



(86) Date de dépôt PCT/PCT Filing Date: 2002/05/04
(87) Date publication PCT/PCT Publication Date: 2002/11/21
(45) Date de délivrance/Issue Date: 2009/09/29
(85) Entrée phase nationale/National Entry: 2003/10/09
(86) N° demande PCT/PCT Application No.: EP 2002/004925
(87) N° publication PCT/PCT Publication No.: 2002/092694
(30) Priorité/Priority: 2001/05/17 (DE101 23 907.6)

(51) Cl.Int./Int.Cl. *C08L 95/00* (2006.01),
C08J 9/00 (2006.01), *C08K 5/5419* (2006.01)

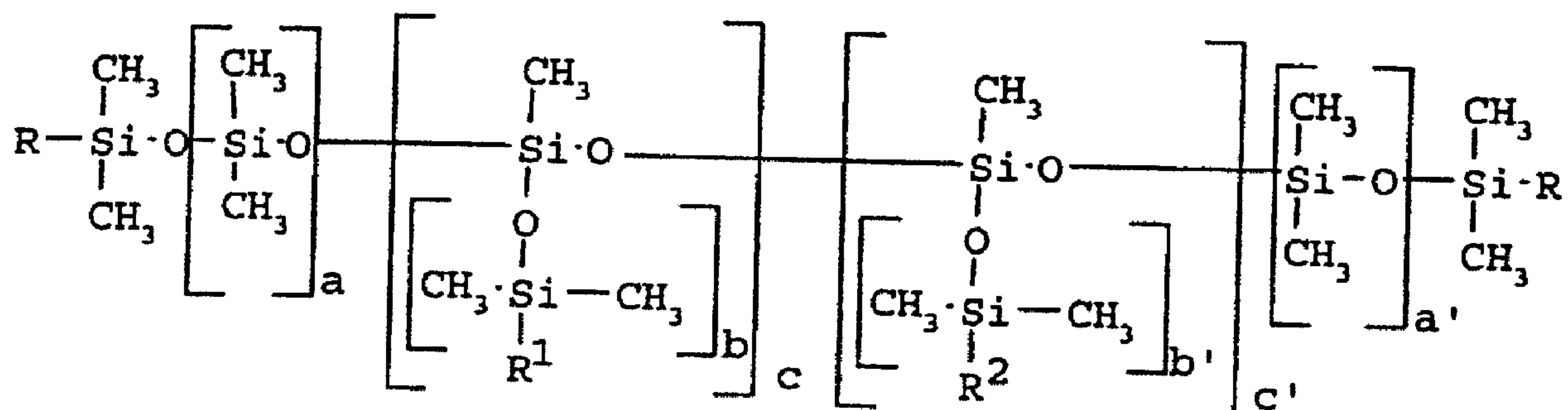
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(54) Titre : PROCEDE DE PRODUCTION DE BITUME MOUSSE PRESENTANT UNE STABILITE ET UN VOLUME DE
MOUSSE AMELIORES

(54) Title: METHOD FOR PRODUCING FOAM BITUMEN WITH IMPROVED FOAM STABILITY AND IMPROVED FOAM
VOLUME



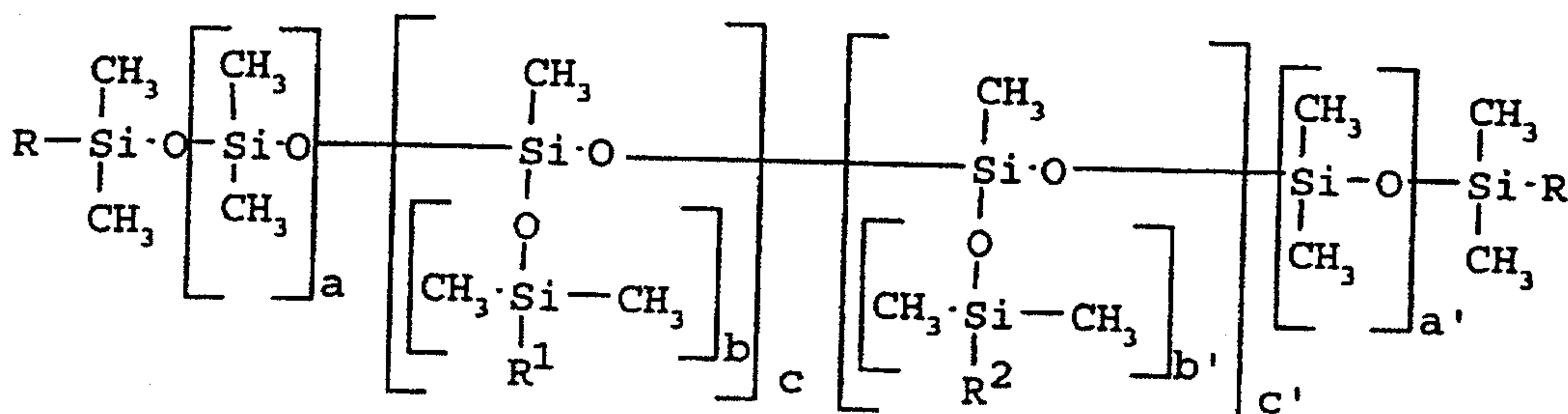
(57) Abrégé/Abstract:

The invention provides a process for producing foamed bitumen from bitumen, water, and additives, which comprises using as additive at least one silicone compound of the general formula (see above formula) in which R, R¹ and R² in the average molecule can be identical or different and denote an alkyl radical having 1 to 30, preferably 8 to 22 carbon atoms or the radical -Z-(C_nH_{2n}O-)_m R₃, where R₃ is a hydrogen radical or an alkyl radical having 1 to 8 carbon atoms, Z is a divalent radical of the formula -O-, -(CH₂)_p -O- or -CH₂-CH(CH₃)-CH₂-O- with p = 2 to 6, n is an average numerical value from 2.7 to 4.0, m is an average numerical value from 5 to 130, a and a' together have an average numerical value from 4 to 1500, b and b' together have an average numerical value from 0 to 100, and c and c' together have an average numerical value from 0 to 50.



Abstract:

The invention provides a process for producing foamed bitumen from bitumen, water, and additives, which comprises using as additive at least one silicone compound of the general formula



10 in which

R, R¹ and R² in the average molecule can be identical or different and denote an alkyl radical having 1 to 30, preferably 8 to 22 carbon atoms or the radical

15 -Z-(C_nH_{2n}O-)_mR₃, where

R₃ is a hydrogen radical or an alkyl radical having 1 to 8 carbon atoms,

Z is a divalent radical of the formula -O-, -
 (CH₂)_p-O- or -CH₂-CH(CH₃)-CH₂-O- with p = 2 to 6,

20 n is an average numerical value from 2.7 to 4.0,

m is an average numerical value from 5 to 130,

a and a' together have an average numerical value from 4 to 1500,

b and b' together have an average numerical value from
25 0 to 100, and

c and c' together have an average numerical value from 0 to 50.

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Goldschmidt AG, Essen

Method For Producing Foam Bitumen With Improved Foam
Stability And Improved Foam Volume

5

The invention relates to a process for producing foamed bitumen having improved foam stability and improved foam volume.

10 According to DIN 55 946 part 1 (12/1983) bitumen is the term for the dark-colored, semisolid to rubbery, meltable, high molecular mass hydrocarbon mixtures obtained in the gentle processing of crude oils, and the fractions of natural asphalts that are soluble in
15 carbon disulfide, and also mineral wax and montan wax.

Bitumen is used in architectural preservation as a coating material or casting compound. Further areas of application are in anti-groundwater sealants, as an
20 electrical insulating material, in the prepared roofing industry, but primarily as a binder for a host of organic and inorganic substrates, such as plastics, paper, paperboard, recyclable materials such as constructional rubble or slags from industrial
25 processes, problematic substances containing asbestos, and, in particular, conventional roadbuilding gravels and sands, crushed rock, and chippings.

Since the customary bitumens are solid at normal
30 temperatures, they must be liquefied in order to produce a coating which adheres to the substrates.

This can be achieved by heating to appropriately high liquefaction temperatures. Disadvantages here are that
35 the operation is very energy-intensive and that as a result of the evaporation of low-boiling constituents in the bitumen there is a perceptible burden on the environment.

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Although dissolving bitumen in appropriate organic solvents circumvents these problems, it too has the drawback that the solvent, on evaporation, burdens the environment over a long period of time and, moreover,
5 raises toxicological concerns.

Replacing the solvent with water requires a considerable proportion of surfactants in order to produce stable, useful dispersions/emulsions. The
10 surfactants are leached by rainwater and hence, in the long term, are likewise emitted to the environment.

Another method of using bitumen in roadbuilding is to process it to foamed bitumen. Foamed bitumen is a term
15 used for bitumen which is foamed using water and air at temperatures above 140°C and applied, as a mixture of air, water, and bitumen, to the aggregates that are to be bound.

20 Mineral materials bound with foamed bitumen offer considerable advantages in roadbuilding as compared with other, comparable technologies: foamed bitumen is outstandingly suitable for stabilizing mineral materials and sands. The foam binds immediately to the
25 surface of the aggregate, especially to the fine fractions of the mineral material mixture, and even moist surfaces are adequately wetted.

Owing to their increased temperature stability and
30 deformation stability, the bitumen-aggregate mixtures produced in this way (which are also referred to as asphalt) are especially suitable as material for base layers and binder layers in roadbuilding.

35 Additionally, however, there is also increasing interest in recycling applications, such as the encapsulation of materials from industrial processes, such as blast furnace slags, metal slags, and

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phosphorus slags, and, in particular, problematic materials containing asbestos.

5 In order to wet and/or encapsulate the mineral materials effectively, the bitumen foam must comply with two fundamental prerequisites: on the one hand, a sufficiently large foam volume, and also a sufficient stability before the foam collapses on itself to a marked extent.

10

These criteria, the degree of expansion and the so-called half-life (the time within which the maximum foam volume has contracted by 50%), are critical characteristics of bitumen foam and depend on a multiplicity of interdependent parameters, for which at 15 the present time there are only inadequate explanations or estimations.

20 Through the addition of additives attempts have been made to improve foam volume and foam stability further in the direction of the requirements of the art, since when aggregates are added, especially mineral aggregates, the contraction process is greatly accelerated.

25

Thus JP-A 2000219762 (CA 133:154518) describes quaternary ammonium salt additives which are based on relatively long-chain amines and alkyimidazolines and which are added in amounts of from 0.01 to 10% by 30 weight to the bitumen.

JP-A 62172039 (CA 108:76723) dissolves bitumen in miscible solvents such as trifunctional polyether polyols and foams the solution using amine-containing 35 and tin-containing catalysts, and also water and silicone oil, to form polyurethane foams.

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JP-A 61115956 (CA 105:119752) mixes bitumen with butadiene-styrene rubber and an azodicarboxamide blowing agent and heats the mixture to 160°C.

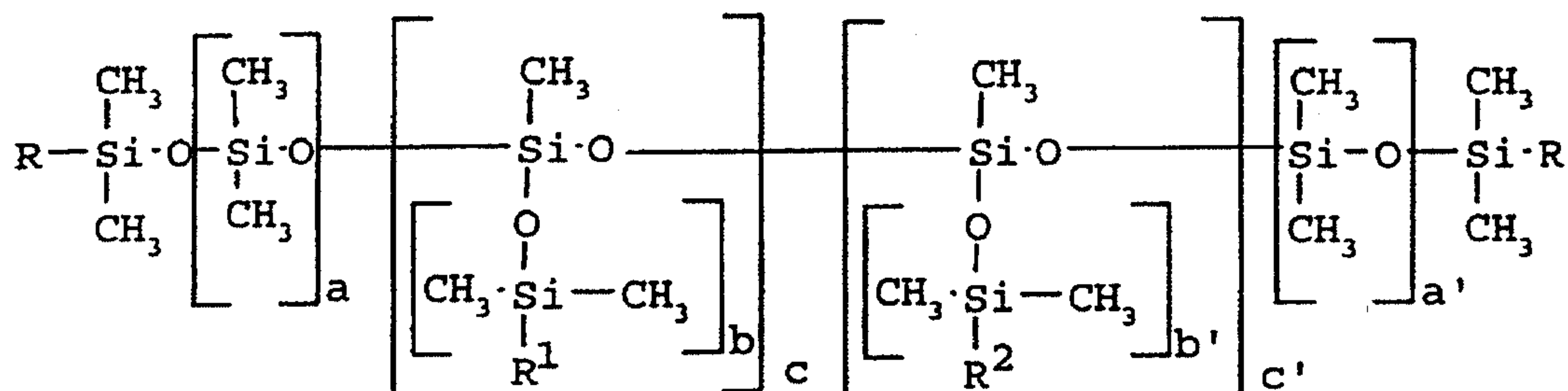
- 5 The foams obtained are intended to have an improved dynamic stability.

Also of considerable significance, furthermore, are the origin of the bitumen, its quality, and the refinery process. The reasons for inadequate foam formation and foam stability are not always evident, since the composition of the bitumen is complex and the refinery processes use antifoams such as silicones, for example. It is assumed, however, that these silicones have an adverse effect on the foam behavior.

Surprisingly it has now been found that, contrary to experience existing to date, certain silicone compounds are not only capable of not adversely affecting volume and stability of foamed bitumen but also, on the contrary, in fact have a positive effect.

One object of the present invention, improving the stability and volume of foamed bitumen, is achieved through the use of special silicone compounds as additives for their improvement.

The invention accordingly provides a process for producing foamed bitumen from bitumen, water, and additives, which comprises using as additive at least one silicone compound of the general formula



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in which

R, R^1 and R^2 in the average molecule can be identical or different and denote an alkyl radical having 1 to 30, preferably 8 to 22 carbon atoms or the radical
 5 $-Z-(C_nH_{2n}O-)_mR^3$, where
 R^3 is a hydrogen radical or an alkyl radical having 1 to 8 carbon atoms,
 Z is a divalent radical of the formula $-O-$,
 10 $-(CH_2)_p-O-$ or $-CH_2-CH(CH_3)-CH_2-O-$ with $p = 2$ to 6,
 n is an average numerical value from 2.7 to 4.0,
 m is an average numerical value from 5 to 130,
 a and a' together have an average numerical value from
 15 4 to 1500,
 b and b' together have an average numerical value from 0 to 100, and
 c and c' together have an average numerical value from 0 to 50.

20

In the formula, R preferably has the meaning of a methyl radical, R^1 preferably the meaning of an alkyl radical having 1 to 30, in particular 8 to 22 carbon atoms, and R^2 that of a polyether radical, in which Z is
 25 $-O-$ or $-(CH_2)_p-O-$, with $p = 3$ or 4. This then gives for the polyether radical the formula $-(CH_2)_3-O-(C_nH_{2n}O-)_mR^3$ and/or $-(CH_2)_4-O-(C_nH_{2n}O-)_mR^3$.

n has an average numerical value of 2.7 to 4.0, a
 30 numerical value of from 2.7 to 3 being preferred. This average numerical value arises during the preparation of the polyether by a blockwise or random addition reaction of corresponding amounts of ethylene oxide and propylene oxide, it also being possible, if desired, to
 35 use higher alkylene oxides, with one of $n =$ approximately 2.7 to 3.5.

m has an average numerical value from 5 to 130 and indicates the average number of oxyalkylene units in

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the polyether radical. Preferred for m is an average numerical value from 6 to 50.

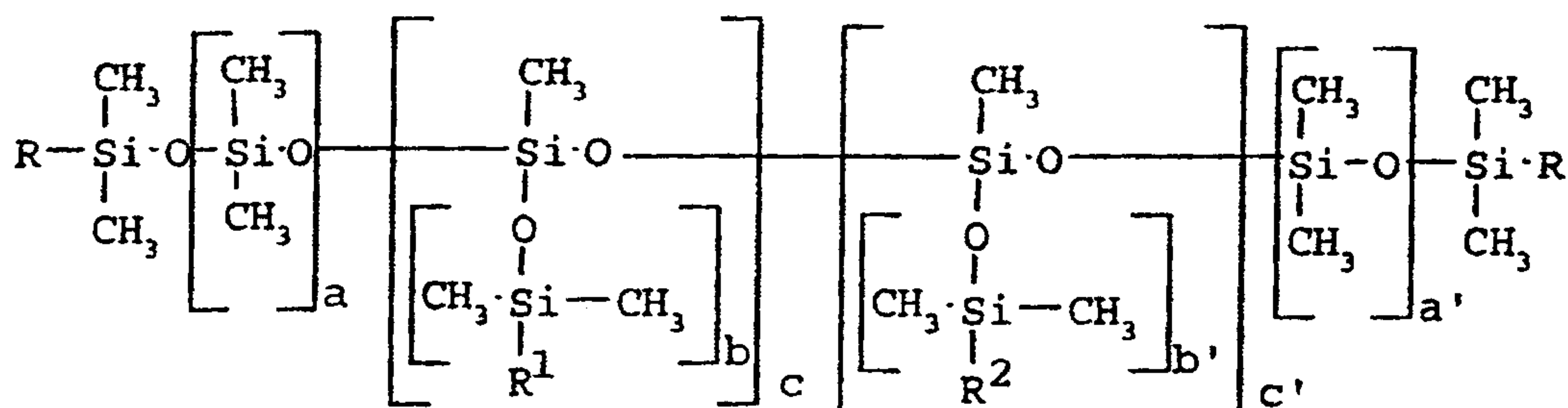
R^3 is a hydrogen radical or an alkyl radical having from 1 to 8 carbon atoms. Particular preference is given to an alkyl radical having from 1 to 5 carbon atoms, especially the butyl radical.

The indices a, a', b, b', and c, c' preferably have the following values:

a and a' together have an average numerical value from 4 to 800,
 b and b' together have an average numerical value from 0 to 50,
 c and c' together have an average numerical value of from 1 to 30.

Especially preferred compounds are those in which R^1 is an alkyl radical having 6 to 22 carbon atoms, R^2 is a polyether radical $-(CH_2)_4-O-C_2H_4O-)_mR^3$ and/or $-(CH_2)_4-O-CH_2-CH(CH_3)-CH_2O)_mR^3$, in which m is an average numerical value from 6 to 50, in particular from about 10 to 30, b and b' = 0, and the ratio $(a+a'):c:c'=(10 \text{ to } 200):(3 \text{ to } 30):(0 \text{ to } 10)$ in particular $(a+a'):c:c'=(60 \text{ to } 80):(15 \text{ to } 25):(0 \text{ to } 5)$.

The invention further provides a bitumen foam produced using at least one silicone compound of the general formula



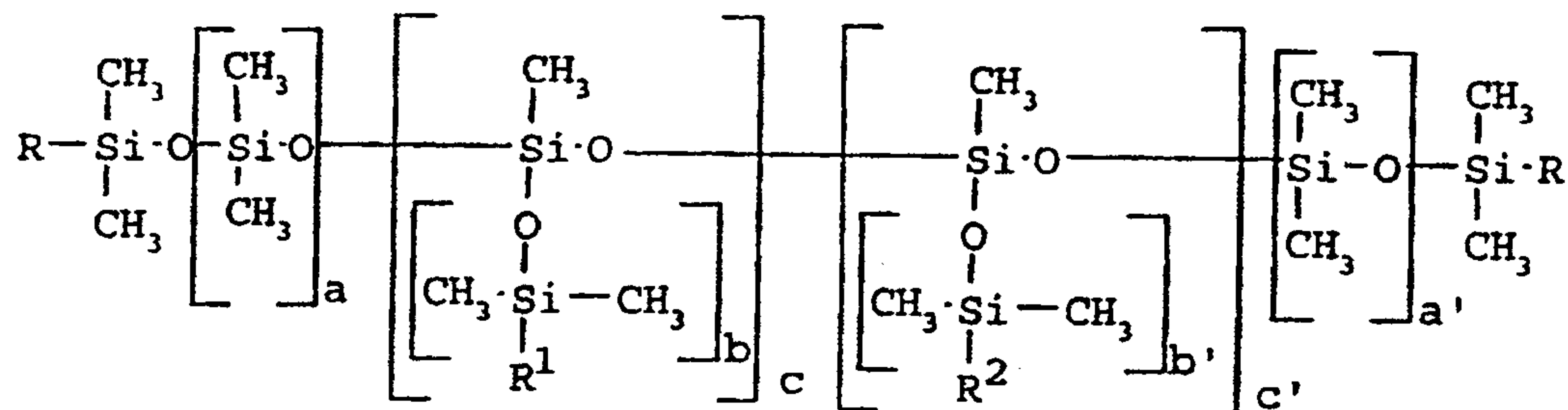
in which

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- R, R¹ and R² in the average molecule can be identical or different and denote an alkyl radical having 1 to 30, preferably 8 to 22 carbon atoms or the radical
- 5 -Z-(C_nH_{2n}O-)_mR³, where
- R³ is a hydrogen radical or an alkyl radical having 1 to 8 carbon atoms,
- Z is a divalent radical of the formula -O-,
- 10 -(CH₂)_p-O- or -CH₂-CH(CH₃)-CH₂-O- with p = 2 to 6,
- n is an average numerical value from 2.7 to 4.0,
- m is an average numerical value from 5 to 130,
- a and a' together have an average numerical value from 4 to 1500,
- 15 b and b' together have an average numerical value from 0 to 100, and
- c and c' together have an average numerical value from 0 to 50.
- 20 The invention further provides for the use of foamed bitumen comprising at least one of the above compounds for adhesively bonding substrates such as, in particular, mineral materials which can be used in roadbuilding.

- 25 The invention further provides a foamable bitumen mixture comprising bitumen, water, and additives, wherein as additive use is made of at least one silicone compound of the general formula

30



in which

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R, R¹ and R² in the average molecule can be identical or different and denote an alkyl radical having 1 to 30, preferably 8 to 22 carbon atoms or the radical -Z-(C_nH_{2n}O-)_mR³, where

5 R³ is a hydrogen radical or an alkyl radical having 1 to 8 carbon atoms,

Z is a divalent radical of the formula -O-,
-(CH₂)_p-O- or -CH₂-CH(CH₃)-CH₂-O- with p = 2 to 6,

10 n is an average numerical value from 2.7 to 4.0,

m is an average numerical value from 5 to 130,

a and a' together have an average numerical value from 4 to 1500,

b and b' together have an average numerical value from

15 0 to 100, and

c and c' together have an average numerical value from 0 to 50.

Further subject matter of the invention is
20 characterized by the claims.

Surprisingly it has been found that with the polysiloxane compounds used in accordance with the invention it is also possible to foam bitumens which do
25 not normally produce foams which can be used industrially, since either the half-life amounts to only a few seconds and/or the foam volumes are not large enough. The technical properties of easy-to-foam bitumens are further greatly improved through the use
30 of the compounds of the invention. This is all the more surprising on account of the fact that in the art to date these compounds are known to have been used as defoamers.

35 The bitumen foam is prepared in principle by injecting a mixture of air and small amounts of cold water (about 1 to 5% by weight, based on bitumen) into an expansion chamber along with bitumen heated to about 140 to 200°C. The water evaporates explosively and forces the mixture

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with high pressure through an atomizer die, generating a bitumen foam having a volume about 15 to 25 times higher than that of the initial bitumen. This foam is applied to the aggregates.

5

In order to wet these aggregates effectively the bitumen foam must, as a fundamental requirement, have in particular, on the one hand, a sufficiently high volume (degree of expansion) and, on the other hand, a
10 sufficient stability (half-life). Consequently, these criteria are also employed for assessing the foam quality.

The expansion ratio (Ex) is defined as the ratio of the
15 maximum foam volume [Vmax] to the volume of the bitumen [Vmin]: $Ex = [Vmax]/[Vmin]$. The volumes are determined by a measuring rod to an accuracy of 1 cm.

The half-life ($T_{1/2}$) is the time within which the foam,
20 after reaching the maximum volume, shrinks back to half the maximum volume. The respective foam volume is determined by means of a measuring rod, while the time is determined by means of a stopwatch and measured to an accuracy of 1 second.

25

The aim is for a foam with as high a volume as possible which at the same time has as long as possible a half-life. Since both values enter into the assessment of foam quality, the foam index (FI) has been proposed as
30 a new quality criterion.

According to the paper by K.J. Jenkins, M.F.C. van de Ven and J. de Groot at the 7th Conference on Asphalt Pavements for Southern Africa, the evaluation of
35 laboratory results has to date ignored the fact that the foam contracts even during the sprayout time and therefore that the measured foam volume (ERm) may deviate considerably from the actual maximum volume (ERa), as a function of the half-life of the foams. In

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order to determine this ratio (ER_m/ER_a) a correction factor (c) has been proposed, and is introduced into the formula in order to determine the foam index FI:

$$FI = \frac{-T_{1/2}}{\ln 2} \left[4 - ER_m - 4 \ln \left[\frac{4}{ER_m} \right] + \left[\frac{1+c}{2c} \right] * ER_m * t_s \right]$$

- 5 FI = foam index;
 ER_m = maximum expansion rate;
 T_{1/2} = half-life; time in sec within which the foam
 volume has contracted by half;
 t_s = spraying time;
 10 c = correction factor, taken from the conference
 papers.

Figure 1 is a graph of the ratio of ER_m to ER_a against half-life measured in seconds, for various spraying times.

15

Since the foam properties are essentially dependent on the type of bitumen used, the bitumen temperature, the air pressure, and, in particular, the water content, the volume flows passed into the expansion chamber and also the
 20 experimental conditions must be carefully attuned to one another. Operation takes place generally at bitumen temperatures of about 140 to 200°C, water contents of about 1 to 5% by weight, based on bitumen, and an air pressure of up to about 5 bar.

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In order to improve the performance properties of the foam, adjuvants and auxiliaries may be added to the water used as blowing agent. The additives used in accordance with the invention are likewise preferably
5 admixed to the water, the amounts being in the range from about 0.01 to 5% by weight, preferably from about 0.02 to 2% by weight, based on bitumen.

In accordance with the invention it is possible in
10 principle to foam any bitumens. The choice of the type used is determined primarily by the technical application. Preference is given to the grades which are commonly used in roadbuilding, i.e., 15, 25, 45, 65, 80, 200, 300, and 400, and especially bitumens with
15 a penetration rating of 70 to 200 (type B 80 to type B 200).

Experimental procedure:

20 The examples below were carried out using a type B 200 E bitumen from the company NYNAS. The experiments were carried out using the foamed bitumen laboratory unit WLB 10 from Wirtgen, D-53578 Windhagen, Germany, in accordance with the given operating instructions.

25 Introduced into the expansion chamber were the bitumen, heated to 170°C, with a pressure of 6.5 bar, the air, with a pressure of 6 bar, and the water (20°C), with a pressure of 5 bar. The batch size was in each case
30 500 g, the bitumen flow rate 100 g/sec, the spraying time 5 sec, and the amount of inventively co-used additive 0.025% by weight, based on bitumen. The stated measurement values are averages from three measurements.

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Experimental results:

	Additive 1				Additive 2			
Water % by wt.	ERm	T1/2	ERa	FI	ERm	T1/2	ERa	FI
1.0	8.4	364.8	8.4	784	8.1	336.6	8.1	650
2.0	20.2	158.7	20.4	2320	19.6	139.4	19.9	1963
3.0	27.8	69.0	28.6	1741	27.2	57.7	28.1	1431
4.0	31.1	30.0	33.1	978	30.7	23.9	33.2	799
4.0	30.1	13.1	34.8	505	30.4	9.9	30.4	429

	Additive 3				Additive 7			
Water % by wt.	ERm	T1/2	ERa	FI	ERm	T1/2	ERa	FI
1.0	8.6	324.9	8.6	751	8.1	417	8.1	798
2.0	22.3	120.0	22.3	2097	21.7	272	21.9	4421
3.0	31.6	44.3	33.5	1399	32.2	178	32.5	5243
4.0	36.5	16.4	40.9	754	39.6	116	40.2	4615
5.0	37.1	6.0	50.1	427	43.8	76	44.9	3521

	Additive 9				Additive 10			
Water % by wt.	ERm	T1/2	ERa	FI	ERm	T1/2	ERa	FI
1.0	8.4	389	8.4	834	8.0	80	8.2	183
2.0	18.0	249	18.1	2948	19.4	35	20.5	560
3.0	23.5	160	23.8	2989	27.1	16	30.4	500
4.0	24.7	102	25.2	2104	31.3	7	40.6	372
4.0	21.7	66	22.3	1149	31.9	3	56.8	306

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	Additive 11				Bitumen without additive			
Water % by wt.	ERm	T1/2	ERa	FI	ERm	T1/2	ERa	FI
1.0	8.4	67	8.6	179	10.1	57	10.4	246
2.0	15.5	32	16.4	359	15.9	30	16.9	357
3.0	21.4	15	24.2	345	20.1	16	22.6	330
4.0	25.9	7	33.6	295	22.8	9	28.0	281
5.0	29.1	3	51.9	277	24.0	5	34.3	238

5 In a comparison of the markedly improved FI values, the experiments with additives 1, 2, 3, 7 and 9 show the advantages when using the additives of the invention in comparison with the noninventive additives 10 and 11 and with the pure bitumen without additive.

10 Definitions are as follows:

15 Additive 1 Polysiloxane BC 793 from Goldschmidt in which $b + b'$, $c + c' > 0$ and R , R^1 , and R^2 are polyethylene oxide/polypropylene oxide chains with molar weights > 1000 ,

20 Additive 2 Polysiloxane B 1484 from Goldschmidt in which $b + b'$, $c + c' > 0$ and R , R^1 , and R^2 are predominantly polypropylene oxide chains with molar weights > 1000 ,

25 Additive 3 Polysiloxane B 1959 from Goldschmidt in which $b + b'$, $c + c' > 0$ and R , R^1 , and R^2 are predominantly polyethylene oxide chains with molar weights > 1000 ,

Additive 7 Polysiloxane TEGO® Addibit FS 700 from Goldschmidt in which $b + b'$, $c + c' = 0$ and R is $-\text{CH}_3$, R^1 is a fatty alkyl

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radical, and R_2 is predominantly polyethylene oxide chains,

5 Additive 9 Polysiloxane TEGOPREN® 6814 from Goldschmidt in which $b + b' = 0$ and R is $-CH_3$, R^1 , and R^2 are fatty alkyl radicals.

Comparative experiments:

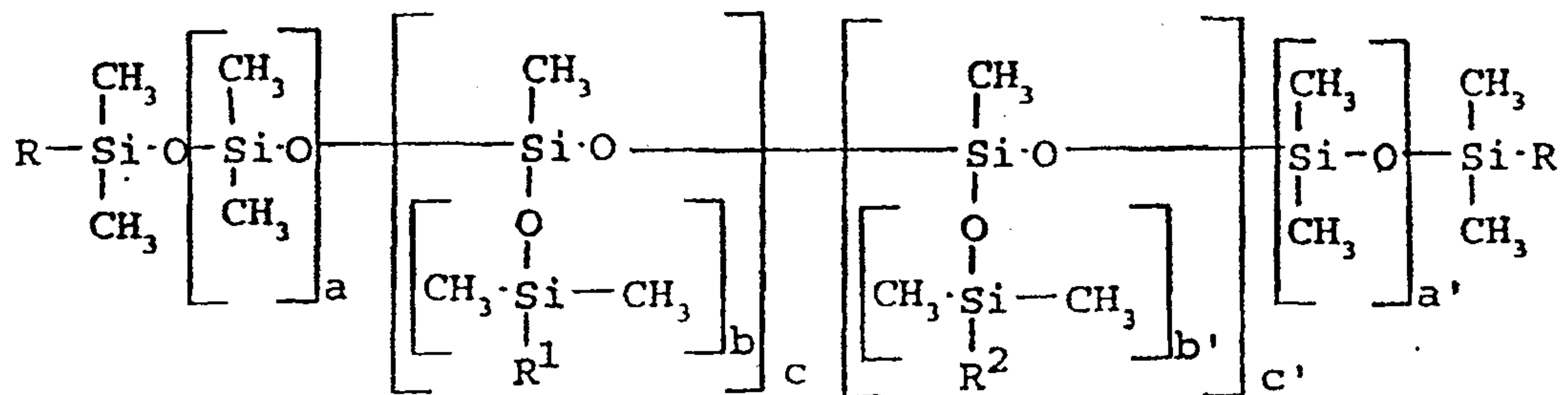
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Additive 10 Si-free polyether with polyethylene and polypropylene chains and a molar weight > 1000 ,

15

Additive 11 Si-free polyether with polypropylene chains and a molar weight > 1000 .

1. A process for producing foamed bitumen from bitumen, water, and an additive, which comprises using as the additive at least one silicone compound of the general formula:



R, R¹ and R² in the average molecule are identical or different and denote an alkyl radical having 1 to 30 carbon atoms, or the radical -Z-(C_nH_{2n}O)_mR³, wherein:

Z is a divalent radical of the formula -O-, $-(CH_2)_p-O-$ or $-CH_2-CH(CH_3)-CH_2-O-$ with $p = 2$ to 6;

m is an average numerical value from 5 to 130;

b and b' together have an average numerical value from 0 to 100; and

c and c' together have an average numerical value from 0 to 50.

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2. A process as claimed in claim 1, wherein R, R¹ and R² in the average molecule are identical or different and denote an alkyl radical having 8 to 22 carbon atoms, or the radical -Z-(C_nH_{2n}O-)_mR³.

3. A process for producing foamed bitumen, which comprises using as an additive at least one silicone compound of the general formula defined in claim 1, in which:

R has the definition of a methyl radical;

R¹ has the definition of an alkyl radical having 1 to 30, carbon atoms;

R² has the definition of a polyether radical in which:

Z is -O- or -(CH₂)_p-O-, with p = 3 or 4;

R³ is a hydrogen radical or an alkyl radical having 1 to 8 carbon atoms.

4. A process as claimed in claim 3, wherein R¹ is an alkyl radical having 8 to 22 carbon atoms.

5. The process for producing foamed bitumen as claimed in any one of claims 1 to 4, wherein n has an average numerical value of from 2.7 to 3.0 and m has an average numerical value of from 6 to 50.

6. A process for producing foamed bitumen as claimed in any one of claims 1 to 5, wherein a and a' together have an average numerical value of from 4 to 800, b and b' together have an average numerical value of from 0 to 50, and c and c' together have an average numerical value of from 1 to 30.

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7. A process for producing foamed bitumen as claimed in any one of claims 1 to 6, wherein:

R is a methyl radical;

R¹ is an alkyl radical having 6 to 22 carbon atoms;

R² is a polyether radical $-(CH_2)_4-O-(C_2H_4O-)_mR^3$ and/or $-(CH_2)_4-O-(CH_2-CH(CH_3)CH_2O)_mR^3$, in which:

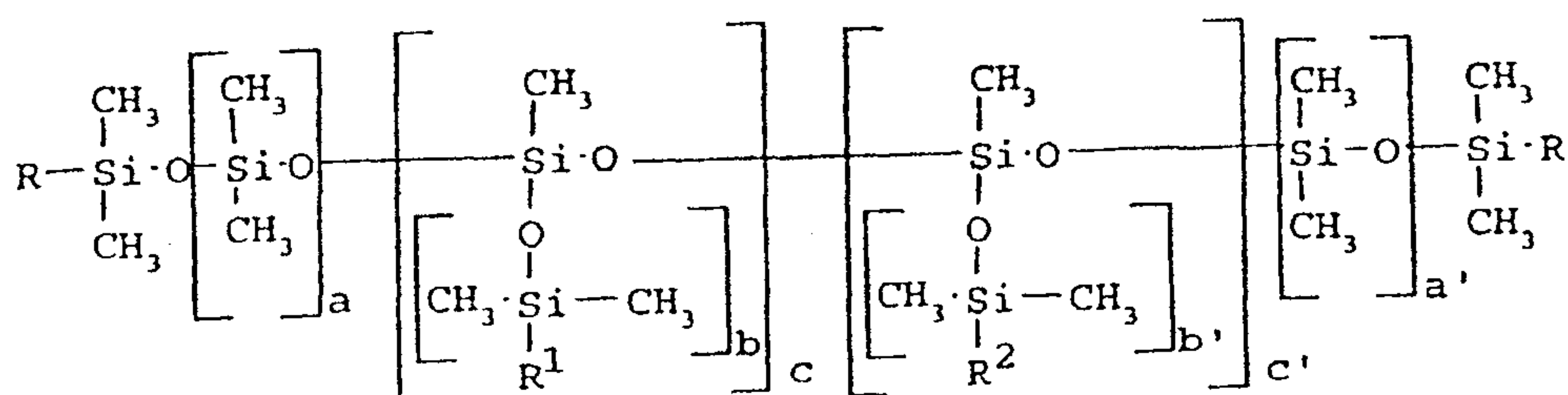
m is an average numerical value of 6 to 50;

b and b' = 0, and the ratio (a+a'):c:c' = (10 to 200):(3 to 30):(0 to 10).

8. A process as claimed in claim 7, wherein m is from about 10 to 30.

9. A process as claimed in claim 7 or 8, wherein the ratio (a+a'):c:c' = (60 to 80):(15 to 25):(0 to 5).

10. A bitumen foam produced using at least one silicone compound of the general formula:



in which:

R, R¹ and R² in the average molecule are identical or different and denote an alkyl radical having 1 to 30 carbon atoms, or the radical $-Z-(C_nH_{2n}O-)_mR^3$, wherein:

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R^3 is a hydrogen radical or an alkyl radical having 1 to 8 carbon atoms;

Z is a divalent radical of the formula $-O-$, $-(CH_2)_p-O-$ or $-CH_2-CH(CH_3)-CH_2-O-$ with $p = 2$ to 6 ;

n is an average numerical value from 2.7 to 4.0;

m is an average numerical value from 5 to 130;

a and a' together have an average numerical value from 4 to 1500;

b and b' together have an average numerical value from 0 to 100; and

c and c' together have an average numerical value from 0 to 50.

11. A bitumen foam as claimed in claim 10, wherein R, R^1 and R^2 in the average molecule are identical or different and denote an alkyl radical having 8 to 22 carbon atoms, or the radical $-Z-(C_nH_{2n}O-)_mR^3$.

12. A bitumen foam as claimed in claim 10, produced using at least one silicone compound in which:

R has the definition of a methyl radical;

R^1 has the definition of an alkyl radical having 1 to 30 carbon atoms;

R^2 has the definition of a polyether radical in which:

Z is $-O-$ or $-(CH_2)_p-O-$, with $p = 3$ or 4 ;

R^3 is a hydrogen radical or an alkyl radical having 1 to 8 carbon atoms.

13. A bitumen foam as claimed in claim 12, wherein R^1 is an alkyl radical having 8 to 22 carbon atoms.

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14. A bitumen foam as claimed in any one of claims 10 to 13, produced using at least one silicone compound in which a and a' together have an average numerical value of from 4 to 800, b and b' together have an average numerical value of from 0 to 50, and c and c' together have an average numerical value of from 1 to 30.

15. A bitumen foam as claimed in any one of claims 10 to 14, produced using at least one silicone compound in which:

R is a methyl radical;

R¹ is an alkyl radical having 6 to 22 carbon atoms;

R² is a polyether radical $-(CH_2)_4-O-(C_2H_4O-)_mR^3$ and/or $-(CH_2)_4-O-(CH_2-CH(CH_3)CH_2O)_mR^3$, in which:

m is an average numerical value of 6 to 50;

b and b' = 0, and the ratio (a+a'):c:c' is (10 to 200):(3 to 30):(0 to 10).

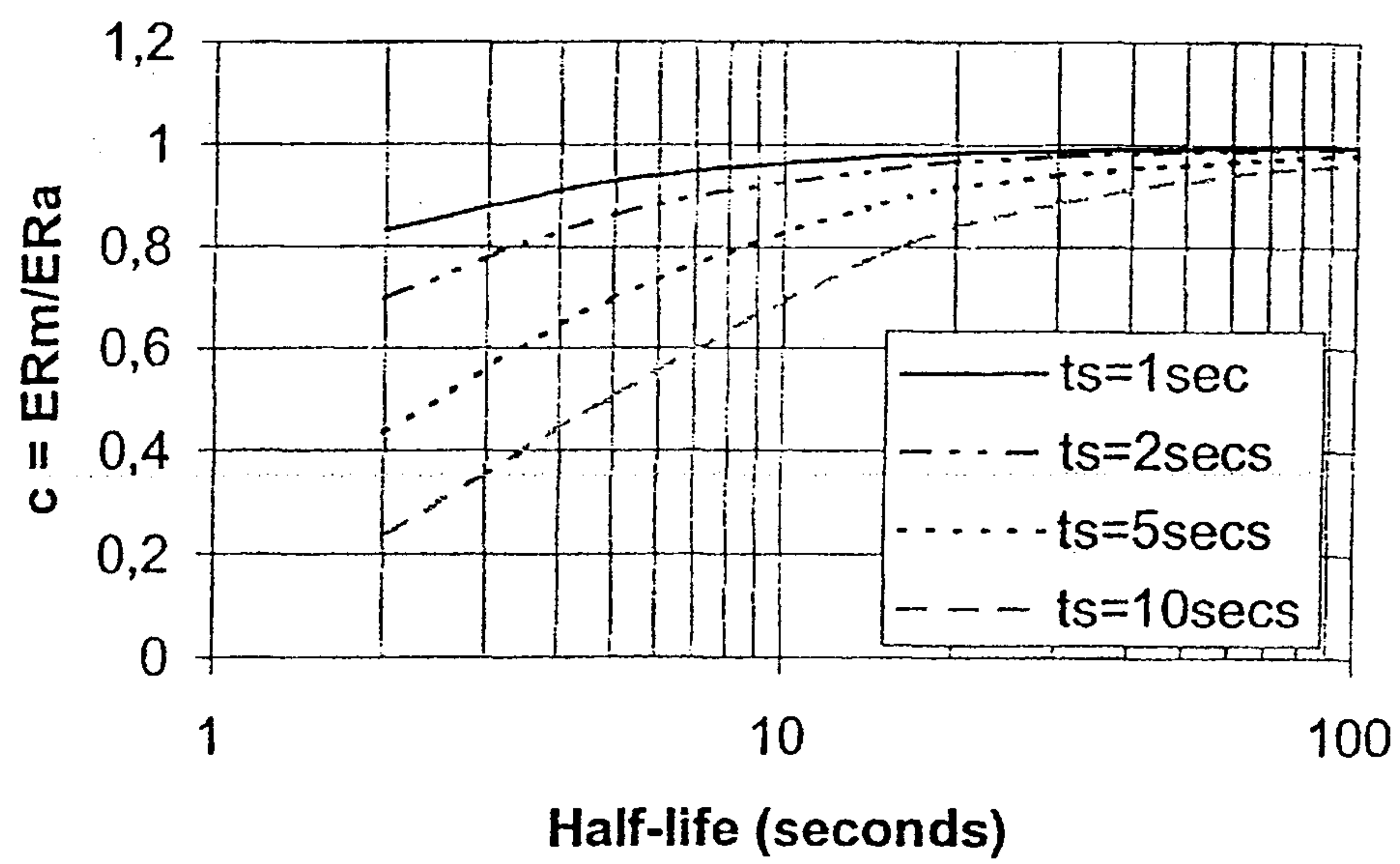
16. A bitumen foam as claimed in claim 15, wherein m is from about 10 to 30.

17. A bitumen foam as claimed in claim 15 or 16, wherein the ratio (a+a'):c:c' (60 to 80):(15 to 25):(0 to 5).

18. Use of foamed bitumen comprising at least one of the compounds as defined in claim 1 for adhesively bonding substrates.

19. The use as claimed in claim 18, wherein the substrates comprise mineral materials which can be used in roadbuilding.

1/1



PRIOR ART

Fig. 1

