

Content and Formation Cause of VOCs in Medical Waste Non- incineration Treatment Project

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Abstract. When medical waste is treated by non-incineration technology, volatile organic compounds in the waste will be volatile out and form odor pollution. This paper studied VOCs productions in medical waste steam treatment project, microwave treatment project and chemical disinfection project. Sampling and analysis were carried out on the waste gas from treatment equipment and the gas in treatment workshop. The contents of nine VOCs were determined. It was found that the VOCs content in the exhaust gas at the outlet of steam treatment unit was much higher than that of microwave and chemical treatment unit, while the content of VOCs in the chemical treatment workshop was higher than that in the steam and microwave treatment workshop. The formation causes of VOCs were also analyzed and discussed in this paper.

1. Introduction

Non-incineration treatment technologies for medical waste include steam sterilization process, microwave sterilization process, chemical disinfection process and so on. Compared with incineration process, those technologies have the advantages of low processing cost, low construction investment and no dioxin pollution, so they had been widely used[1]. Because medical waste contains a small quantity of liquid components, when it was treated by non-incineration technologies, the organic pollutants will volatilize out, forming VOCs pollution. Therefore, how to control odor pollution effectively becomes the problem in non-incineration treatment technology. In order to select an appropriate odor removal method, the chemical components and content of VOCs must be determined.

In this paper, three medical waste treatment projects which adopted different non-incineration technologies were examined, their odorous compounds were carried out for sampling and analysis, The reasons for its formation were also discussed. This paper could provide the reference data for further research on how to purification. The medical waste treatment projects studied in this paper are located in Hubei Province, Henan province and Gansu province China. The project in Hubei province adopts steam sterilization treatment technology, its treating capacity is 8 tons per day, and medical waste disposal center in Henan belong to chemical treatment process, its capacity is 5 tons per day, Gansu project use microwave treatment method, processing capacity of 4 tons per day.



2. Detection method and apparatus

2.1 Methods and national standard

Table 1. The standard of Detection method

VOCs	Detection method	standard
Ammonia	Sodium hypochlorite –salicylic acid spectrophotometry	HJ 534-2009[2]
Hydrogen sulfide	Methylene blue spectrophotometric method	Methods for air and waste gas monitoring and Analysis[3]
Methyl-sulphydryl, dimethyl sulfide and methyl disulfide	Gas chromatography-mass spectrometry (GC-MS); Gas chromatography flame photometric detection (GC-FPD)	GB/T 14678-1993[4] Method of USA[5]
TVOC	gas chromatography Gas chromatography-mass spectrometry	GB/T18883-2002[6] Method of USA
Trimethylamine	gas chromatography	GB/T 14676-1993[7]
Carbon disulfide	Diethylamine spectrophotometric	GB/T 14680-1993[8]
Styrene	gas chromatography	HJ 583-2010[9]

2.2. Core testing instruments

(1) Gas chromatography flame photometric detector, manufactured by SHIMADZU, model: GC-2010 Plus-FPD.

(2) Gas chromatography mass spectrometer, manufactured by Agilent, model: 7890A-5975C GC-MS.

(3) Ultraviolet visible spectrophotometer, manufactured by SHIMADZU, model: UV-1800.

2.3. Sampling

The VOCs were detected in two cases. In the first case, the exhaust gas samples were collected from the outlet of treatment equipment in different operation stages. In the Second one, the waste gas samples were taken from different site in treatment workshop. Table 2 and table 3 show the average VOCs content value of six times in equipment outlet and workshop.

2.4. Detection results

Table 2. Average VOCs content of equipment outlet in three project mg/m³

	Trimethylamine	Methylsulphydryl	Dimethyl sulfide	Methyl disulfide	Carbon disulfide	Ammonia	Hydrogen sulfide	Styrene	TVOC
Steam	0.00125	0.037	0.046	0.904	28.2	4.10	0.204	0.903	72.22
Microwave	0.00125	0.0001	0.0001	0.0001	0.17	1.70	0.020	0.019	4.19
Chemical	0.00125	0.0001	0.0001	0.0001	1.18	1.75	0.004	0.010	3.50
standard ^a	0.05	0.004	0.03	0.03	2.0	1.0	0.03	3.0	10

^a Factory value of odor pollutants regulated in GB14554-1993[10]

Table 3. Average of VOCs content in workshop of three project mg/m³

	Trimethylamine	Methylsulphydryl	Dimethyl sulfide	Methyl disulfide	Carbon disulfide	Ammonia	Hydrogen sulfide	Styrene	TVOC
Steam	0.00125	0.00024	0.00025	0.0007	0.11	0.078	0.006	0.0068	0.497
Microwave	0.00125	0.0001	0.0001	0.0001	0.05	0.149	0.005	0.0065	0.86
Chemical	0.00125	0.0001	0.0001	0.0001	0.33	0.241	0.003	0.002	1.63

Through the detected results, it can be found:

I Among three treatment process, relatively large content of VOCs in the exhaust gas at the outlet of the equipment existed in steam treatment project. Except trimethylamine and styrene, other seven kinds of volatile organic components could not meet the requirements of standard discharge requirement.

II Both in microwave and chemical disinfection process, VOCs content of equipment exports were relatively low. Only ammonia content was higher than the discharge standard.

III In medical waste treatment workshop, the concentration of odor gas was far lower than the concentration of the equipment outlet.

IV Odor pollution in steam treatment workshop was lower than microwave and chemical treatment workshop.

3. Discussion

Content of medical wastes are roughly same in different areas. Volatile organic compounds and their contents in medical waste are approximately equal before treatment. In addition, there are no other chemical agents used in the steam and microwave treatment processes, although some oxides are added as disinfectants in chemical treatment process, such disinfectants are generally not volatile. However, it could be concluded from result that VOCs contents of exhaust gas varied with different projects. This difference could only be caused by that the original VOCs in medical waste had been released to varying degrees. This was discussed below in more detail according to the operating conditions of various processing techniques.

The basic procedure of medical waste steam treatment is to put medical waste in airtight chamber and spray steam directly into it to finish moist heat sterilization. According to Chinese standard, steam sterilizing temperature is 134°C and sterilizing time is 45 minutes. In order to make the steam heat quickly and evenly reach the inside of medical waste, the original air in the sterilizer is removed by vacuum before sterilization. After sterilization, vacuum drying is also required. Longer sterilization times and higher vacuum requirements as well as subsequent vacuum drying procedures force VOCs in medical waste to completely volatilize into the exhaust gas. Therefore, exhaust gas has a higher VOCs in steam treatment technology. Microwave sterilization is the process combining microwave and steam together. It is also carried in airtight chamber. Microwave sterilizing temperature is 135°C, sterilizing time is only 5 minutes, and no vacuum drying requirements. Therefore, the volatilization of VOCs is relatively low. Chemical disinfection use strong oxidizing disinfectants to destroy the pathogenic bacteria in medical wastes. Its disinfection temperature is only 90°C, this condition (low temperature, no vacuum, without drying) led to less VOCs volatilization. In the three treatment technologies, the exhaust gas from the equipment outlet is collected centrally, and the process of loading and unloading is mostly micro negative pressure operation. Therefore, the VOCs from the equipment is much more than that in the workshop. In contrast to microwave and chemical treatment plants, the VOCs in the steam treatment workshop is lower, because the tightness of the steam equipment is better.

The primary purpose of medical waste treatment is to destroy pathogenic bacteria, so that it loses infectivity. Steam treatment process has the best sterilization effect and was widely used. But it needs to remove VOCs in order to prevent odour pollution,

Reference

- [1] Ranjana Verma, Medical Waste Disposal: Incineration and Non Incineration Technology their Effects and prospects, *Nature & Environment*, Vol. 19 (2), 2014: p195-198.
- [2] HJ534-2009, Ambient air__ determination of ammonia Sodium hypochlorite –salicylic acid spectrophotometry.
- [3] China EPA 2003, *Method for analysis of air and waste gas*(Fourth Edition)(Beijing: China Environmental Press)p512-513.
- [4] GB/T14678-93, Air quality __determination of sulfuretted hydrogen, methyl sulphydryl, dimethyl

- sulfide and dimethyl disulfide __Gas chromatography.
- [5] USA, EPA, Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition, Compendium Method TO-14, TO-15.
 - [6] GB/T18883-2002, Indoor air quality standard.
 - [7] GB/T14676-93, Air quality __determination of trimethylamine __Gas chromatography.
 - [8] GB/T14680-93, Air quality __determination of carbon disulfide __Diethylamine spectrophotometric method.
 - [9] HJ583-2010, Ambient air—Determination of benzene and its analogies using sorbent adsorption thermal desorption and Gas Chromatography.
 - [10] GB14554-93, Emission standards for odor pollutions.