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Study on the distribution pattern of PAHs in the coking dust from the coking environment

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Abstract

This paper conducts a study and analyzes five kinds of dust samples of different environment, including an office area,a ground station of the new plant, the first workshop of coking, a top of coke oven and a ground station of the old plant in coking plant and obtaines the distribution pattern of PAHs in the coking dust by the way of ultrasonic extraction and high performance liquid chromatography. The data show that PAHs from the first workshop turns out to be the richest with its content getting up to 12.00 $\mu g \cdot m^{-3}$. By analyzing the single component distribution of PAHs, the results show that there are fourteen kinds of PAHs produced at 5 sites. Through analyzing the particle size of coking dust, its size is mainly below 10μm and its contents exceeds to 75%. The first workshop environment is the highest and reaching 98.39%.

Keywords: coking; the environment dust; PAHs; distribution pattern.

1. Introduction

Polycyclic Aromatic Hydrocarbons is a kind of typical and ubiquitous persistent organic pollutants which has carcinogenicity-mutagenicity-teratogenicity effect and it comes mainly from incomplete combustion of fossil fuels, timber, tobacco and plastic [1]. Due to a harmful effect on human health, Polycyclic Aromatic Hydrocarbons has been paid wide attention by international scientists and scholars.

The coking operation of coking plant is a process that dry distillates the coal under the conditions of anaerobic high temperature in the coke oven and then produces the metallurgical coke which is indispensable to industries, for example iron-making. During the process of dry distillation, the organic components which are distilled by a complex procedure of cracking and polymerization and then generate large amount of single-ring and polycyclic aromatic compounds and other pollutants. PAHs emissions from the process of coking is a major source of polycyclic aromatic hydrocarbons in the atmosphere and it's seriously endangering people's health [2-4].

Based on the process characteristics of coking and the layout of coking plant, this paper conducts a comparative study and analysis of five sampling points determined in a coking plant in Tangshan and obtains the distribution pattern of PAHs in the coking dust by the way of ultrasonic extraction and high performance liquid chromatography. The distribution pattern provides a theoretical basis for the realization of controlling the PAHs content emissions from the coking and reducing environmental pollution.

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2. Experiment part

2.1. Sample collection

The samples of experiment come from a coking plant in Tangshan. The dust samples in environment are collected by the TH-150Ⅲ intelligent mid-flow rate air suspension-atom sampler. Based on the process characteristics of coking and the layout of coking plant, this paper determines five sampling points:

Sampling point 1- office area (southeast of office building, 10m away from the coking plant);
Sampling point 2- ground station of the new plant;
Sampling point 3- first workshop of coking (located downwind of coke oven and coke dry quenching);
Sampling point 4- top of coke oven;
Sampling point 5- ground station of the old plant (located downwind of coal yard).

2.2. Experimental instrument

Experimental instrument mainly includes Agilent-1100 high performance liquid chromatography with UV detector and fluorescence detector, KQ-250 DE CNC ultrasonic washer, 80-3 Large-capacity centrifuge.

3. Experimental results and discussion

3.1. Dust concentration of PAHs in different sites

Dust concentration of PAHs in coking plant is given in Table 1.

Table 1. The mass concentration of PAHs in dust

Sampling site	Sample name	Concentration of PAHs/(μg·m^{-3})
1	Office area	0.19
2	Ground station of new plant	1.14
3	First workshop of coking	12.00
4	Top of coke oven	1.04
5	Ground station of old plant	9.00

These data show that the mass concentration of PAHs in various points of the plant area were higher than the office area because of the coking's impact. In the plant area, concentrations of PAHs in the first workshop of coking reaches 12.00μg·m^{-3}. The dust come from the process of coking and the coal dry distillate always advances in high temperature environment without air which provides the conditions for the formation of PAHs. In such high temperature environment, the increasing of the activation degree of particles emittes from coke oven that leads to the increasing of adsorption of particles. So long as there is an effective collision between particles and free PAHs during the diffusion process it is easy to be adsorbed [5]. As a result, the concentration of PAHs is highest. The office area is located upwind of the plant, so its concentration of PAHs is the lowest .The reason that the concentration of PAHs in new ground station is lower than the old one is that the equipments in the ground station of new plant is newer and the effect of sealing and dusting is better.

3.2. Distribution pattern of PAHs in the coking dust

The composition and mass ratio of PAHs single component in dust is given in Table 2.

Based on Table 2, there are 14 kinds of PAHs in the 5 sampling sites and all of them are PAHs compounds which U.S. EPA preceding controlled. The detection of five samples all includes AcP, PhA, AnT, BaA, Chr, BbF, BkF, BaP, DbA and BghiP.

Detection of dust in office area includes 13 kinds of PAHs compounds. Among them, the content of BaP is the highest and its mass fraction is 18.69%. Detection of dust in ground station of new plant includes 10 kinds of PAHs compounds and Chr's mass fraction is the highest one reached 49.82%. Detection of dust in first workshop of coking including 13kinds of PAHs compounds and BaP's mass fraction is the highest one that reaches 17.72%. Detection of dust in top of coke oven including 13 kinds of PAHs compounds and Chr's mass fraction is the highest that reaches 23.85%. Detection of dust in

ground station of old plant includes 13 kinds of PAHs compounds and BaP's mass fraction is the highest one that reaches 16.88%.

Table 2. The composition and mass ratio of PAHs single component in dust (%)

PAHs	Office area	New ground station	First workshop of coking	Top of coke oven	Old ground station	PAHs	Office area	New ground station	First workshop of coking	Top of coke oven	Old ground station
NaP	4.66	0	0	1.63	0	BaA	0.45	3.43	9.68	7.60	9.86
AcP	3.52	1.58	6.50	5.10	7.06	Chr	12.92	49.82	14.08	23.85	13.37
`Flu	3.13	0	0.10	1.06	0.06	BbF	12.61	5.63	10.54	10.19	10.32
PhA	15.01	27.73	1.01	4.42	0.72	BkF	4.29	2.20	4.37	4.23	4.31
AnT	1.28	0.26	0.51	0.96	0.60	BaP	18.69	7.66	17.72	17.02	16.88
FluA	6.03	0	16.20	4.23	13.11	DbA	4.63	1.32	3.55	3.85	3.33
Pyr	0	0	5.33	0	9.88	BghiP	12.80	0.35	10.43	15.87	10.49

3.3. Distribution Pattern of PAHs in different particle size of dust

The contents of PAHs in different diameter dust are given in Table 3.

Table 3. The contents of PAHs in different diameter dust (%)

Diameter	Office area	New ground station	First workshop	Top of coke oven	Old ground station
0-10μm	83.45%	95.62%	98.39%	75.61%	81.14%
10-100μm	16.55%	4.38%	1.61%	24.39%	18.86%

The particles which air equivalence≤10μm is called inhaled particle matter and represented as $PM_{10.}$ Based on the table 3, PAHs of the five samples dust mainly concentrate on PM_{10} and mass fractions are over 75%. The mass fraction of first workshop is the highest that reaches 98.39% which exhibits the accumulation characteristics to small-size particle and is harmful to human health.

4 Conclusions

This paper collectes dust samples in five sites of coking plant and analyzes distribution pattern of PAHs. The conclusions are as follows:

(1) The distribution pattern of total PAHs in dust: under the condition of coking, the mass concentration of PAHs in various points of the plant area are higher than the office area. In the plant area, concentrations of PAHs in the first workshop of coking is the highest that reaches 12.00μg·m^{-3}and in the office area is the lowest that reaches 0.19 μg·m^{-3};

(2) There are 14 kinds of PAHs in the 5 sampling sites and all of them are PAHs compounds which U.S. EPA preceding controlled. The detection of five samples all includes AcP,PhA,AnT,BaA,Chr,BbF,BkF,BaP,DbA and BghiP and mass concentrations of Chr and BaP are higher than others'.

(3) PAHs of the five samples dust mainly concentrate on PM_{10} and mass fractions beyonds 75%. The mass fraction of the first workshop is highest that reaches 98.39%.

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