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Influence of VOC Emission on Asphalt Components

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Abstract. Volatile organic compounds (VOC) emission from asphalts not only causes the change in the performances of the bitumen, but also its chemical compositions. In this paper four-component analysis was carried out to study the influence of VOC emission from different kinds of asphalts on their chemical compositions under different conditions. The results show that four-component of asphalts are different depending on asphalt kinds. Also as VOC emission increases, the total contents of resins and asphaltenes increase, but the total contents of saturates and aromatics decrease. VOC emission under different temperatures also has a great impact on the asphalt chemical components. The decrease of saturates and aromatics in high temperature is larger than in low temperature, and there are significant differences between the asphalt surface layer and the internal in chemical components.

Introduction

Asphalt is an extremely complex mixture of more than one thousand of different types of hydrocarbons, which is traditionally regarded as a colloidal system consisting of high molecular weight of asphaltene micelles dispersed or dissolved in a lower molecular weight oily medium [1]. Asphalt can produce volatile organic compounds in the ambient temperature during the long-term service process, especially in the high temperature atmosphere, leading to the deterioration of its performances and reducing the life expectancy [2]. VOC emission from the asphalt is always accompanied with its aging process. During the VOC emission process, some light components in the asphalt can volatilize into the atmosphere and the others may be combined with the oxygen into large molecular structures [3-5].Meanwhile, the four-component changed obviously with VOC emission. Bituminous material is inevitably affected by natural environmental factors such as light, oxygen, temperature, and the content of each component will changed with the time going on. The objective of this research is to study the influences of VOC emission during service process on the asphalt chemical component by simulating different conditions in the laboratory-based environment. Thin-layer chromatography with flame ionization detection (TLC-FID) was used in the paper to detect four components of the asphalt [6]. Based on the characteristics of asphalt's four components, the reason of VOC emission is partly the volatilization of saturates and aromatics, which are exactly dispersion medium and light components in asphalt [7]. Thus, this paper explores influence of VOC emission under different conditions on components of asphalt.

Experimental

Theory and methods of experiments. Four components (saturates, aromatics, resins and asphaltenes) of the asphalt were measured by Thin-layer chromatography with flame ionization detection (TLC-FID), produced by Japan Yate Long Company. Due to the number of current intensity is proportional to organic material, these ion currents is detected by the hydrogen flame ionization detector which it can achieve quantitative detection. Chromatographic conditions: scan speed (30s / root), hydrogen flow rate (160ml/min), air flow (1.5-2L/min).

Experimental materials. Six kinds of asphalts, namely AH-70, AH-90, Qinghai-90, SBS modified asphalt, TPS modified asphalt and Trinidad Lake modified asphalt were investigated in this paper. Four reagents including methylene chloride, n-heptane, toluene, ethanol were used in this paper.

Results and Discussion

Chemical components. Asphalts were selected and denoted as AH-70, AH-90, Qinghai-90, SBS modified asphalt TPS modified asphalt and Trinidad Lake modified asphalt to conduct the four-component testing. And the total contents of asphaltenes and resins replaced by Re+As value, the total contents of aromatics and saturates replaced by Ar+Sa value were also analyzed in this research.

Table 1 Four components of asphalt from different places

(%)	AH-70	AH-90	Qinghai-90	SK-90	SBS	TPS	Trinidad Lake
Saturates	14.38	21.04	22.74	11.88	10.19	9.33	3.24
Aromatics	59.57	36.84	49.94	36.78	55.93	64.55	30.31
Resins	12.56	27.73	9.17	43.02	18.84	12.14	48.83
Asphaltenes	13.49	14.39	25.05	8.32	14.83	13.97	17.61
Sa+ Ar	73.95	57.88	72.68	48.66	66.12	73.88	33.55
Re + As	26.05	42.12	34.22	51.34	33.67	26.11	66.44

As shown in Table 1, there are significant differences among four-component contents of different asphalt, such as AH-70 and AH-90. And for AH-90, Qinghai -90 and SK-90, asphalt labeled 90 chemical components and asphalt labeled 70 are different with the same brand AH. For SBS modified asphalt, the most part is aromatic and resin. For Trinidad Lake modified asphalt, the content of saturates apparently just has a small proportion, while the total content of aromatic and resin are the most.

Table 2 Component contents change of Qinghai -90 before and after VOC emission

(%)	Qinghai 90	Qinghai 90-UV-four days	Qinghai 90-UV-twelve days
Saturates	22.74	23.21	22.11
Aromatics	49.94	38.93	38.49
Resins	9.17	12.81	13.53
Asphaltenes	25.05	25.05	25.87
Sa+ Ar	72.68	62.14	60.6
Re + As	34.22	37.86	39.4

While saturates and aromatics are the smaller molecular composition in the asphalt, the changes of these components were investigated in this research. Selecting in the same temperature and light intensity for 4 days and 12 days, we can compare their four-component contents before and after VOC emission. As shown in table 2, four components have the same trend: Saturates just change a little, aromatics decrease, resins and asphaltenes increase obviously. And Qinghai90 asphalt shows a smallest loss of saturates and aromatics in UV-four day condition while a biggest in UV-twelve days. Because during the VOC emission process, some light components in the asphalt can volatilize into the atmosphere and the others may be combined with the oxygen into large molecular structures.

Chemical components before and after VOC emission under different conditions. Select AH-70 asphalt to test the four-component contents before and after VOC emission with different temperature (asphalt mass 3.0g, insulation time 10min), asphalt mass (temperature110℃, insulation time 15min) and insulation time (temperature110℃, asphalt mass3.0g).

Four components change with different temperature. Asphalt will form a membrane on the surface under the high temperature. This paper studies chemical components between the surface and internal in asphalt under different temperature. As shown in the Table 3, saturates and aromatics decrease, while resins and asphaltenes increase in compared with the fresh asphalt.

Heated the AH-70 asphalt to 70 ℃, there is no membrane on the surface of asphalt. But it formed at 110℃, 150℃and 190℃. And it had big differences in four components between surface asphalt and internal asphalt under different temperatures. Table 3 shows that the reduction of saturates and aromatics increases with the increasing temperatures. The total contents of saturates and aromatics in the surface is less than in the internal in the asphalt. However, asphalts compositions presented more resins and asphaltenes in compare with the surface asphalt. So the membrane on the asphalt may prevent the emission of VOC under the high temperature. AH-70 asphalt shows a smallest loss of saturates and aromatics in 70℃ condition while a biggest loss in 190℃ condition. So temperature has the biggest contribution to the decrease of saturates and aromatics. So negative value of saturates and aromatics contents change rate demonstrates that the released specimen presented a smaller content of saturates and aromatics and a bigger content of asphaltee and resin compared to the 70℃asphalt.

Table 3 Chemical components before and after VOC emission under different temperature

(%)	70℃	110℃	110℃ Surface	150℃	150℃Surface	190℃	190℃ Surface
Saturates	13.85	12.66	11.24	12.4	10.47	4.25	3.97
Aromatics	58.59	57.64	56.57	55.17	54.34	55.91	54.34
Resins	14	12.35	13.62	9.54	11.84	14.83	16.88
Asphaltenes	13.56	17.35	18.57	22.89	23.35	25.01	24.81
Sa+ Ar	72.44	70.3	67.81	67.57	64.81	60.16	58.31
Re + As	27.56	29.7	32.19	32.43	35.19	39.84	41.69

Four components change with different asphalt mass. The cause of the decreasing tendency may be partly that saturates and aromatics could be vaporization into the air. In addition, some saturates and aromatics may be combined oxygen into large molecular structures. Asphalt will form a membrane on the surface of different mass at 110℃. Saturates and aromatics on the asphalt surface are less than in the internal and the decreasing tendency becomes more and more increasing.

Table 4 Chemical components before and after VOC emission in different mass

(%)	3.0g	3.0g surface	6.0g	6.0g surface	9.0g	9.0g surface
Saturates	11.45	8.17	12.06	9.56	12.68	10.46
Aromatics	57.44	60.16	61.59	64.06	61.89	63.11
Resins	13.39	13.57	13.01	13.65	12.55	13.9
Asphaltenes	17.72	18.1	13.34	12.73	12.89	12.53
Sa+ Ar	68.89	68.33	73.65	73.62	74.57	73.57
Re + As	31.11	31.67	26.35	26.38	25.44	26.43

Four components change with different insulation time. During the VOC emission process, some light components in the asphalt can volatilize into the atmosphere and the others may be combined with the oxygen into large molecular structures. The total content of saturates and aromatics gradually decrease with the release time.

Table 5 Chemical components before and after VOC emission in different insulation time

(%)	10min	10min surface	15min	15min surface	30min	30min surface
Saturates	12.66	11.24	11.45	8.17	10.29	6.25
Aromatics	57.64	56.57	57.44	60.16	57.36	58.21
Resins	12.35	13.62	13.39	13.57	15.56	12.98
Asphaltenes	17.35	18.57	17.72	18.1	16.79	22.56
Sa+ Ar	70.3	67.81	68.89	68.33	67.65	64.46
Re + As	29.7	32.19	31.11	31.67	32.35	35.54

Summary

Chemical compounds of the asphalt were influenced by VOC emission under different conditions. The conclusions are as follows: VOC emission can change chemical components of asphalt. Asphalt labeled 90 chemical components and asphalt labeled 70 are different with the same brand, also compared to asphalt from the same place, chemical components are different. Light components in the asphalt can volatilize under the circumstances in high temperature. Such as saturates and aromatics decrease. Changes in different conditions are different and different tendencies of asphalt in different asphalt mass, insulation time and temperature; Asphalt will form a membrane on the surface under the high temperature. Changes in internal asphalt are smaller than in the surface which may be due to the membrane can prevent the oxygen combining saturates and aromatics into large molecular.

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