

BITUMEN COMPOSITION CONTAINING FULLY OR PARTIALLY HYDROGENATED BLOCK COPOLYMER AND
A
PROCESS FOR ITS PREPARATION

Field of the Invention

This invention relates to a process for preparing a polymer-modified bitumen composition. The invention further relates to a concentrated polymer-modified bitumen composition and a diluted polymer-modified bitumen composition comprising said concentrated polymer-modified bitumen composition. The invention further relates to the use of said diluted polymer-modified bitumen composition in asphalt mixtures for road applications.

Background of the Invention

Bitumen is used as a binder in road asphalt mixtures, and has developed continually to meet ever-increasing performance demands from road building constructors. In general bitumen performs well in road asphalt, but increasingly heavy traffic loads and high traffic volume have led to the wear of many roads through rutting and cracking of the surface.

In their article titled "Polymer modification of bitumen: Advances and challenges", published in May 2014 in the European Polymer Journal, volume 54, pages 18-38, J. Zhu et al. describe the modification of bitumen with polymers. By polymer modification of bitumen is herein understood to mean the incorporation of polymers in bitumen, for example by mechanical mixing or by chemical reaction. According to J. Zhu et al. polymer modification is reported to lead to improved properties, such as higher stiffness at high temperatures, a higher cracking resistance at low temperatures, a better moisture resistance and/or a longer fatigue life. J. Zhu

et al, however, indicated that in addition to the reported advantages, researchers also encountered various challenges, including high costs and poor storage stability.

5 WO2015/170739 describes an asphalt composition use for e.g. road surfacing containing 0.5 to 20 parts mass of a block copolymer and 100 parts mass of asphalt. The block copolymer comprises a polymer block (A) containing 20-60% mass vinyl aromatic monomer units as main
10 component, and copolymer block (B) containing conjugated diene monomer units and vinyl aromatic monomer units. The content of copolymer block (A) in the block copolymer is 10-40% mass. The hydrogenation rate of double bonds in the conjugated diene monomer units of the block
15 copolymer is 40-100%.

It would be an advancement in the art to provide a process for producing polymer-modified bitumen that would allow for an overall reduction in manufacturing cycle time and energy consumption whilst maintaining good
20 storage stability, good road application properties and good rutting and cracking properties.

Summary of the Invention

According to the present invention there is provided a process for preparing a polymer-modified bitumen
25 composition comprising the steps of:

(i) preparing a masterbatch of a concentrated polymer-modified bitumen composition comprising blending (a) from 3.5 to 30 wt%, by weight of the concentrated polymer-modified bitumen composition, of a fully or partially
30 hydrogenated block copolymer; (b) from 60.0 wt% to 96.5 wt%, based on the total weight of the concentrated polymer-modified bitumen, of a bitumen component; (c) optionally a flux component; and (d) optionally one or

more additional components;

(ii) diluting the masterbatch of concentrated polymer-modified bitumen composition produced in step (i) with one or more additional bitumen components thereby producing a diluted polymer-modified bitumen composition comprising 4 wt% or less, based on the total weight of the diluted polymer-modified bitumen composition, of fully or partially hydrogenated block copolymer.

According to another aspect of the present invention there is provided a concentrated polymer-modified bitumen composition, comprising:

(i) from 3.5 to 30.0 wt%, based on the total weight of the concentrated polymer-modified bitumen composition, of a partially or fully hydrogenated block copolymer;

(ii) from 60.0 to 96.0 wt%, based on the total weight of the composition, of a bitumen component; and

(iii) from 0.5 wt% to 10.0 wt%, based on the total weight of the composition, of a flux component; and

(iv) optionally one or more additional components.

According to yet a further aspect of the present invention there is provided a diluted polymer-modified bitumen composition, comprising:

(i) from 0.5 wt% to 5.0 wt%, based on the total weight of the diluted polymer-modified bitumen composition, of a partially or fully hydrogenated block copolymer;

(ii) from 90 wt% to 99.0 wt%, based on the total weight of the composition, of a bitumen component;

(iii) from 0.5 wt% to 5.0 wt%, based on the total weight of the composition, of a flux component; and

(iv) optionally one or more additional components.

The process according to the present invention advantageously allows for the long-term storage of the polymer-modified bitumen at a high concentration of the

block copolymer thereby allowing for a high storage stability. In addition, the process of the present invention allows for a reduction in the overall manufacturing cycle time of polymer-modified bitumen, as well as a reduction in energy consumption. Furthermore, application of the diluted polymer-modified bitumen composition allows the paving to be carried out at a low concentration of block copolymer, allowing for good rutting and cracking properties and at reduced energy consumption.

Brief Description of the Drawings

Figure 1 is a graph of the experimental data of Table 2 and shows storage stability measurements (Delta in softening point °C) of masterbatches produced in the Examples here in below using various grades of bitumen with varying polymer concentrations.

Detailed Description of the Invention

The process herein comprises a first step of preparing a masterbatch of a concentrated polymer-modified bitumen composition. Such masterbatch is prepared by blending a block copolymer with a bitumen component, preferably one or more flux components, and optionally one or more additional components.

The block copolymer is present in an amount of from 3.5 to 30 wt%, preferably from 5% to 15wt%, by weight of the concentrated polymer-modified bitumen composition. A high concentration of block copolymer in the masterbatch contributes to the high stability characteristics. In order to maximise storage stability of the masterbatch, the block copolymer is preferably present at a level of from 8 to 15 wt%, more preferably from 10 to 15 wt%, even more preferably from 11 to 15 wt%, by weight of the concentrated polymer-modified bitumen composition. If

the polymer content in the masterbatch is too high then this may lead to high viscosity and gelling of the masterbatch which in turn could lead to issues with pumpability.

5 The block copolymer for use herein preferably comprises at least one polymer block derived from a vinyl aromatic hydrocarbon monomer and at least one polymer block derived from a conjugated diene monomer. The block copolymer may be linear or radial, symmetric or
10 asymmetric, and may have a structure represented by the formula A-B, A-B-A, B-A-B, A-B-A-B etc. wherein A is the polymer block of a vinyl aromatic hydrocarbon and B is polymer block of a conjugated diene. The block copolymer preferably contains up to 40% by weight of vinyl aromatic
15 hydrocarbon, more preferably from 30 to 40% by weight of vinyl aromatic hydrocarbon.

 The vinyl aromatic hydrocarbon is preferably styrene, o-methylstyrene, p-methylstyrene, p-tert-butylstyrene, 1,3-dimethylstyrene, α-methylstyrene, vinyl naphthalene or
20 vinylanthracene, most preferably styrene. Mixtures of vinyl aromatic hydrocarbons may be used.

 The conjugated diene preferably has from 4 to 8 carbon atoms, and is more preferably selected from 1,3-butadiene, 2-methyl-1,3-butadiene (isoprene), 2,3-
25 dimethyl-1,3-butadiene, 1,3-pentadiene, and 1,3-hexadiene. Most preferably the conjugated diene is 1,3-butadiene or isoprene. Mixtures of conjugated dienes may be used.

 The block copolymer is fully or partially
30 hydrogenated which means that all or a certain percentage of the double bonds in the conjugated diene moieties are hydrogenated. Preferably the block copolymer is from 40 to 100 wt% hydrogenated, more preferably 40 to 99.5 wt%

hydrogenated, even more preferably from 50 to 90 wt%
hydrogenated, and especially from 60 to 90 wt%
hydrogenated.

5 Examples of suitable fully or partially hydrogenated
block copolymers for use herein include a fully or
partially hydrogenated styrene- β -isoprene polymer (SEP),
a fully or partially hydrogenated styrene- β -isoprene- β -
styrene polymer (SEPS), a fully or partially hydrogenated
10 styrene-isoprene-styrene polymer (SIS), a fully or
partially hydrogenated styrene- β -butadiene- β -styrene
copolymer (SEBS), and a fully or partially hydrogenated
styrene- β -isoprene/butadiene- β -styrene copolymer (SEEPS).

In a preferred embodiment herein, the block copolymer
comprises a polymer block (A) comprising vinyl aromatic
15 monomer units as main component, and copolymer block (B)
comprising conjugated diene monomer units and vinyl
aromatic monomer units, wherein the content of the vinyl
aromatic monomer units in the block copolymer is in the
range from 20 to 60 mass%, the content of the copolymer
20 block (A) in the block copolymer is in the range from 10
to 40 mass% and the hydrogenation rate of double bonds in
the conjugated diene monomer units of the block copolymer
is in the range from 40 to 100%, preferably in the range
from 50 to 90%, more preferably in the range from 60 to
25 90%. Polymers of this type are disclosed in
WO2015/170739, incorporated herein by reference in its
entirety. It has been found that polymers of this type
enable a final (diluted) polymer-modified bitumen to be
produced which contains significantly less polymer.

30 In a preferred embodiment herein, the conjugated
diene monomers units of the block copolymer comprise (a)
conjugated diene monomer units derived from 1,2-bonds
and/or 3,4-bonds and (b) conjugated diene monomer units

derived from 1,4-bonds, and if the total content of conjugated monomer diene units is taken to be 100 mass%, the content of alkenyl monomer units (a1) obtained by hydrogenating the conjugated diene monomer units (a) is in the range from 10 to 50 mass%, the content of alkenyl monomer units (b1) obtained by hydrogenating the conjugated diene monomer units (b) is in the range from 0 to 80 mass%, and the total content of unhydrogenated conjugated diene monomers units (a2) following hydrogenation and unhydrogenated conjugated diene monomer units (b2) following hydrogenation is in the range from 0 to 90 mass%.

Preferably, the content of conjugated diene monomer units (a) derived from 1,2-bonds and/or 3,4-bonds is in the range from 10 to 50 mass% relative to the total content of the conjugated diene monomer of the block copolymer.

The weight average molecular weight of the block copolymer for use herein is preferably in the range of from 50,000 to 300,000.

In a preferred embodiment herein the block copolymer has at least one type of functional group selected from hydroxyl groups, acid anhydride groups, epoxy groups, amino groups, amide groups, silanol groups and alkoxysilane groups.

During preparation of the masterbatch, the block copolymer is blended with a bitumen component. Preferably high shear mixing is used for blending of the block copolymer with the bitumen component during preparation of the masterbatch. As used herein, the term "high shear mixing" means mixing at a speed from 4000 to 6000 rpm. Preferably a Silverson high shear mixer is used in the process herein for producing the masterbatch.

Preferably, the time taken to produce the masterbatch in step (i) of the process herein is from 0.5 hours to 6 hours.

5 The bitumen used in the process of the present invention may be a residue from the distillation of crude oil, a cracked residue, naturally occurring bitumen or a blend of various bitumen types. Examples of bitumen that may be conveniently used in the present invention include distillation or "straight run" bitumen, precipitation
10 bitumen, e.g. propane bitumen, oxidized or blown bitumen, naphthenic bitumen, paraffinic bitumen or mixtures thereof.

Various grades of bitumen may be used in the process of the present invention, such as, for example, 35/50,
15 50/70, 70/100, 100/150, 160/220 grades.

The bitumen component is present in the masterbatch of the concentrated polymer modified bitumen at a level of from 60.0wt% to 96.5 wt%, preferably from 70.0 wt% to 96.5 wt%, more preferably from 85 to 92 wt%, based on the
20 total weight of the concentrated polymer-modified bitumen.

The masterbatch of the concentrated polymer modified bitumen may also comprise one or more additional components suitable for use in a bitumen formulation.
25 Such additional components are well known to those skilled in the art and include, for example, waxes, anti-stripping agents, viscosity modifiers, penetration correctors (for example, Gilsonite), softening agents, process oils, GTL oils, aromatic oils, paraffinic oils,
30 and petroleum distillates, and the like.

In a preferred embodiment herein the concentrated polymer-modified bitumen composition comprises (i) from 3.5 to 30.0 wt%, based on the total weight of the

concentrated polymer-modified bitumen composition, of a partially or fully hydrogenated block copolymer;

(ii) from 60.0 to 96.0 wt%, based on the total weight of the composition, of a bitumen component;

5 (iii) from 0.5 wt% to 10.0 wt%, based on the total weight of the composition, of a flux component; and

(iv) optionally one or more additional components.

The flux component for use herein reduces the viscosity of the polymer-modified bitumen and causes it
10 to more easily coat the newly spread aggregate thereby forming a stronger bond or adhesion. Any flux component suitable for use in polymer-modified bitumen can be used herein. Suitable flux components for use herein include aromatic, naphthenic or paraffinic flux oils, petroleum
15 extracts, e.g. aromatic extracts, distillates or residues, mineral derived or synthetic base oils, and vegetable oils. Examples of suitable flux components include bright stock furfuryl extract (BFE), Fischer-Tropsch derived base oils such as HVI 160B supplied by
20 Shell, de-asphalted cylinder oil (DACO), softener oils like TDAE VIVATEC supplied by H&R group, and lubricating base oils such as re-refined SN150 supplied by Whelan Refining Limited (UK).

The flux component used herein can help to improve
25 storage stability and viscosity criteria, as well as improve compatibility between the bitumen and the polymer and is preferably present at a level of from 5% to 7% by weight of the concentrated polymer-modified bitumen composition.

30 A preferred flux component for use herein is brightstock furfuryl extract (BFE).

After the masterbatch of concentrated polymer-modified bitumen has been prepared it may be stored in a

suitable storage tank or container until it is ready to be used or until it is ready to be transported to another location. One advantage of the present invention is the excellent storage stability of the prepared masterbatch of concentrated polymer-modified bitumen which means that it can suitably be stored for a period of time until it is needed. As used herein, the term "storage stable" means that the difference between the top and bottom softening points of the masterbatch of concentrated polymer-modified bitumen composition should be equal to or less than 5°C (according to CEN 13399-2010).

In a preferred embodiment, the masterbatch of the concentrated polymer-modified bitumen is mixed with the one or more additional bitumen components at low shear. As used herein, the term "low shear mixing" means mixing at a speed from 10 to 1500, preferably 250 to 500, even more preferably from 250 to 350 rpm. Preferably, low shear mixing involves the use of a simple agitator. The diluting of the masterbatch with bitumen component(s), preferably at low shear, enables the production of different grades of polymer-modified bitumen having different levels of polymer.

Advantageously, the manufacturing cycle time and overall energy consumption of the process of the present invention is significantly less than the manufacturing cycle time and overall energy consumption of conventional "direct-to-grade" processes for producing polymer-modified bitumen. "Direct-to-grade" processes typically involve the mixing of polymer with bitumen at high shear to produce only one grade of polymer-modified bitumen at a time. By contrast, the present invention allows dilution of the masterbatch, preferably at low shear, to produce various grades of polymer-modified bitumen in a

shorter manufacturing cycle time and using less energy.

The kinematic viscosity of the masterbatch of concentrated polymer-modified bitumen composition is preferably in the range of from 9000 to 12000 mm²/s, preferably in the range from 10000 to 11000 mm²/s at 180°C.

The dynamic viscosity of the masterbatch of concentrated polymer-modified bitumen composition is preferably in the range of from 1000 to 1200 cPs at 180°C.

In order for the masterbatch of concentrated polymer-modified bitumen composition to meet the desired viscosity criteria it is preferred that the block copolymer is present at a level of from 5 wt% to 7 wt%, by weight of the concentrated polymer-modified bitumen composition.

In a preferred embodiment the masterbatch of the concentrated polymer-modified bitumen composition is flowable at 180°C.

In a second step of the process herein, the masterbatch of concentrated polymer-modified bitumen is diluted with one or more additional bitumen components thereby producing a final polymer-modified bitumen composition comprising 4 wt% or less, preferably 3.5 wt% or less, for example in the range of from 1.0 to 3.5 wt%, or in the range of from 1.5 to 3.5 wt%, based on the total weight of the final (diluted) polymer-modified bitumen composition, of a partially or fully hydrogenated block copolymer.

The one or more additional bitumen components which is used for diluting the concentrated polymer-modified bitumen composition can be the same or different as the bitumen component which is used for producing the

masterbatch of concentrated polymer-modified bitumen composition.

5 The weight ratio of one or more additional bitumen components to the concentrated polymer-modified bitumen composition is preferably at least 2:1, more preferably at least 3:1.

10 The final polymer-modified bitumen composition is a diluted version of the concentrated polymer-modified bitumen composition produced in the first step of the process described hereinabove.

Hence according to the present invention there is provided a diluted polymer-modified bitumen composition, comprising:

- 15 (i) from 0.5 wt% to 5.0 wt%, based on the total weight of the diluted polymer-modified bitumen composition, of a partially or fully hydrogenated block copolymer;
- (ii) from 90 wt% to 99.0 wt%, based on the total weight of the diluted polymer-modified bitumen composition, of a bitumen component;
- 20 (iii) from 0.5 wt% to 10.0 wt%, preferably from 2 wt% to 8wt%, based on the total weight of the diluted polymer-modified bitumen composition, of a flux component; and
- (iv) optionally one or more additional components.

25 The polymer-modified bitumen compositions can comprise one or more additional components such as, for example, performance additives, waxes, fillers, Fischer-Tropsch waxes, Fischer-Tropsch base oils, aromatic oils, processing oils, and the like. Such additional components are well known to those skilled in the art.

30 The final (diluted) polymer-modified bitumen composition should meet the desired polymer-modified bitumen specification.

The final (diluted) polymer-modified bitumen

composition can be used as a binder in an asphalt composition for road paving applications. Hence according to the present invention there is provided an asphalt composition comprising a diluted polymer-modified bitumen composition as described herein.

The invention is further illustrated by the following non-limiting examples.

Examples

Various masterbatches of a concentrated polymer-modified bitumen composition were prepared using various grades of bitumen (35/50, 50/70, 70/100, 100/150, 160/220) and different block copolymers at various concentrations (5-12 wt% of block copolymer by weight of the concentrated polymer-modified bitumen composition).

The following experimental set-up was used to prepare the masterbatch:

- 1) Weighing balance (Mettler Toledo XP 2002S);
- 2) Heating plate;
- 3) Temperature controller;
- 4) Silverson high shear mixer L5M;
- 5) IKA low shear mixer, IKA-Werke, Eurostar power control visco;
- 6) Memmert heating oven.

For the following experiments, a partially hydrogenated polymer as disclosed and prepared in WO2015/170739 was used.

The 70/100 pen grade bitumen was heated for 2 hours to reach 180°C. Bitumen homogenization was carried out by stirring at low rotation per minute (1200 rpm) using the high shear Silverson mixer. At 175°C, the partially hydrogenated block copolymer was added slowly over a 5 to 7 minute time period using the Silverson high shear mixer at 1500-1600 rpm to provide a masterbatch having a final

level of partially hydrogenated block copolymer of 5 wt%. After addition of the partially hydrogenated block copolymer, mixing is carried out in a Silverson high shear mixer for 3 hours at 180°C at 6000 rpm.

5 The same method of preparation was used for other bitumen grades (35/50, 50/70, 100/150, 160/220) and for other concentrations of partially hydrogenated block copolymer (2.5%, 3.5%, 7%, 9% and 11 wt%).

10 By way of comparison, a non-hydrogenated SBS linear polymer (D1101 commercially available from Kraton) was used for preparation of masterbatches at 10 wt and 12 wt% polymer concentration using the same procedure as used above for preparing the masterbatches using partially hydrogenated block copolymer.

15 The masterbatches were tested using the equipment and test methods detailed in Table 1 below.

Table 1

Parameter	Test Method	Equipment used
Softening point	EN 1427-2015	Infratest
Dynamic viscosity	EN 13302	Brookfield viscometer
Storage Stability	CEN 13399-2010	-

20 Impact of various parameters on the storage stability of the masterbatch was studied. A masterbatch was considered storage stable if after storing at 180°C for 3 days (CEN 13399-2007) the change in softening point between the top and bottom of the storage stability tube was equal to or less than 5°C.

25 The results of the storage stability experiments are set out in Table 2 below. In Table 2 polymer "HP" denotes "hydrogenated polymer" and "SBS" denotes non-hydrogenated "styrene-butadiene-styrene polymer".

Table 2

Bitumen grade	Polymer type	Wt% Polymer	Storage stability		
			Softening point at Top of tube	Softening point at Bottom of tube	Delta in softening point between top and bottom of tube
			°C	°C	°C
35/50	HP	7	119.8	93.4	26.4
50/70	HP	9	124.2	111	13.2
50/70	HP	11	127.2	124.8	2.4
70/100	HP	2.5	82.5	77.9	4.6
70/100	HP	5	109.6	77.4	32.2
70/100	HP	7	120.8	91.8	29
70/100	HP	9	126.8	116.7	10.1
70/100	HP	10	124.5	115.2	9.3
70/100	HP	11	123.5	122.9	0.6
100/200	HP	9	120	110.2	9.8
100/200	HP	10	124.2	118.3	5.9
100/200	HP	11	125.2	123.6	1.6
100/200	HP	12	125.7	125	0.7
160/220	HP	9	116	95	21
160/220	HP	10	116	105	11
160/220	HP	11	125.4	119.8	5.6
70/100	SBS	10	106.4	93.2	13.2
70/100	SBS	12	109	102	7

Figure 1 is a graph of the storage stability data shown in Table 2, showing the delta in softening point °C of various masterbatches produced in the Examples using various grades of bitumen with varying polymer concentration. In Figure 1, "HP" means hydrogenated polymer and "SBS" means non-hydrogenated styrene-butadiene-styrene polymer.

It can be seen from the data in Table 2 and Figure 1 that all grades of bitumen (except 35/50 which was not studied above 7 wt%) were found to be storage stable at around 11% hydrogenated polymer concentration. It can

also be seen from the data in Table 2 and Figure 1 that the grades of bitumen which contained non-hydrogenated SBS were not storage stable.

C L A I M S

1. A process for preparing a polymer-modified bitumen composition comprising the steps of:

(i) preparing a masterbatch of a concentrated polymer-modified bitumen composition comprising blending (a) from 11 to 15 wt%, by weight of the concentrated polymer-modified bitumen composition, of a fully or partially hydrogenated block copolymer; (b) from 60.0wt% to 96.5 wt%, based on the total weight of the concentrated polymer-modified bitumen, of a bitumen component; (c) from 5 to 7 wt%, by weight of the concentrated polymer-modified bitumen composition, of a flux component; and (d) optionally one or more additional components;

(ii) diluting the masterbatch of concentrated polymer-modified bitumen composition produced in step (i) with one or more additional bitumen components thereby producing a diluted polymer-modified bitumen composition comprising 4 wt% or less, based on the total weight of the diluted polymer-modified bitumen composition, of the fully or partially hydrogenated block copolymer,

wherein the fully or partially hydrogenated block copolymer comprises a polymer block (A) comprising vinyl aromatic monomer units as main component, and copolymer block (B) comprising conjugated diene monomer units and vinyl aromatic monomer units, wherein the content of the vinyl aromatic monomer units in the block copolymer is in the range from 20 to 60 mass%, the content of the copolymer block (A) in the block copolymer is in the range from 10 to 40 mass% and the hydrogenation rate of double bonds in the conjugated diene monomer units of the block copolymer is in the range from 40 to 100%;

wherein the bitumen component is a 70/100
penetration grade bitumen; and

wherein the flux component is bright stock furfuryl
extract.

- 5 2. A process according to Claim 1 wherein the
hydrogenation rate of double bonds in the conjugated
diene monomer units of the block copolymer is in the
range from 50 to 90%.
- 10 3. A process according to Claims 1 or 2 wherein the
hydrogenation rate of double bonds in the conjugated
diene monomers units of the block copolymer is in the
range from 60 to 90%.
- 15 4. A process according to any of Claims 1 to 3 wherein
the conjugated diene monomer units of the block copolymer
comprise (a) conjugated diene monomer units derived from
1,2-bonds and/or 3,4-bonds and (b) conjugated diene
monomer units derived from 1,4-bonds, and if the total
content of conjugated monomer diene units is taken to be
100 mass%, the content of alkenyl monomer units (a1)
20 obtained by hydrogenating the conjugated diene monomer
units (a) is in the range from 10 to 50 mass%, the
content of alkenyl monomer units (b1) obtained by
hydrogenating the conjugated diene monomer units (b) is
in the range from 0 to 80 mass%, and the total content of
25 unhydrogenated conjugated diene monomers units (a2)
following hydrogenation and unhydrogenated conjugated
diene monomer units (b2) following hydrogenation is in
the range from 0 to 90 mass%.
- 30 5. A process according to any of Claims 1 to 4 wherein
the fully or partially hydrogenated block copolymer has a
weight average molecular weight in the range from 50,000
to 300,000.
6. A process according to any of Claims 1 to 5 wherein

the block copolymer has at least one type of functional group selected from hydroxyl groups, acid anhydride groups, epoxy groups, amino groups, amide groups, silanol groups and alkoxy silane groups.

5 7. A process according to any of Claims 1 to 6 wherein the content of conjugated diene monomer units (a) derived from 1,2-bonds and/or 3,4-bonds is in the range from 10 to 50 mass% relative to the total content of the conjugated diene monomer of the block copolymer.

10 8. A concentrated polymer-modified bitumen composition, comprising:

(i) from 11 to 15 wt%, based on the total weight of the concentrated polymer-modified bitumen composition, of a partially or fully hydrogenated block copolymer;

15 (ii) from 60.0 to 96.5 wt%, based on the total weight of the composition, of a bitumen component;

(iii) from 5 to 7 wt%, based on the total weight of the composition, of a flux component; and

(iv) optionally one or more additional components,

20 wherein the fully or partially hydrogenated block copolymer comprises a polymer block (A) comprising vinyl aromatic monomer units as main component, and copolymer block (B) comprising conjugated diene monomer units and vinyl aromatic monomer units, wherein the content of the vinyl aromatic monomer units in the block copolymer is in the range from 20 to 60 mass%, the content of the copolymer block (A) in the block copolymer is in the range from 10 to 40 mass% and the hydrogenation rate of double bonds in the conjugated diene monomer units of the
25 block copolymer is in the range from 40 to 100%;

30 wherein the bitumen component is a 70/100 penetration grade bitumen; and

wherein the flux component is bright stock furfuryl
extract.