Clear binder in warm mix coloured asphalt, a high-quality, circular and safe application

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Summary
To promote road safety, coloured pavements such as f.e. red, blue or yellow coloured bicycle lanes and intersections/plateaus are applied in the Netherlands and increasingly abroad. Other arguments for applying coloured pavements include reducing heat stress in inner-city areas or are aesthetic in nature. These coloured pavements can be realised in different ways, such as painting the road surface to using coloured crushed stones in combination with synthetic pigmentable (clear) binders as coloured asphalt, all with their specific advantages and disadvantages.

In practice, a coloured asphalt pavement with a (high-quality) clear binder shows the best results with a long service life. These clear binders have the advantage that a bright colour can be achieved with relatively little added pigment. This is, in contrast to conventional black bitumen with which a dark colour is still obtained, with a lot of added (powder) pigment. However, concerns have arisen in the market about the quality and workability of clear binders and whether coloured asphalt with a clear binder is circular and health and safety responsible. Recent research shows that these concerns are unfounded and that a high-quality warm mix asphalt (WMA) can be responsibly produced and applied with a clear binder.

This paper will discuss the specific aspects related to pigmentable (clear) binders and how best to apply them in practice. This will be done by means of a simulation test regarding occupational health and safety aspects in the laboratory. The circular aspects of coloured asphalt will also be discussed.

Keywords: synthetic pigmentable clear binders, coloured asphalt, synthetic clear binders, circularity, warm mix asphalt (WMA).

1. Introduction

To promote road safety, coloured pavements, such as f.e. red, blue or yellow coloured bicycle lanes, intersections and plateaus, are used in the Netherlands and increasingly abroad. There is no single method for producing coloured pavements. The following methods can be distinguished:

- Surface treatment with coloured crushed stone;
- Coloured epoxy resin coating;
- Coloured asphalt with black bitumen;
- Coloured asphalt with unmodified (without polymer) clear binders;
- Coloured asphalt with polymer modified clear binders.

Coloured road surfaces can be used in several ways. Besides accentuation for road safety, light-coloured road surfaces (yellow/white) contribute to CO_2-reduction by reducing lighting and heat stress in urban areas.

However, concerns have arisen in the market as to whether these synthetic pigmentable clear binders can still be used, due to handling and health and safety reasons. While this type of coloured asphalt does give the best results both in terms of colour and service life. Recent research shows that these concerns are unfounded and that a clear binder can be used responsibly to produce a high-quality warm mix asphalt (WMA).

This contribution will delve deeper into the specific aspects of pigmentable (clear) binders and how to apply them in practice in the best way. The circular and health and safety aspects of coloured asphalt will also be discussed.

2. Coloured asphalt in practice

The different techniques for achieving a coloured road surface differ from each other in both quality and cost. A bituminous surface treatment with coloured crushed stone will be the cheapest. The weather conditions during construction will then largely determine the service life. If the crushed stone does not bond well with the emulsion, the service life will be very short (e.g. when laid in poor weather conditions). This also applies to an epoxy resin coating (it can only be applied to a dry surface).

Coloured asphalt produced with standard black bitumen and substantial amounts of colour pigment is regularly used because of its lower (initial) costs compared to asphalt with a clear binder. A disadvantage is that the colour is much darker than what is possible with clear binder (in the case of red-coloured asphalt, it is actually purple instead of red). Also, due to the large amount of pigment in black bitumen, the quality (especially ageing resistance) seems to decrease compared to standard black asphalt. The possible cause of this is that the pigments used are not compatible with certain types of bitumen. This may even manifest itself immediately after asphalting in the form of an almost non-compactable 'dry' asphalt mixture.

Coloured asphalt with clear binders generally gives the best quality. However, an unmodified (low-grade) clear binder will perform worse than a standard black asphalt. This will then manifest itself in premature ravelling. Since little research has been done on properties on a laboratory scale, only visual inspections can give an impression of performance. More research should be done on this.

2.1 Case studies

To assess the performance of coloured road sections, several locations with red asphalt have been visually assessed in the Koggenland / Beemster region in the Netherlands (in 2019). The exact date of construction is not known for most locations, but they are at least 10 years old. The inspections show that at the locations where a polymer modified clear binder has been applied, the damage pattern is limited compared to the (cheaper) variants. The unmodified variant was often applied, especially in the past, in situations for which it was not suitable such as in traffic humps, resulting in premature damage.

<u>Surface treatment</u>


Figure 1: Left bituminous surface treatment.
Figure 2: Red epoxy coating on the right (with red asphalt with clear binder on the left).

A bituminous surface treatment with chipped red crushed stone gives a bright red colour. However, this application is not suitable for high-traffic locations. This will result in rapid wear and tear.

<u>Coloured asphalt with black bitumen</u>


Figure 3 and 4: Typical damage pattern of red asphalt with black bitumen. Exact date of construction is not known, but probably less than 10 years ago.

Coloured asphalt with clear binder

Figure 5 and 6: Typical damage pattern of red asphalt with unmodified clear binder. Date of construction for the situation on the left was around 2004. Ravelling was clearly visible here in 2019, but this also applied to the intermediate (black) asphalt.

Figure 7 and 8: Red asphalt with polymer modified clear binder. Apart from edge damage, no further damage in 2019.

A coloured asphalt with a (polymer modified) clear binder will behave like a standard black asphalt. Deformations from the subgrade (such as subsidence and root growth) will therefore manifest themselves in the asphalt and may become visible on the surface (see Figure 10).

Thus, based on visual (summary) assessments, it can be said that using a coloured asphalt with a polymer modified clear binder in practice provides the best quality coloured asphalt. The quality depends on the type of clear binder and can therefore vary. Because coloured asphalt with a clear binder is not subject to CE requirements, there is little data on its asphalt properties. Visual inspections do show that a polymer modified clear binder performs better compared to a unmodified variant.

Figure 9 and 10: Bicycle path with polymer modified clear binder constructed in 2005. Apart from root and edge damage, no further damage in 2023.

3. Synthetic pigmentable clear binder

Synthetic pigmentable clear binders have the advantage that a bright coloured asphalt can be achieved with relatively little pigment. This is in contrast to conventional black bitumen with which a dark colour is still obtained with 5% (powder) pigment. There are no standards for clear binders in the Netherlands. As a result, there may be clear binders on the market with mediocre performance that are used for the wrong application. COPRO has therefore drawn up specifications for the Belgian market, which are included in PTV 858 [1].

Synthetic pigmentable clear binders generally consist of petrochemical components derived from petroleum (just like conventional bitumen). With the right composition of components in a synthetic clear binder, the properties of a conventional (polymer modified) bitumen can then be simulated with a light brown colour (see Figure 11) [2]. Depending on the supplier and product type, the properties may well vary from low quality standard bitumen to high quality polymer modified bitumen. Depending on the type of binder, the asphalt mixing and processing temperature should therefore be adjusted accordingly [3].

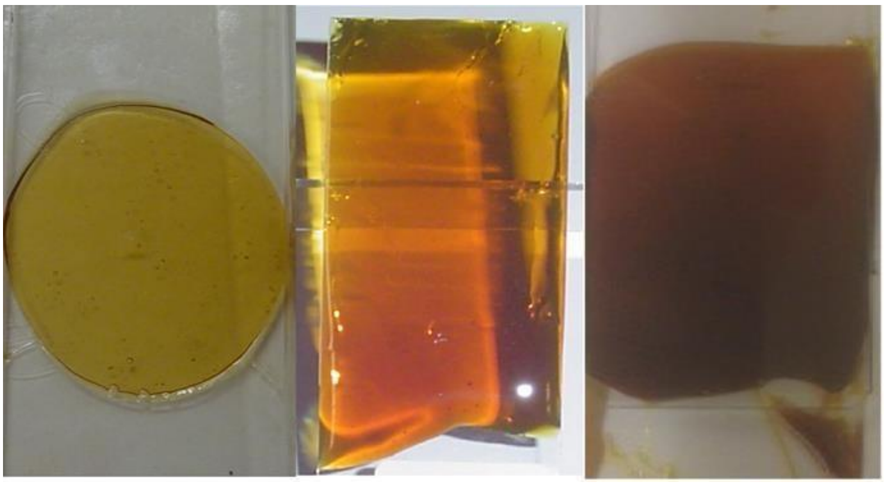


Figure 11: Typical colour of a synthetic clear binder on a glass slide.

3.1 Asphalt mixing temperature

Due to the specific composition of synthetic pigmentable clear binders, it is important not to heat and mix this type of binder above the temperatures recommended by the supplier. Because the synthetic clear binder contains few large (dark coloured) heavy molecules, if temperatures are too high, the binder is more likely to degrade, resulting in excessive vapour formation. It is worth noting that the viscosity of these special binders at higher temperatures is lower than that of conventional bitumen at the same temperature. In practice, this means that the mixing temperature of coloured asphalt with a synthetic pigmentable clear binder will be lower than for a standard asphalt.

Also, the pigment itself is sensitive to too high temperatures. Certain colour pigments can destabilise and change colour at too high temperatures. It is therefore important to produce this type of asphalt at the right temperatures and actually pay attention to this. In practice, mixing temperatures are sometimes too high. This gives an easy-to-process asphalt mixture, but can also lead to unnecessary emission of asphalt fumes resulting in odour complaints.

New developments in the market also make it possible to produce warm mix asphalt (WMA /low temperature asphalt) with synthetic pigmentable clear binders. With these so-called LT binders, it is possible to produce asphalt at a 30 °C lower temperature (120-140°C) and to compact (120-130°C), compared to the standard usual temperatures. Due to the 30°C lower temperature, in addition to gas savings, the emission of volatile compounds during production and processing will also be significantly reduced. The explanation for the substantial reduction of vapour formation at low temperatures is, that the boiling point of 90% of the constituents of synthetic clear binders is above 140ºC [4]. Producing asphalt at temperature below 140°C is in line with the intention of Bouwend Nederland to stop high-temperature road asphalt production by 2025 [5].

3.2 Characteristics synthetic pigmentable clear binders

For synthetic pigmentable clear binders, there are no (European) specifications, as mentioned earlier. Because these binders do simulate standard (polymer modified) bitumen, these binders can be characterised according to the bitumen standard for polymer modified bitumen (EN 14023).

The table below shows supplier-specified (polymer modified) synthetic pigmentable clear binders commonly used in the Netherlands. Product A concerns a unmodified variant. Product B and C are polymer modified.

Table 1: Specifications commonly used synthetic pigmentable clear binders in the Netherlands.

Property			Unit	Product A	Product B	Product B (LT)	Product C (LT)
Penetration			[dmm]	70-100	70-100	70-100	50-70
Softening point			[°C]	40-50	50-60	50-60	≥ 65
Breaking point of Fraaβ			[°C]	-	≤ -10	≤ -10	≤ -10
Elastic rebound			[%]	-	≥ 70	≥ 70	-
Viscosity	135°C		[mPa.s]	150-250	500-700	500-700	< 500
	185°C		[mPa.s]	-	100-200	100-200	-
Recommended mixing temperature			[°C]	150	160	120-140	140-160

3.3 Quality asphalt with synthetic pigmentable clear binder

The asphalt quality depends on the type of synthetic pigmentable clear binder applied. The binder quality can vary between standard penetration bitumen to high-quality polymer modified grade. Table 2 below and Figure 1 show the asphalt properties as an example between a high-quality PG76 synthetic clear binder and a standard polymer modified bitumen (PmB).

Table 2: 4-point deflection properties CE asphalt Color PG76 and a standard PmB.

Feature	Color PG 76	PmB	Unit
Rigidity S_{mix} (8Hz)	5153	7698	[MPa]
Fatigue resistance ε_6	258	160	[µm/m]
Track resistance f_c	0,04	-	m/pulse]

The table shows that a synthetic pigmentable clear binder can at least meet the performance of a standard PmB (its resistance to fatigue and rutting is very high). Early failure on mechanical properties is therefore not expected for this type of binder. The stiffness does decrease due to the modification, but this parameter is not normative for an overlay.

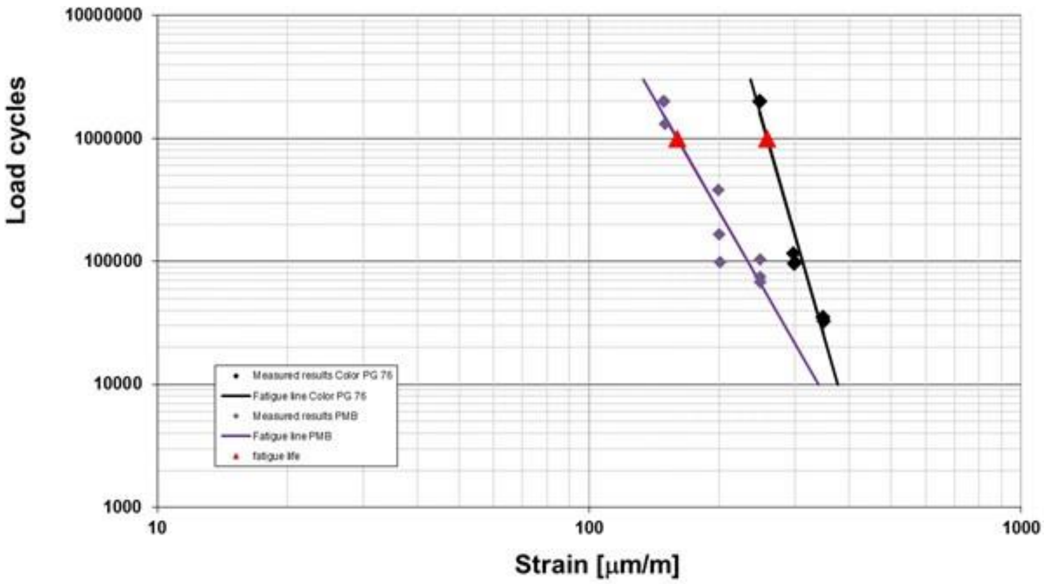


Figure 1: Compare fatigue line Color PG76 and standard PmB 4-point bending study.

3.4 Occupational health aspects synthetic pigmentable clear binders

As mentioned earlier, coloured asphalt is produced in the same way as a regular asphalt with standard bitumen. However, because the bitumen has been replaced by a synthetic clear binder, such a coloured asphalt mixture does not behave 100% the same as a standard asphalt mixture. Due to the nature of the clear binder, this type of asphalt is more sensitive to (too) high temperatures during asphalt production. It is therefore important not to exceed the maximum recommended mixing temperatures specified by supplier. Given the boiling point of these components [4], it is possible to avoid emissions of these components if these asphalt mixtures are produced/processed at low temperatures.

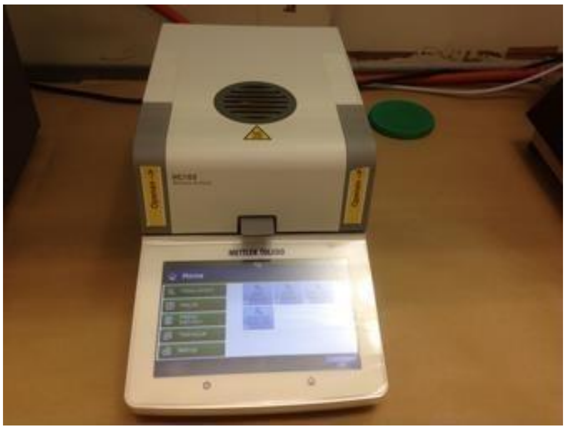
Using the mass loss method described below with the thermobalance, the effect of temperature can be easily determined. On a more quantitative way, a GC-MS (mass spectrometry) test can be used to determine the nature of the vapour.

Mass loss thermobalance

Determination of mass loss at 160 and 180°C for 4 hours.

Equipment

- Thermobalance (Mettler-Toledo HC 103):



Working method

- Weigh about 5 grams of bitumen into the alumina dish (as much as needed to cover the dish with a thin and even layer).
- Determine the mass loss (LOD - loss on drying) for 4 hours at 160°C.
- Repeat the test with a new sample at 180°C.
- Plot the result on a graph (mass loss plotted against time [minutes]).

Result

- Graph showing mass loss plotted against time.
- Mass loss after 4 hours (240 minutes).

Mass loss result

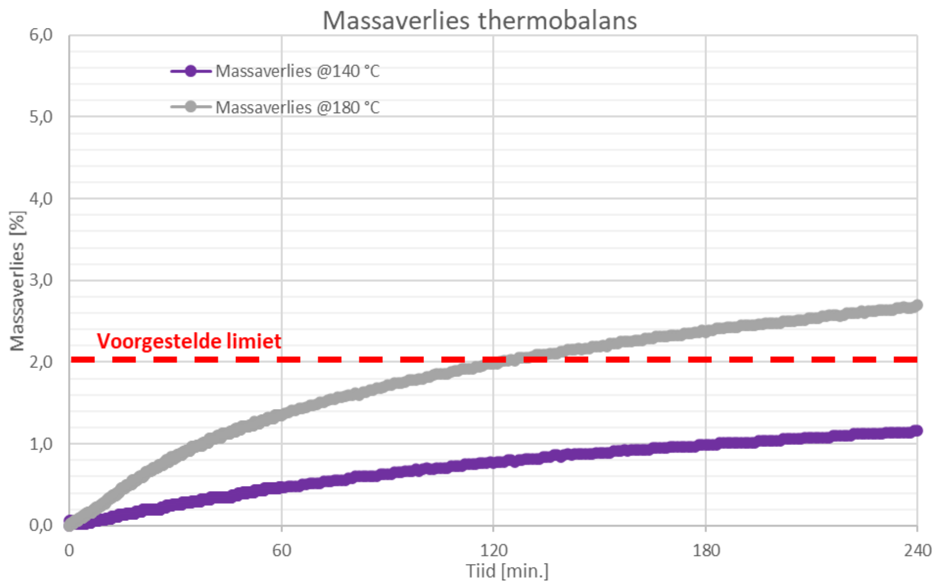


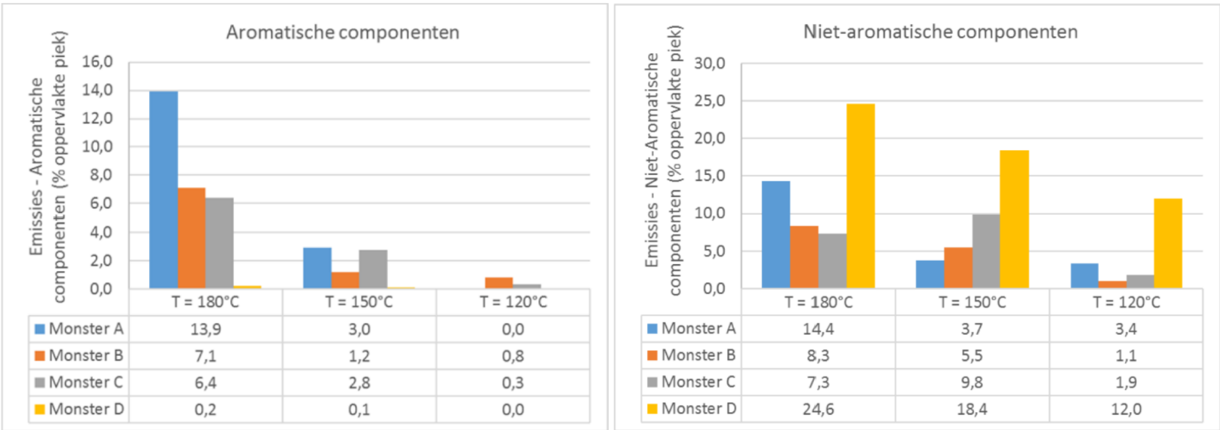
Figure 2: Mass loss curve polymer modified clear binder at 140 and 180°C.

Figure 2 clearly shows the temperature effect on mass loss. In practice, this mass loss is related to the emission of vapours from the binder. Processing at a lower temperature is more favourable here. Asphalt processing as warm mix asphalt (WMA) at lower temperatures is therefore preferred.

Headspace GC-MS

Headspace GC-MS can be used to quantify the vapour formation of a substance. The method consists of a gas chromatograph and a mass spectrometer. The gas chromatograph provides separation of the various components, followed by identification by means of a mass spectrometer. By heating a (clear) binder sample in a sealed sample bottle at the desired test temperature (for binders relevant temperatures 120, 150 and 180°C). The resulting volatile components can then be injected into the gas chromatograph and further analysed.

Research [4] between 3 types of synthetic pigmentable clear binders compared to a standard bitumen 70/100 shows that the clear binders are characterised by higher emission of aromatic components compared to standard bitumen. On the contrary, the emission of non-aromatic components are higher for a standard bitumen than for clear binders. This explains that clear binders have a more specific odour than standard bitumen. Figures 3 and 4 graphically show the relative emission at different temperatures of aromatic and non-aromatic components for the different clear binders studied and a reference bitumen.



Figures 3 and 4: Relative emission aromatic and non-aromatic components plotted against temperature of clear binders (sample A, B and C) and reference bitumen 70/100 (sample D) [4].

From the results, it is clear to see that the emission of clear binders at a temperature of 180°C contain mainly aromatic components. The most common compounds are Indene and Cumene with the C_9H_x molecular structure. These components cause prickling and cough on inhalation and redness and pain/irritation in eye contact and also have a typical odour.

At lower temperatures, the emission of aromatic components decreases drastically (80-90% reduction). The explanation for this is that the boiling point of the aromatic components are on average above 140°C. This means that processing of clear binders as LT (low temperature) variant will have similar emission vapours as a standard bitumen (mainly emission of non-aromatic constituents).

It should be noted that visible vapour formation during asphalting does not automatically mean emission of harmful substances. For example, asphalting on a moist surface will generate substantial water vapour.

4. *Simulation test emissions coloured asphalt*

The production and processing of asphalt releases emissions. For safe processing, these emissions must be as low as possible. A study was carried out in Ooms Productens' laboratory to quantify these emissions during the hardening process for a red coloured asphalt mixture with a synthetic pigmentable clear binder [5]. For this purpose, 3 batches of 120 kg of asphalt were manufactured in the laboratory and placed in a sealed container of 1 m^2 at a mixing temperature of 130-140°C (simulation transport asphalt mixture). Emissions were collected for 3 hours in an activated carbon tube filter for the Tauw exposure study and in a separate filter according to IFA method 6305-2. The amount of emissions collected in the filters and quantification of components for the Tauw exposure study, were determined by external laboratories.

Similarly, 3 batches of asphalt were produced for the emission measurement during cooling (simulation emission during asphalting). For this, the mixed asphalt was placed in the open area of the laboratory and emissions were also collected for 3 hours for the Tauw exposure study and IFA method.

The asphalt mixture used was an AC 11 surf with 5.8% synthetic pigmentable clear binder 70/100 (LT) with Cloburn red aggregate and low dust pigment. The asphalt was mixed at temperatures between 130-140°C.

<u>Situation A Fingerprint - determination of emission composition</u>
The measurement set-up for situation A: Determination composition of emissions in an enclosed room (worst-case scenario) is shown in the figure below.

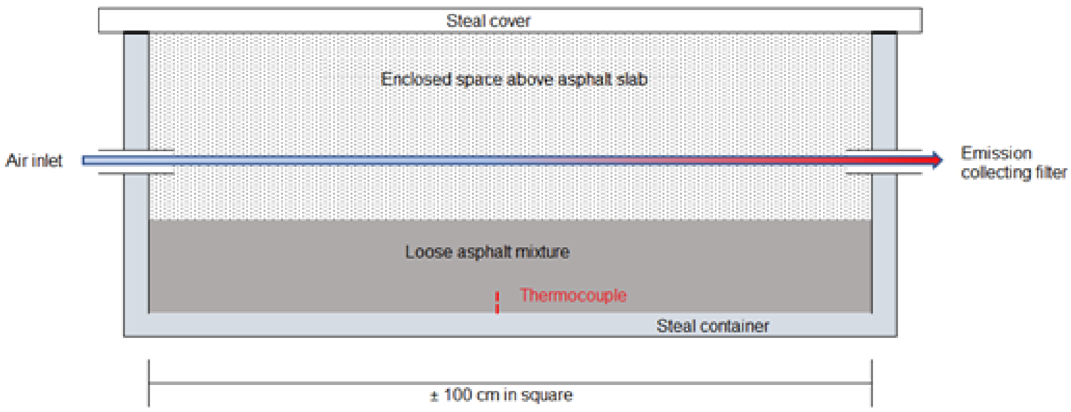


Figure 5: Schematic representation of test setup emission during transport.

The collected filters were examined for the Tauw exposure study for the following components (and related compounds), which are the most suspicious based on the headspace GC-MS study.

Table 3: Components examined

CAS number	Substance name
91-20-3	Naphthalene
95-13-6	Indene
98-82-8	Cumene
100-42-5	Styrene (compounds)
Volatile substances	TVOC
7783-06-4	Hydrogen sulphide (H_2S)

The filters collected for the IFA method were only analysed for total amount of emission.

Situation B Emissions during asphalt processing

The measurement setup for situation B: Determination of emission in open space (simulation emission during asphalting) is shown in the figure below.

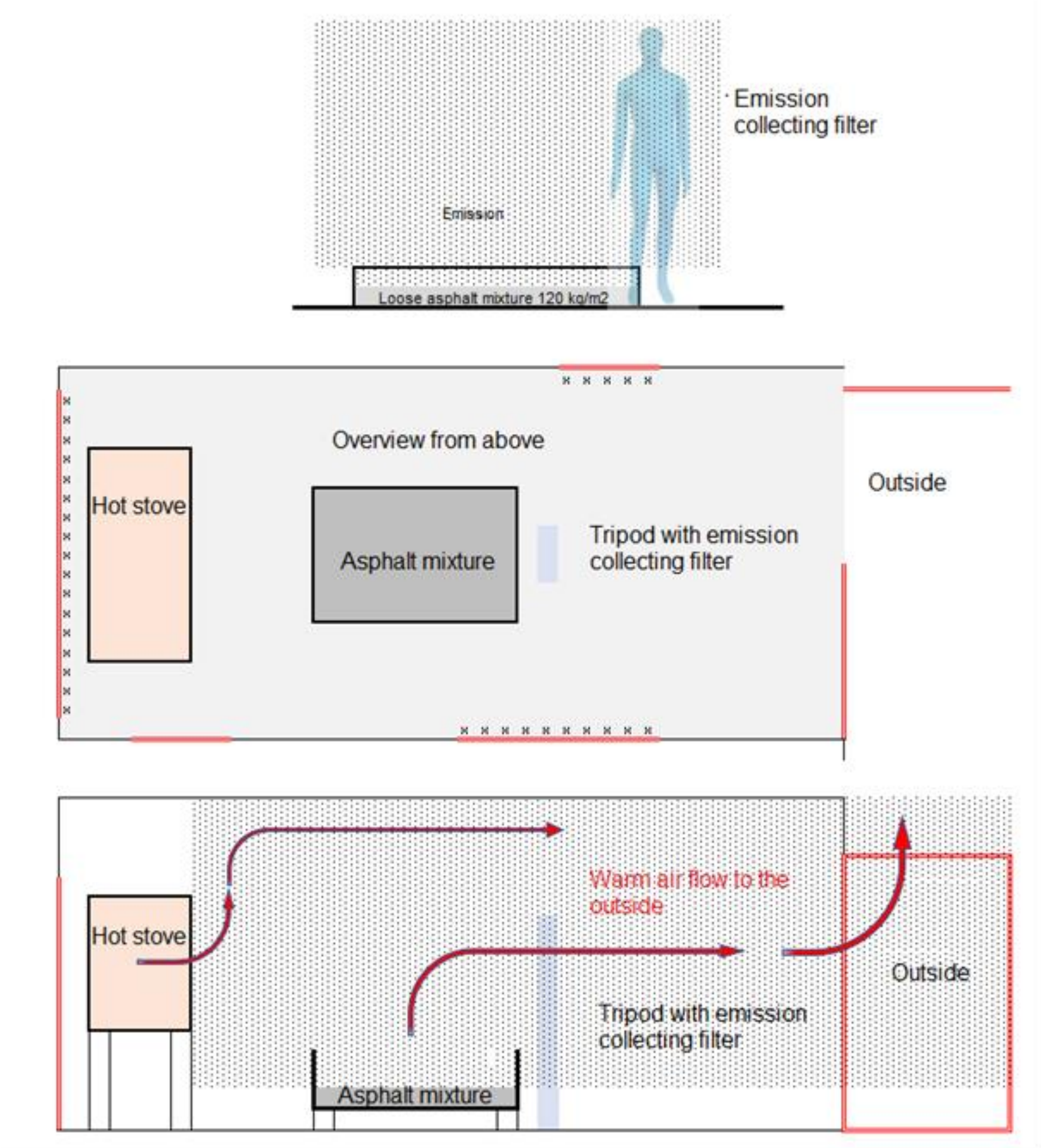


Figure 6: Schematic representation of test set-up emissions during asphalt processing.

Collection of emissions in the filters took place near the open bin with warm asphalt in the airflow to the outside. Analysis of the collected filters was done in a similar way to that for situation A.

4.1 Tauw exposure survey results

Tables 4 and 5 summarise the measurements from the exposure study. The full results are included in the Tauw report [6].

Table 4: Measurement results air measurements situation A (fingerprint)

Component	Cas no	Concentration	entration	entration	Exposure limit
		mg/m3	mg/m3	mg/m3	mg/m3
		Test 1	2	3	TGG 8 hours
Hydrogen sulphide	4-6-7783	< 0.03	< 0.03	< 0.03	2.3
Cyclohexane	110-82-7	< 0.11	< 0.11	< 0.11	700
n-Hexane	110-54-3	0.15	0.11	0.25	72
Heptane	142-82-5	0.27	0.23	0.5	1.200
n-Pentane	109-66-0	< 0.11	< 0.11	0.31	1.800
iso-Pentane	78-78-4	< 0.11	< 0.11	< 0.11	1.800
Neopentane	463-82-1	< 0.11	< 0.11	< 0.11	1.800
1,2,3-Trimethylbenzene	526-73-8	< 0.11	< 0.11	< 0.11	100
Benzene	71-43-2	< 0.11	< 0.11	< 0.11	0,7
o-Xylene	95-47-6	< 0.11	< 0.11	0.19	221
1,2,4-Trimethylbenzene	95-63-6	0.13	0.14	0.28	100
1,3,5-Trimethylbenzene	108-67-8	< 0.11	< 0.11	< 0.11	100
Styrene	100-42-5	0.46	0.43	0.88	85
Toluene	108-88-3	0.19	0.15	0.28	150
Ethylbenzene	100-41-4	0.37	0.32	0.61	215
Cumene (Isopropylbenzene)	98-82-8	3	2,84	5.14	50
m+p-Xylenes	179601-23-1	0.23	< 0.22	0.4	210
alpha-Methylstyrene	98-83-9	1.04	1.06	2.43	20
Naphthalene	91-20-3	< 0.11	< 0.11	0.23	50
Indene	95-13-6	2.73	3.56	7.74	45
C6-C12 hydrocarbons	-	4.42	3.84	8.3	-
TVOC	-	40.9	42.85	88.49	-
Temperature [°C]	-	131	133	138	

The measurement for situation A, where vapour formation was measured in an enclosed room, shows that even in this worst-case scenario, the exposure limit value (GSW) has not been exceeded as time-weighted average (TGG). However, it can be clearly seen that emissions increase with increasing temperature (about factor 2 at 10°C rise). The limit value (GSW) is a concentration level of a gas, vapour, aerosol, fibre or of dust in the air at the workplace. When setting this value, the basic assumption is that - as far as current knowledge goes - workers' health will not be adversely affected. Even in the event of repeated exposure to that concentration, over a longer or even a working lifetime.

The measurement for situation B, where the vapour formation in the open area was measured (simulation emission behind the asphalt spreader), shows that in this case the emission was below the detection limit in all cases and thus well below the limit value (GSW) as time- weighted average (TGG).

All concentrations are below 10% GSW except for benzene. For the benzene component, it is not possible to report below 16% GSW with the aspirated flow rate in 3 hours.

Table 5: Measurement results air measurements situation B (open space)

Component	Cas no	Concentration	entration	entration	Exposure limit
		mg/m3	mg/m3	mg/m3	mg/m3
		Test 1	2	3	TGG 8 hours
Hydrogen sulphide	4-6-7783	< 0.11	< 0.11	< 0.11	2,3
Cyclohexane	110-82-7	< 0.11	< 0.11	< 0.11	700
n-Hexane	110-54-3	< 0.11	< 0.11	< 0.11	72
Heptane	142-82-5	< 0.11	< 0.11	< 0.11	1.200
n-Pentane	109-66-0	< 0.11	< 0.11	< 0.11	1.800
iso-Pentane	78-78-4	< 1.06	< 1.06	< 1.06	1.800
Neopentane	463-82-1	< 0.53	< 0.53	< 0.53	1.800
1,2,3-Trimethylbenzene	526-73-8	< 0.11	< 0.11	< 0.11	100
Benzene	71-43-2	< 0.11	< 0.11	< 0.11	0,7
o-Xylene	95-47-6	< 0.11	< 0.11	< 0.11	221
1,2,4-Trimethylbenzene	95-63-6	< 0.11	< 0.11	< 0.11	100
1,3,5-Trimethylbenzene	108-67-8	< 0.11	< 0.11	< 0.11	100
Styrene	100-42-5	< 0.11	< 0.11	< 0.11	85
Toluene	108-88-3	< 0.11	< 0.11	< 0.11	150
Ethylbenzene	100-41-4	< 0.11	< 0.11	< 0.11	215
Cumene (Isopropylbenzene)	98-82-8	< 0.21	< 0.21	< 0.21	50
m+p-Xylenes	179601-23-1	< 0.11	< 0.11	< 0.11	210
alpha-Methylstyrene	98-83-9	< 0.11	< 0.11	< 0.11	20
Naphthalene	91-20-3	< 0.11	< 0.11	< 0.11	50
Indene	95-13-6	< 0.11	< 0.11	< 0.11	45
C6-C12 hydrocarbons	-	< 0.11	< 0.11	< 0.11	-
TVOC	-	< 0.11	< 0.11	< 0.11	-
Temperature [°C]	-	140	133	135	-

4.2 IFA method results

The emission collected in the filters was analyzed by the Aneco laboratory in Germany. The results of the analysis are shown in the tables below.

Table 6: Emission closed container

Simulation	Asphalt	Binder	Temperature [°C]	Emission [mg/m^3]
A1	AC 11 surf	Color 70/100 LT	131	74
A2	AC 11 surf	Color 70/100 LT	133	72
A3	AC 11 surf	Color 70/100 LT	138	97
Average			134	81

Table 7: Emission in open air

Simulation	Asphalt	Binder	Temperature [°C]	Emission [mg/m^3]
B1	AC 11 surf	Color 70/100 LT	140	0.9
B2	AC 11 surf	Color 70/100 LT	133	0.7
B3	AC 11 surf	Color 70/100 LT	135	0.4
Average			136	0.7

Table 7 shows that the emission of vapours and aerosols in open space, such as during asphalting of an asphalt mixture with a synthetic pigmentable clear binder, to be lower than the proposed maximum value of 1.5 mg/m^3 during asphalting (based on German guideline).

5. Circularity coloured asphalt

Asphalt is widely reused in the Netherlands in the form of partial recycling (PR) in new asphalt. Recycling can be done with standard asphalt as well as with old polymer modified asphalt (PmA) and coloured asphalt with clear binders without problems and without much effort, up to percentages of 60-70% PR for sub-bases (AC base asphalt). The obtained quality of the new asphalt to date is at least comparable to the quality of standard asphalt without PR. This is possible because a clear binder is fully compatible with (rejuvenated) bitumen and also still contains active polymers. This is because the composition of a synthetic pigmentable clear binder consists of ingredients that can also be used in polymer modified bitumen. Reuse of coloured asphalt with a synthetic pigmentable clear binder is therefore no problem at all.

Application in a standard (black) surface layer is not preferable, because of the different coloured crushed stone. It is therefore important in such a case to properly homogenise the coloured asphalt granulate with the existing asphalt granulate. Otherwise, there is a risk of discolouration visible on the road surface after the new bitumen wears off at the surface.

Horizontal recycling of coloured asphalt granulate can, however, make a significant contribution to achieving road authorities' goals of achieving more sustainable asphalt mixtures. Due to logistical reasons, coloured asphalt granulate is currently not kept separately at the asphalt plant. Should this be the case in the future, a coloured asphalt could also be easily produced from recycled asphalt. Due to the different colour of standard (black) asphalt granulate, it does not make sense to use this material in coloured asphalt.

6. Discussion

With the right selection of materials, it is possible to produce coloured asphalt with a service life at least equal to standard (black) asphalt. For a bright colour, the application of a synthetic pigmentable clear binder is required here. Synthetic pigmentable clear binders have different properties than might be expected from conventional penetration bitumen. This must therefore be taken into account when mixing in the asphalt plant. If the correct production and processing instructions are applied, there are no indications that this coloured asphalt will cause problems in terms of both quality and working conditions. This is in contrast to the alternative in which additives are added to black bitumen. In practice, this asphalt seems to have a shorter lifespan.

Only deviation from the instructions (excessive mixing temperature) when using a clear binder can cause excessive vapour and emission formation. This deviation can lead to sensory nuisance. This applies not only to synthetic pigmentable clear binders but to binders in general. With the application of clear binders in a warm mix asphalt (WMA), the production temperature of the asphalt is such (lower than 140°C) that the risk of sensory effects is reduced to zero and comparable to conventional binders. These new developments are possible on the basis of warm mix asphalt (WMA) technology, which is also possible in combination with synthetic pigmentable clear binders, provides improved processing properties at lower asphalt temperatures and significantly reduces fumes during production and paving of the asphalt.

The emission study of the processing of coloured asphalt with a synthetic pigmentable clear binder shows that in the processing phase of the asphalt, the emission of suspicious components remains well below the 10% limit as included in the Occupational Health and Safety Standards at the recommended processing temperatures of 130-140°C.

Emissions in a storage bin (worst-case scenario) also remain within the limit value. It should be noted here that emissions in an enclosed non-ventilated area, such as in the asphalt plant, could always exceed the set standards. Just like when using standard bitumen.

Studies based on total vapour and aerosol emissions according to IFA method 6305-2 confirm the findings of the Tauw exposure study. Emission of vapours and aerosols in open space such as during asphalting of an asphalt mixture is lower than the proposed maximum value of 1.5 mg/m^3 based on German regulations during asphalting.

It has been demonstrated that a synthetic pigmentable clear binder is fully compatible with existing bitumen. Recycling of coloured asphalt is therefore fully possible. When recycling in conventional asphalt, however, it is important to properly homogenise the coloured asphalt granulate by the ‘black’ asphalt granulate to avoid problems in colour. For PR asphalt, in general terms, the optimisation lies in the logistics side; separate storage and reprocessing of materials. The same also applies to coloured asphalt with synthetic pigmentable clear binder. This optimisation can be seen in the market in the creation of so-called asphalt banks

Therefore, based on practical experience, there is no indication that synthetic pigmentable clear binders would be less sustainable and circular than currently available alternatives. More research is needed to properly substantiate this.

7. References

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