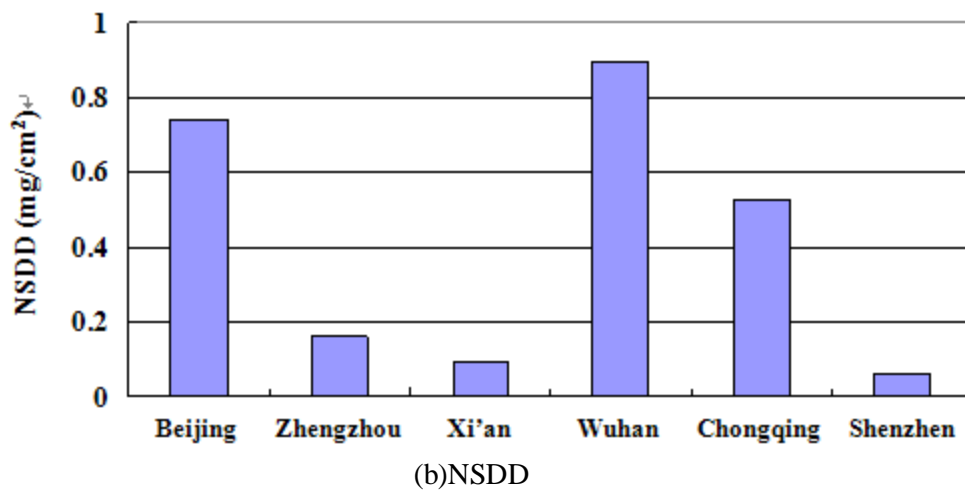


Figure 6. Comparison of ESDD and NSDD in different regions ((a) ESDD, (b) NSDD).

3.3. Component analysis

Table 2. Component analysis results of haze samples.

Region	Beijing	Shenzhen	Wuhan	Zhengzhou	Chongqing	Xi'an
Na(ug/L)	1374.85	127.92	378.62	557.11	94.58	646.89
Mg(ug/L)	444.91	50.11	146.66	454.76	40.7	311.06
K(ug/L)	506.05	143.33	301.79	462.64	123.94	366.43
Ca(ug/L)	1735	242.06	738.3	2041.63	188.77	1321.02
Zn(ug/L)	7.92	3.86	8.8	6.16	5.76	5.86
Si(ug/L)	1733	415	689.9	1149	151.6	1033
F-(ug/L)	426	552.9	1132.1	2634.3	599.2	280.2
Cl-(ug/L)	9914.6	923.4	2347.9	3880.5	821.3	3749.4
SO ₄ ²⁻ (ug/L)	24817.6	2187.1	7587.1	32757.5	1329	19174.4
NO ₃ -(ug/L)	5544	850.8	2022.6	6799	349.9	4370.5

The component and concentration were measured by ion chromatography, and the results were listed in table 2 and Figure7. It could be seen that the sulfate ion concentration were highest, up to 30mg/L; followed by chloride and nitrate ions, which were 3~10mg/L. the concentration of other elements, such as calcium and silicone, were low to 1~2mg/L.

It was found from the comparison between the regions, Beijing, Zhengzhou and Xi'an had the highest ion concentrations, Shenzhen and Chongqing were lowest among them.

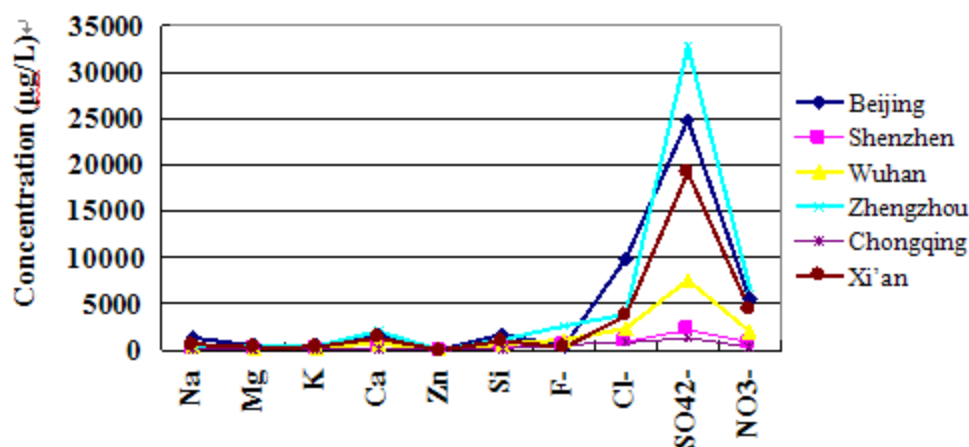


Figure 7. Composition analysis of samples from six typical cities.

4. Conclusions

Based on the principle of heat release charge, a novel fog-haze collecting device was designed and produced. Take advantage of the new collector, haze samples in six typical cities were obtained without energy consumption. With the help of this collect method and corresponding analysis, It was found that haze aerosol particle size was large in northern area, and small in southern regions. The ESDD in northern region was about eight times that in southern region. The cities with higher NSDD were Beijing, Zhengzhou and xi'an, the density was more than 0.5 mg/cm^2 , other cities were less than 0.1 mg/cm^2 .

Acknowledgement

In this paper, the research was sponsored by the science and technology project of Beijing Guodian Futong company: Study and application of repair technology about aging insulation device in station (Project No. FTZY201805).

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