Health & Safety

Air particle measurements during paving of low-temperature asphalt

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Abstract

Background The concentration of fumes from asphalt mixtures in air during paving are positively correlated to the paving temperatures. High concentrations of asphalt fume can cause respiratory irritation of the asphalt workers. The characteristics of the asphalt fume, like size and number distribution, is scarcely studied. Recent advances in analytical chemistry have allowed for studies on possibly hazardous ultrafine particles. In this study we aimed to increase the knowledge of asphalt fume composition during paving using low temperature asphalt (LTA). Method Paving at temperatures below 140°C was performed for two days on a rural, low trafficked road in the south of Sweden in the autumn of 2017. A trolley equipped with SMPS (Scanning Mobility Particle Sizer) and APS (Aerodynamic Particle Sizer) was rolled about 5-10 meters behind the paver, to measure particles sized 15-5000 nm. Background measurements were performed before, after and in between LTA paving activities. Results The average concentration of particles in the air during LTA paving was low; 7000 particles/cm3 and the background was approximately 1500 particles/cm3. Most of the particles were sized <500 nm and 80% of the particles were sized <100 nm. Comparing these results with previous published data the results indicate that LTA paving generate less particles but possibly somewhat smaller particles than showed in previously. Conclusion This first measuring campaign showed that LTA paving caused low concentrations of asphalt fumes in the air, comparable to common particle concentrations in ambient urban air.

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4. Introduction

Bitumen emissions formed at elevated temperatures are complex in composition containing hydrocarbons as gas, vapour and aerosol particles. The emissions formed during paving of hot asphalt are mainly derived from bitumen but other confounders such as diesel exhaust, road dust and additives may add to the total emissions from paving. When studying bitumen fumes during paving it is therefore important to be aware of contributions from confounders and, if possible, even keep them to a minimum.

Reducing the asphalt paving temperature results in reduced fume concentration [1]. Over recent years, the asphalt industry strives to reduce paving temperatures continuously for a variety of reasons: to save energy, reduce CO_2 emission and reduce occupational exposure to bitumen fumes. This has led to an increased focus in developing new low-temperature-asphalt (LTA) products. There is no clear LTA definition but in general these products are produced at temperatures 20 to 40 degrees lower than equivalent conventional asphalt, i.e.100-140°C [2, 3].

The particle characteristics of the asphalt fume, like size and number distribution, is scarcely studied but with new instrumentation now becoming available, the number of field studies including measurements of ultrafine particles are now rising [4, 5]. The objective of this study is to increase the knowledge of particulate characteristics (size, number, concentration) of asphalt fumes during paving using low temperature asphalt.

5. Method, results and discussion

5.1. Method

The aim of the study is to measure concentration, mass and size distribution of particles formed during paving using LTA at 140°C. Due to lack of reference objects (paving with hot mix asphalt under similar or equal conditions) control measurement using hot mix asphalt (160°C) was not performed. The temperature of the newly paved asphalt was continuously measured from the roof of the paver using a heat camera.

The measurements were performed during 8 hours for two days of paving below 140 °C on a rural, low trafficked road (both directions for a few kilometers) in the south of Sweden in October 2017. The road was closed off to traffic (except a few inhabitants and the trucks delivering asphalt) and situated in a forest. During the measurements all passing traffic was logged, for increased understanding of possible particle confounders. Both days were sunny, approximately 10°C with colder mornings, wind 2-5 m/s and no precipitation.

To measure concentration, mass and size of the particles in the fume, two devices were used: Scanning Mobility Particle Sizer (SMPS) and Aerodynamic Particle Sizer (APS) covering 15-5000 nm, similar to Nilsson et al 2018 [5]. The SMPS and the APS were mounted on a trolley, which was pulled, approximately 5-10 meter, behind the paver. To supply electricity to the measurement equipment, a petrol-powered generator with nearly no particle emissions was pulled at a further distance 5-10 meter behind the trolley (Figure 1) to minimize additional confounding fumes.

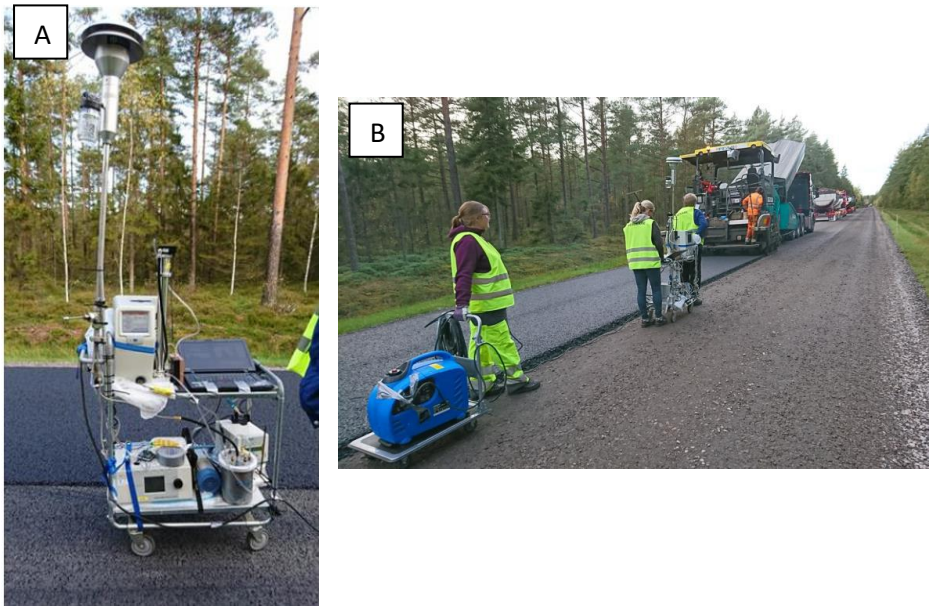

Figure 1. A. Equipped trolley
B. Paving and measurement train: asphalt truck, paver, trolley with equipment and last of all power generator.

5.2. Results

The temperature of the LTA mix varied between 125-140°C. On average, eight passenger cars, three heavy vehicles and three asphalt trucks passed the equipped trolley every hour. On a few occasions, the particle contribution of the passing vehicle was obvious, and the measurement was deducted from the final results. Due to the obvious difficulties to measure the peak of the plume from the paving operation, only data points twice as high as the background levels were used analyzing the particles number size distribution. About 70% of the data met this cut-off.

The amount of particles in the air was measured as particle concentration and expressed in particles/cm^3. Average particle concentration during paving was relatively low, 7,000 particles/cm^3, and the background measured before and after paving was 1,500 particles/cm^3, which is to be respected as a very clean background (rural background) The particle size ranged from 15 to 5000 nm with 80% of particles smaller than 100 nm.

5.3. Discussion

To assess the impact of paving temperature reduction, ideally a control measurement paving at conventional temperature of 160 °C would have been performed in similar conditions including location, weather, equipment and other possible confounders. This was unfortunately not feasible since no conventional paving was planned in the region, so the results were compared to previous studies.

Elihn et al 2008 [4] used different conditions: a highway was paved in one direction while traffic passed in the lane next to the paving team. The background levels during their study was 7,000 particles/cm^3 whereas measurements during paving gave on average were 27,000 particles/cm^3, using P-Trak equipment (measuring 20 nm-1 µm). The range of the particle sizes was comparable to the present study of 15 nm-5 µm. The geometric mean particle diameter was 70 nm, higher than in the present study (55 nm).

Nilsson et al, 2018 [5] investigated the impact of crumb rubber asphalt paving (at 160°C) and found particle concentrations between 20,000-140,000 particles/cm^3. Here, the geometric mean diameter was 50-80 nm, including both type of asphalt mix monitored.

A Norwegian study published in 2011 compared LTA and conventional mix during paving and found the particle mass concentration in the breathing zone of the workers of 0.12 mg/m^3 and 0.38 mg/m^3 respectively, measured by

Dust-Track [6]]. In this study, using different analytical equipment and not measuring in the breathing zone, 0.02 mg/m^3 was detected.

Most studies focus on bitumen fumes exposure measured as vapour and aerosol the respiratory zone of the workers [7, 8]. For measuring particles, only a few comparable studies are available and none used fully comparable set-ups. Confounders are partly unknown in these studies further introducing possible unknown factors. Elihn et al 2008 reported no smoking during work hours. In Nilsson et al 2018, it was clear that the traffic was the largest contributor to the increased number of particles. Even if the data of the different studies cannot be fully compared, the current study clearly shows much lower particle concentrations than studies performed at higher temperatures.

In the current study, there is a substantial reduction of number particles in the air compared to previous studies which could be due to the reduced paving temperature. The average particle concentration during paving with LTA was 7,000 particles/cm^3 which is similar to background values of central mid-size Swedish cities with about 90,000 inhabitants.

5.4. Conclusion

The average concentration of particles in the air during LTA paving was low; 7,000 particles/cm^3 and the background was approximately 1,500 particles/cm^3. Most particles were sized <500 nm and 80% of the particles were sized <100 nm with a geometric mean diameter of 55 nm. Comparing these results with previous published data the results indicate that LTA paving generate considerably less particles than measured at higher temperatures during conventional paving.

This first measuring campaign reported in this study shows that LTA paving caused low particle concentrations in the air, comparable to common particle concentrations in ambient urban air.

6. Acknowledgement

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7. References

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